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4R Nutrient Stewardship Approach

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INTRODUCTION

4R nutrient stewardship is a new innovative approach which is being adopted and recommended by the world's fertilizer industry for enhancing fertilizer use efficiency. This approach takes into account the economic, social, and environmental aspects of nutrient management and is necessary for sustaining agricultural systems. The approach is based on a simple concept which emphasizes to apply the right source of nutrient, at the right time, at the right rate and in the right place but the implementation is site-specific and knowledge-intensive. The 4R Nutrient Stewardship approach is an effective tool in the development and maintaining of sustainable agricultural systems owing to its application which can have multi-dimensional positive impacts in to secure natural, human, social, physical and financial capital. There is an consecutive link between applying the right nutrient source, at the right rate, right timing, and right placement, and favourable impacts on components of the natural capital apparent through improved soil health, better crop performance, decreased environmental pollution, and the sheltering of wildlife. Similarly, pragmatic effects are anticipated on financial capital, as farmer income improve, bringing about enhancement in their quality of life and elevated economic activity in their communities.

However, executing the framework of 4R Nutrient Stewardship can also enhance the social, human, and physical capital. The construction of site-specific nutrient management practices, for example, requires research work in farmer fields, demanding their active involvement, which results in improved communication among stakeholders (researchers, farmers, government and business representatives). Moreover, the educational aspect of the participants will also improve through both formal and non-formal activities. There are plenty of examples of successful organizations headed and run by farmers that create and disseminate agricultural technologies.

The adoption of new and promising technologies related to 4R Nutrient Stewardship can also lead to positive outcomes on physical capital, because it generally encircle better infrastructure to enter markets both for inputs and outputs and for communication. Transportation of fertilizers, harvests and other inputs require good road infrastructure. The improving access by members of the farming community to newest information through cellular telephones and digital communication mediums reflects in improved communication resources for society. When observed in a wide and integrated way, 4R Nutrient Stewardship can have likely far-reaching implications on the sustainability of agricultural systems that stretch beyond the immediate gains in terms of crop nutrition.

1. Right source:

Selecting the right fertilizer source begins with determining which nutrients are actually required to meet production goals. Nutrients that are limiting can be determined through the use of soil and plant analysis, tissue tests, nutrient omission plots, leaf color sensors, or visual deficiency symptoms. All of these need to be done in advance of the fertilizer application decision. It is common to focus on a single nutrient that is in short supply to the exclusion of other nutrients. All the nutrients function together to support healthy plant growth. Each plant nutrient is available in different chemical forms and they undergo unique reactions after entering the soil. Regardless of their original source and their soil reactivity, they must be in a soluble and plant-available form before they can be taken up by plants.

The core scientific principles that define right source for a specific set of conditions are the following.

i. Supply nutrients in plant-available forms. The nutrient applied is plant-available, or is in a form that converts timely into a plant-available form in the soil.

ii. Suit soil physical and chemical properties. Examples include avoiding nitrate application to flooded soils, surface applications of urea on high pH soils, etc.

iii. Recognize synergisms among nutrient elements and sources. Examples include the P-zinc interaction, N increasing P availability, fertilizer complementing manure, etc.

iv. Recognize blend compatibility. Certain combinations of sources attract moisture when mixed, limiting uniformity of application of the blended material; granule size should be similar to avoid product segregation, etc.

v. Recognize benefits and sensitivities to associated elements. Most nutrients have an accompanying ion that may be beneficial, neutral or detrimental to the crop. For example, the chloride (Cl-) accompanying K in muriate of potash is beneficial to corn, but can be detrimental to the quality of tobacco and some fruits Some sources of P fertilizer may contain plant-available Ca and S, and small amounts of Mg and micronutrients.

vi. Control effects of non-nutritive elements. For example, natural deposits of some phosphate rock contain non-nutritive trace elements. The level of addition of these elements should be kept within acceptable thresholds. Many factors need to be in consideration for selecting the right source.

2. Right Rate:

Application of a nutrient in excessive or less amount may have negative consequences. Liebig’s Law of the Minimum states that the yield of a crop will be determined by the element present in the most limiting quantity. In other words, the deficiency of one nutrient cannot be overcome by the excess of another. Thus, all of the 17 essential elements must be present in quantities sufficient to meet the requirements of the growing crop. The right rate is conditional on source, time, and place. The nutrient source needs to release the right amount of available forms at the right time and in the right place to meet the needs of the growing plants.

The core scientific principles that define right rate for a specific set of conditions are the following.

i. Assess plant nutrient demand. Yield is directly related to the quantity of nutrients taken up by the crop until maturity. The selection of a meaningful yield target attainable with optimal crop and nutrient management and its variability within fields and season to season thus provides important guidance on the estimation of total crop nutrient demand.

ii. Use adequate methods to assess soil nutrient supply. Practices used may include soil and plant analysis, response experiments, omission plots, etc.

iii. Assess all available nutrient sources. For most farms, this assessment includes quantity and plant availability of nutrients in manure, composts, biosolids, residues, atmospheric deposition, and irrigation water, as well as commercial fertilizers.

iv. Predict fertilizer use efficiency. Some loss is unavoidable, so to meet plant demand, the amount must be considered.

v. Consider soil resource impacts. If the output of nutrients from a cropping system exceeds inputs, soil fertility declines in the long term.

vi. Consider rate-specific economics. For nutrients unlikely to be retained in the soil, the most economic rate of application is where the last unit of nutrient applied is equal in value to the increase in crop yield it generates (law of diminishing returns). For nutrients retained in the soil, their value to future crops should be considered. Assess probabilities of predicting economically optimum rates and the effect on net returns arising from error in prediction.

3. Right Time:

The core scientific principles that define right time for a specific set of conditions are the following.

i. Assess timing of plant uptake. Nutrients should be applied to match the seasonal crop nutrient demand, which depends on planting date, plant growth characteristics, sensitivity to deficiencies at particular growth stages, etc.

ii. Assess dynamics of soil nutrient supply. Mineralization of soil organic matter supplies a large quantity of some nutrients, but if the crop's uptake need precedes its release, deficiencies may limit productivity.

iii. Recognize dynamics of soil nutrient loss. For example, in temperate regions, leaching losses tend to be more frequent in the spring and fall.

iv. Evaluate logistics of field operations. For example, multiple applications of nutrients may or may not combine with those of crop protection products. Nutrient applications should not delay time-sensitive operations such as planting.

4. Right Place:

Right place means positioning needed nutrient supplies strategically so that a plant has access to them. Proper placement allows a plant to develop properly and realize its potential yield, given the environmental conditions in which it grows. Right place is, in practice, continually evolving. Plant genetics, placement technologies, tillage practices, plant spacing, crop rotation or intercropping, weather variability, and a host of other factors can all affect which placement is appropriate. Consequently, there is much yet to learn about what constitutes the "right" in right place and how well it can be predicted when management decisions need to be made.

The core scientific principles that define right place for a specific nutrient application are the following:

i. Consider where plant roots are growing. Nutrients need to be placed where they can be taken up by growing roots when needed.

ii. Consider soil chemical reactions. Concentrating soil retained nutrients like P in bands or smaller soil volumes can improve availability.

iii. Suit the goals of the tillage system. Subsurface placement techniques that maintain crop residue cover on the soil can help conserve nutrients and water.

iv. Manage spatial variability. Assess soil differences within and among fields in crop

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productivity, soil nutrient supply capacity, and vulnerability to nutrient loss.

CONCLUSIONS

Source, rate, time, and place are completely interconnected in nutrient management. 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. Every nutrient application can be described as a combination of source, rate, time, and place.