Agri Articles
(e-Magazine for Agricultural Articles)
Volume: 03, Issue: 06 (NOV-DEC, 2023)
Available online at http://www.agriarticles.com
©Agri Articles, ISSN: 2582-9882

The 4R of Nutrient Management

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Three key plant nutrients—nitrogen, phosphate, and potash—are needed to produce crops that are utilised as fuel, fibre, food, and feed. However, phosphate and nitrogen can damage the ecosystem if applied excessively. Adopting optimum nutrient management practises can lead to the efficient use of nutrients. The suitable fertiliser product must be chosen, and the proper amount must be applied at the right time and location to meet plant needs and minimise nitrogen losses. Additionally, enhancing soil organic matter, controlling pests, managing soil moisture, and reducing soil erosion can be accomplished by spreading manure and implementing a crop production management system.

Introduction

A paradigm known as 4R Nutrient Stewardship makes it possible to accomplish cropping system objectives like higher yield, more farmer profitability, better sustainability, and enhanced environmental protection. To achieve those goals, the 4R concept incorporates the right fertilizer source at the right rate, right time and in the right place.

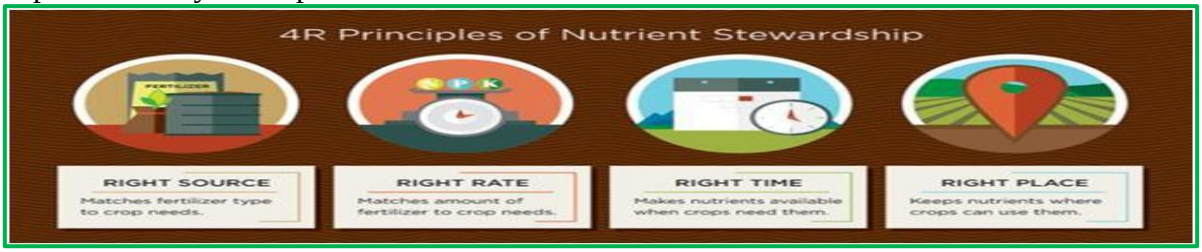
The four "rights" offer a straightforward check list for determining if a certain crop has received adequate fertilisation. Farmers and advisors can use the following question to help them find areas where fertilising a particular crop in a particular field can be improved:

"Was the crop given the right source of nutrients at the right rate, time, and place?"

The basic concepts for the mineral feeding of plants growing in soils are provided by the sciences of physics, chemistry, and biology. The scientific fields of soil fertility and plant nutrition have grown as a result of the practical management of plant nutrition through the application of these sciences.

The idea of 4R nutrient management

Although source, location, and time are more often ignored, they may also present greater opportunities for performance improvement. The surrounding plant-soil-climate system is influenced by plant nutrition techniques. Fertiliser use needs to improve plant system performance in order to be sustainable. In addition to the 4Rs, other management practises including tillage, drainage, cultivar selection, plant protection, weed control, etc., can have an impact on the system's performance.



Right Source: he following fundamental scientific concepts determine the appropriate source under a given set of circumstances:

- **Examine about the application's rate, time, and location.**
- **Give nutrients in a form that is absorbed by plants:** The applied nutrient is either plant-available or in a form that the soil will eventually change into one that is.
- **Fit chemical and physical characteristics of the soil:** Examples include applying urea topically on high pH soils and refraining from applying nitrate to wet soils.
- **Identify how different nutrient sources and elements work together**: The P-zinc interaction, N raising P availability, fertiliser enhancing manure, etc. are a few examples.
- **Determine if a blend is compatible:** The blended material's ability to be applied uniformly is limited by certain combinations of sources that draw moisture when combined; for example, identical granule sizes should prevent product segregation.

• **Acknowledge the advantages and sensitivity to related components**: The majority of nutrients come with an ion that could be advantageous, neutral, or harmful to the crop. For instance, maize benefits from the chloride that surrounds K in muriate of potash, but tobacco and various fruits may suffer as a result. Small levels of Mg and micronutrients, as well as plant-available Ca and S, may be included in some sources of P fertiliser.

- **Manage the impact of non-nutritive components:** For instance, non-nutritive trace elements can be found in some phosphate rock's natural deposits. It is important to keep the addition of these components within reasonable bounds.

Right Rate: The following fundamental scientific ideas determine the appropriate rate for a given set of circumstances:

- Source of application, timing, and location.
- Determine the nutritional needs of plants: The amount of nutrients a crop absorbs up until it reaches maturity is closely correlated with its yield. Important guidance on estimating the overall crop nutrient demand is thus provided by the selection of a meaningful yield objective that can be achieved with optimal crop and nutrient management, given its variability within fields and from season to season.
- Adequately measure the amount of nutrients present in the soil: Response tests, omission plots, soil and plant studies, and other techniques may be employed.
- Evaluate every source of nutrients that are accessible: This evaluation takes into account the amount and plant availability of nutrients found in manure, composts, biosolids, crop residues, atmospheric deposition, irrigation water, and commercial fertilisers for the majority of farms.
- Estimate the efficiency of fertiliser use: In order to meet plant demand, the amount of inevitable loss must be taken into account. Think about the effects on soil resources. Long-term soil fertility decreases when cropping systems produce more nutrients than they take in.

• Keep rate-specific economics in mind. The greatest cost-effective rate of fertiliser application for nutrients that are unlikely to be kept in the soil is when the last unit of nutrient applied equals the increase in crop yield that it produces in terms of value (law of diminishing returns). The worth of nutrients that are held in the soil for upcoming crops needs to be taken into account. Analyse the likelihood of projecting economically optimal rates and the impact that prediction mistake will have on net returns.

Right Time: The following are the appropriate times under particular circumstances:

- The application source, rate, and location.
- Examine when plants absorb nutrients: It is important to apply nutrients in a way that corresponds with the seasonal crop nutrient requirement, which is determined by factors

such as planting date, plant development traits, and susceptibility to shortages at specific growth stages, etc.

- Evaluate the soil's nutrient supply patterns: Large amounts of various nutrients are supplied by the mineralization of soil organic matter, although productivity may be limited if crop absorption requirements are met before nutrients are released.
- Understand the dynamics of nitrogen loss from soil: For instance, leaching losses are typically more common in the spring and autumn in temperate locations.
- Field operations logistics: For instance, crop protection chemicals may or may not interact with multiple applications of fertilisers. Time-sensitive tasks like planting shouldn't be postponed by nutrient sprays.

Right place: The term "right place" refers to the deliberate placement of necessary nutrition sources such that a plant can reach them. Given the growing environment, appropriate placement enables a plant to develop healthily and reach its full potential output. In reality, right spot is always changing. Proper fertiliser placement can be impacted by a wide range of circumstances, including but not limited to the following:

- Plant genetics
- Plant spacing
- Placement technologies
- Crop rotation or intercropping
- Tillage practices
- Weather variability

Therefore, much remains to be discovered regarding the definition of the "right" in the appropriate context and the degree to which it may be forecasted in advance of managerial decision-making. The following fundamental scientific ideas specify the ideal location for a certain nutrition application:

- Take into account application time, rate, and source.
- The locations of plant roots: When needed, nutrients must be positioned where roots can absorb them.
- The chemical reactions in soil: It is possible to increase availability by concentrating soil-retained nutrients, such as P, in bands or smaller soil volumes.
- Tillage system: Techniques for subsurface placement that keep crop leftovers covered in the soil can aid in the conservation of water and nutrients.
- The variability in space: Analyse the variations in crop yield, soil nutrient supply capacity, and susceptibility to nutrient loss in different fields and within the same field.

Benefits of Using the 4Rs

1. **Increased agricultural output can be achieved by 4R nutrient stewardship:**

- Improving nutrient management is just smart business when it comes to handling changes in input and fertiliser pricing as well as the selling of crops.
- Improved fertiliser efficiency increases the quantity produced per acre for each unit of nutrient applied, without sacrificing yield potential. Higher crop yields are well proven with improved crop and soil management.

2. **Mitigating environmental damage with 4R nutrient stewardship:**

- Retaining nutrients within a field's boundaries and in the crop rooting zone greatly reduces the amount that is not utilised by plants and thus escapes into the environment as pollution. This helps to maintain natural ecosystems by allowing crops to grow on less land.

Conclusion

For a crop to produce sustainable economic, social, and environmental consequences, the right fertiliser source must be delivered at the right rate, at the right time, and in the right location. There is mutual reliance and connectivity among the 4Rs. Applying the appropriate source at the appropriate rate, at the appropriate time, and in the appropriate location is the basic yet comprehensive message of 4R Nutrient Stewardship, which places an emphasis on sustainability. Everyone who is involved in applying crop nutrients—from those who apply them to those who offer recommendations—must take sustainability into account when designing their strategies. Policy-level assistance is required for the creation and provision of decision-support for site-specific adaptive management practises.