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Site-Specific Nutrient Management for Sustainable Crop Production

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Site-specific nutrient management (SSNM) as developed through more than a decade of research with rice (*Oryza sativa* L.) in Asia, now provides scientific principles on best nutrient management practices for rice, maize (*Zea mays* L.), and wheat (*Triticum aestivum* L.) in India. These scientific principles of SSNM enable the pre-season determination of crop needs for fertilizer nitrogen (N), the within-season distribution of fertilizer N to meet crop needs, and the pre-season determination of fertilizer phosphorus (P) and potassium (K) rates to match crop needs and sustain soil fertility. Under SSNM best management of fertilizers for each crop is tailored to field-specific conditions with the help of tools that use information technology and other means like decision support software, videos, quick guides for fertilizing crop, and the leaf colour chart (LCC) for managing fertilizers.

Introduction

Over the past four decades, crop management in India has been driven by increasing use of external inputs. The nutrient management and recommendations process in India are still based upon response data averaged over a large geographic area. Agriculture holdings in India are highly fragmented and this pattern of farming increase variability between fields due to individual farmer's knowledge, farm management and resource availability. Fertilizer nutrient have played a major role in improving crop productivity. During the period, 1951-2012 food grain production in the country increased about five times from 51 million tonnes to a record 259 million tonnes (Mt), while fertilizer nutrient use increased by nearly 12 times from 1.95 million tonnes to more than 23 million tonnes in 2007-08 (Rao, 2009). Notwithstanding these impressive developments food grain demand has been estimated to be increased to 300 million tonnes/year by 2025, for which the country would require 45 million tonnes of nutrients (ICAR, 2008). Major factors contributing to the low and decline crop responses to fertilizer nutrients are:

1. Continuous nutrient mining due to imbalance nutrient use, which is leading to depletion of some of major, secondary and micronutrients.
2. Mismanagement of irrigation systems leading to serious soil quality degradation.

The nutrient use efficiency except potassium is very low in India. Considering the fertilizer cost and fertilizer availability, this limited resource needs to be saved for sustainable crop production through improving the nutrient use efficiency by Site-Specific application. The concept of site-specific nutrient management (SSNM) for

crop emerged in the mid-1990s. Site-specific nutrient management (SSNM) is a set of scientific principles for optimally supplying essential nutrients. It enables farmers to tailor nutrient management to the specific conditions of their field and provides a framework for best management practices for crop.

What is SSNM?

- Site-specific nutrient management (SSNM) is an approach to feeding crops with nutrients as and when needed.
- The application and management of nutrients are dynamically adjusted to crop needs of the location and season.
- The SSNM approach aims to increase farmers profit through increased yield of crops per unit of applied fertilizer, higher crop yields and reduced disease and insect damage.
- Site-specific nutrient management (SSNM) enables farmers to optimally supply their crops with essential nutrients.

Why Do We Need SSNM?

Soil and crop residue supply essential nutrients for crop, but high yields require additional nutrients. Farmers often apply fertilizer at a rate and time not well matched to the needs of their crop. SSNM provides principles and guidelines that enable farmers to apply fertilizer that match the needs of their crop in a specific field and season. It aims for efficient nutrient use by crop, and hence, help the farmer obtain high crop yields, translating to high cash value of the harvest per unit of fertilizer applied. We need SSNM mainly for two reasons:

(i) Nutrient Use Efficiency: Under current management practices, farmer often fail to apply N, P and K in the optimal ratio to meet the needs of crop plants. Site-Specific Nutrient Management provides an approach for "feeding" crop with nutrients as and when they are needed. Current fertilizer recommendations often advise fixed rates and timings for large crop growing areas. Such recommendations assume the crop need for nutrients is constant from one place to another, one year to the next. But crop growth and crop demand for nutrients are strongly influenced by climate and other growing conditions.

(ii) Increased profitability: The major benefit for farmers from improved nutrient management strategies is an increase in the profitability of cropping system. The principles of SSNM can accommodate a wide range of socio-economic conditions, including situations of labour shortage. Small amount of additional labour may be required, but labour costs for nutrient management are relatively small. Efficient N management may also results in off- farm environmental benefits through a reduction of fertilizer N use without a reduction in yield (Wang et al., 2001) especially in situations where N inputs are very large. These may increase profitability.

Steps in SSNM

Site-specific nutrient management approach involves three basic steps:

Step1: ***Establish an attainable yield target:*** Crop yields are location and season specific - depending upon climate, cultivar and crop management. The yield target for a given

location and season is the estimated grain yield attainable with farmer's crop management when N, P, and K constraints are overcome.

Step 2: Effectively use of existing nutrients: The SSNM approach promotes the optimal use of existing (indigenous) nutrients coming from the soil, organic amendments, crop residue, manure, and irrigation water.

Step 3: Apply fertilizer to fill the deficit between crop needs and indigenous supply: Fertilizer N, P, and K are applied to supplement the nutrients from indigenous sources and achieve the yield target. The quantity of required fertilizer is determined by the deficit between the crop's total needs for nutrients (as determined by the yield target) and the supply of these nutrients from indigenous sources (as determined by the nutrient limited yield).

When to Use SSNM?

- In the areas where low yields are obtained despite the high yield potential due to inefficient and unbalanced fertilizer application.
- In the areas where deficiency of one or more nutrients is common, it results in the nutrient deficiency symptoms.
- Areas where the incidence of pests and diseases is more due to excess use of N fertilizer.
- In the areas where variability in soil fertility is more due to imbalance use of fertilizers, it leads to strong mining of native nutrients such as P and K.
- In the areas of insufficient and inadequate splitting and time of application of N fertilizer.

Nutrient Management

(1) Nitrogen Management

Nitrogen is an essential element for plant growth. Crop plants can obtain much of their required N from the soil and organic amendments, but the supply of N from these naturally occurring indigenous sources is seldom sufficient for high crop yield. Supplemental N from fertilizers is typically essential for higher yields and profit from irrigated and favourable rain fed crop fields. The demand of crop for N is strongly related to growth stage. For best effect, farmers should apply fertilizer N several times during the growing season to ensure that the N supply matches the crop need for N at the critical growth stages.

Leaf colour chart method: The leaf colour chart (LCC) is an easy-to-use and inexpensive diagnostic tool to monitor plant N status during the season and as a decision it is used to plan fertilizer N for top dressings. Farmers often use colour of leaf as a visual indicator for nitrogen status of the crop and to determine the need for fertilizer N application during the cropping season. A predetermined amount of fertilizer N is applied when the colour of plant leaves falls below a critical LCC threshold that indicates N deficiency in the crop. This helps farmers to adjust fertilizer N application to season-specific climatic condition that affect crop growth (real-time N management). Good real-time N management reduces N fertilizer needs, increase N-use efficiency and reduces the crops susceptibility to pest and disease. It has six scales, the intensity increases with increase in scale. The top most fully expanded leaf is selected and the middle

portion of leaf is matched with LCC to measure the scale. If the LCC value falls below the critical value then immediately, N fertilizer is applied in the standing crop.

How to use the LCC: Randomly select at least 10 disease-free plants in a field with uniform plant population. Select the topmost fully expanded leaf from each plant. Place the middle part of the leaf on the chart and compare the leaf colour with the colour panels of the LCC. Do not detach or destroy the leaf. Measure the leaf colour under the shade of your body (direct sunlight affects leaf colour readings). If possible, the same person should take LCC readings at the same time of the day every time. Determine the average LCC reading for the selected leaves.

(2) Phosphorous and Potassium Management

Phosphorus (P) and potassium (K) are essential elements for plant growth. Phosphorus is particularly important in the early growth stages. It promotes root development, tillering, and early flowering. Potassium strengthens plant cell walls, and contributes to greater canopy photosynthesis and crop growth. It does not have pronounced effect on tillering, but it can increase the number of spikelets per panicle (flowers per grain bunch) and percentage of filled grain.

Nutrient omission plot technique: The nutrient omission plot technique is a tool for determining the amount of fertilizer N, P, and K required for attaining a yield target. In this technique, four plots (each 25 m^2 size) are placed in a field with the following treatments:

Plot 1. Full fertilization: NPK applied
Plot 2 N omission (–N): No N applied, PK applied
Plot 3 P omission (–P): No P applied, NK applied
Plot 4 K omission (–K): No K applied, NP applied

Fertilizer N, P, and K are applied at sufficiently high rates to ensure that yield is not limited by an insufficient supply of the added nutrients. Grain yield in the plot with full fertilization and relatively good crop management can be used to estimate an attainable yield target. Nutrient-limited yields are determined from plots in which the nutrient of interest is not added. For example, the N-limited yield is determined in an N omission plot receiving no N fertilizer but sufficient P and K to ensure that they do not limit yield. The K-limited yield is determined in a K omission plot receiving no K fertilizer but a sufficient supply of other nutrients. The difference in grain yields between a fully fertilized plot and an N omission plot illustrates the deficit between the crop demand for N and indigenous supply of N, which must be met by fertilizers.

Advantages of SSNM:

- Uniform crop stand with more yields
- Increase in fertilizer and other input use efficiency
- More saving of inputs leads to more profit
- Ensures the balanced application of fertilizer
- Protection of environment
- Less pest and disease incidence
- Identification of yield potential variability within field

Problems in Adopting SSNM in India

Small land holdings where small and marginal farmers follow subsistence farming, do not allow successful use of high tech. tools such as GPS and GIS. High cost of equipments and lack of availability is other major problem. Though LCC is cheaper, transfer of technology is again a problem.

Conclusion

Site-Specific nutrient management (SSNM) is an approach mapping the variation with in the field for feeding crops with nutrients as and when needed. Site-Specific nutrient management aims at increasing farmers' economy return and reducing negative impact on environment. SSNM is integrated practices such as maximum economy yield management, best management practices, as well as general agronomic principles. Site-Specific nutrient management will be the key to nutritional security of the country in the coming years.

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