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Nitrogen Fertilization Management in Cereal Crops Through Precision-Smart Technologies

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Agriculture glory of India must be support all the way through attain self-sufficiency in food production first; secondly by improving our agriculture image at global arena, through strong presence in global agriculture market. No doubt, Cereals and coarse cereals should be a front leader in this endeavor because they are the major source of food and fodder. India is the second largest and first producer of rice, wheat and millets, the world's most important energy driving staples food. Total cereal production of India is 251 Million tons during 2017-18 (FAI, 2017-18). All cereal grains contain high energy values, mainly from the starch fraction, but, some amount also from the invisible fat and protein portions. Nitrogen being a major nutrient for production of cereals. It is vital element for proper growth and development of plants which significantly augment and enhances the yield and its quality by playing an essential role in biochemical and physiological functions of plant. Nitrogen use efficiency is very less (25-30%) because it is lost very easily through volatilization and leaching so precision nitrogen management is required. The development of N management strategies that use innovative techniques, such as remote sensing, global positioning systems, and variable-rate application to account for within field variation might help to increase the efficiency of N use, reduce environmental impact and improve overall product quality at the farm level.

Significance and Fate of Nitrogen Fertilizer

There is no way of leaving N from crop production scenario of the country where without N fertilization grain production would have been 80 million tonnes which now stands at 234.47 MT with N fertilizer. However, barring di-nitrogen (N2), which cannot be directly used in agriculture, all reactive forms of nitrogen (urea, ammonia, nitrate and their derivatives) used to produce food can threaten the environment. N based fertilizers constitute a major fertilizers constitute a major fraction, nearly 60 percent, of the total fertilizer material. Worldwide, Nitrogen Use Efficiency for cereal production (wheat, rice, maize, barley, sorghum, millet, oat and rye) is low as 33%. The unaccounted 67% represents an annual loss of N fertilizer worth up to Rs. 72000 cr.

The major factor responsible for the low response of crops to fertilizer nitrogen is its low use efficiency, particularly in case of rice crop where it is only 30–40% of applied N due to various N loss mechanisms, namely, surface run-off, ammonia volatilization, leaching and de- nitrification. In 1995, the global estimate of nitrogen loss, from the applied fertilizer N through ammonia volatilization was 11.2 Mt (14.45%), while that through NO and N2O through de-nitrification was 1.5 Mt (1%). India's contribution to these losses could approximately be 10% of the total. Ammonia added to the atmosphere leads to the acid rain,

while NO and N2O are responsible for the depletion of ozone layer in the atmosphere. In addition, nitrates leach to the groundwater and lead to the nitrate pollution of drinking water which is injurious to health. Loss of N from soil plant system results from gaseous plant emission, de-nitrification, surface runoff, volatilization and leaching beyond rooting zones of crops.

Impact of Indiscriminate Use of Nitrogen

Plants receiving high doses of nitrogen have leaves become dark green color and excess negative growth occurs. As a result, the stems are not able to hold plants upright and they lodge or fall over with the slightest of wind, resulting in reduced yield, quality and harvest ability. Crop maturity is delayed and the plants are more susceptible to disease and insect pest (Gajera et al., 2014).

Is Nitrogen Management in Precision Farming Essential?

India is the third largest producer and second largest consumer of Chemical fertilizers in the world, after China. The total production of N in India was 13.43 million tons during 2017-18. However, the consumption of N was 16.96 million tons during 2017-18.So3.53 million tonnes N was imported by India during 2017-18. The partial decontrol of fertilizer sector (2010) which has led to sharp increase in prices of phosphate and potassic fertilizers and relatively cheaper nitrogenous fertilizers resulted in sharp fall in demand and consumption of phosphate and potassic fertilizers. The sale of urea increased by 4.4 percent during 2011-12 compared with 2010-11 while sale of DAP declined by 2.9 percent and MOP by nearly 23 percent. This has led to deterioration in the N: P: K ratio, which will adversely affect the productivity of soil.

What does PNM Mean?

Precision nitrogen management consists of 4 R's i.e. applying the right rate at right time in the right place using the right source and balance.

Diagnostic Tools required in Precision Nitrogen Management (PNM) are furnished below:

- Leaf color chart (LCC)
- Site specific nutrient management (SSNM)
- Chlorophyll meter (SPAD meter• Crop canopy sensor
- Crop simulation model
- Slow release nitrogen fertilizer (SRNF)

Leaf Color Chart (LCC)

Leaf color charts (LCC) offer substantial opportunities for farmers to estimate plant nitrogen (N) demand in real time for their efficient use. Indian farmers generally apply fertilizer N in a series of split applications, but the number of splits, amount of N applied per split and the time of applications vary substantially.

Steps for LCC Usage in Field

- Select at least 10 disease-free plants
- Select the topmost fully expanded leaf and compare the leaf colour with the colour panels of the LCC and do not detach or destroy the leaf
- Measure the leaf color under the shade of your body
- Determine the average LCC reading for the selected leaves
- If more than five out of ten leaves read below a set critical value apply nitrogen fertilizers immediately to avoid yield loss

Benefits of Leaf Color Chart

- The LCC is a cheaper method
- Farmers can easily use the Leaf color charts to qualitatively assess foliar N status and adjust N topdressing accordingly

• It helps to manage N for large area leading to improved fertilizer N use efficiency Average saving in N was 25 kg ha-1 by using LCC method without any reduction in yield.
• LCC at 14 days interval or at critical growth stages of active panicle initiation (PI) and 10 days after active PI would save 40 % of N as compared to blanket recommend at Site-Specific Nutrient Management (SSNM)

Site-specific nutrient management (SS NM) is the dynamic, field-specific management of nutrients in a particular cropping season to optimize the supply and demand of nutrients according to their differences in cycling through soil-plant systems.
SSNM Intends to Escalate Income Via:
• High yield
• High efficiency of fertilizer use
• Providing a locally-adapted nutrient best management practice tailored to the field- and season-specific needs for a crop

What does SSNM Approach Mean?
• The site-specific nutrient management (SSNM) approach was developed in Asian rice-producing countries through partnerships of the Irrigated Rice Research Consortium (IRRC).
• It emphasizes 'feeding' crop with nutrients as and when needed.
• SSNM strives to enable farmers to dynamically adjust fertilizer use to optimally fill the deficit between the nutrient needs of a high-yielding crop and the nutrient supply from naturally occurring indigenous sources such as soil, organic amendments, crop residues, manures, and irrigation water.
• The SSNM approach does not specifically aim to either reduce or increase fertilizer use.
• Instead, it aims to apply nutrients at optimal rates and times to achieve high yield and high efficiency of nutrient use by the crop, leading to high cash value of the harvest per unit of fertilizer invested.

Fundamental Idea of SSNM
The concept of SSNM for rice was developed in the mid-1990s and then evaluated from 1997 to 2000 in about 200 irrigated rice farms at eight sites in six Asian countries. SSNM aimed at dynamic field-specific management of N, P, and K fertilizers to optimize the supply and crop demand for nutrients.
The crop's need for fertilizer N, P, or K was determined from the gap between the crop demand for sufficient nutrient to achieve a yield target and the nutrient supply from indigenous sources.

Benefits of SSNM
• Nutrient use efficiency: SSNM provides an approach for feeding crop with nutrient as and when needed.
• Increase profitability: The major benefit for farmers from improved nutrient management strategy is an increase in the profitability.
• SSNM eliminates wastage of fertilizer by avoiding fertilizer application when the Crop does not require nutrient input.
• It also ensures that N, P and K are applied in the ratio.
• A site-specific nutrient management performance in a rice-wheat cropping system reported that site specific management of N gave 20% higher yield and save 10% nitrogen in Rice-wheat cropping sequence as compared to Farmers' fertilizer practices (FFP).
• This increase was attributed to more uniform N applications among sites under SSNM as compared to under FFP

Soil Plant Analysis Development Meter

The SPAD meter or chlorophyll meter is a simple, portable diagnostic tool that measures the greenness or relative chlorophyll content of leaves. Meter readings are given in Minolta Company-defined SPAD (Soil Plant Analysis Development) values. There is a strong linear relationship between SPAD values and leaf nitrogen concentration, but this relationship varies with crop growth stage and/or variety. The linear relationship between nitrogen and SPAD values has led to the adaptation of the SPAD meter to assess crop nitrogen status and to determine the plant's need for additional nitrogen fertilizer. SPAD readings indicate that plant nitrogen status and the amount of nitrogen to be applied are determined by the physiological nitrogen requirement of crops at different growth stages. It is a simple, quick and non-destructive in situ tool for measuring relative content of chlorophyll in leaf that is directly proportional to leaf N content. The chlorophyll present in the plant is closely related to the nutritional condition of the plant. Higher SPAD value indicates a healthier plant. A decrease in the SPAD value indicates a decrease in the chlorophyll content and nitrogen concentration; it is show the lack of nitrogen available in the soil. This problem can be solved by adding fertilizer to the soil.

Significance

• Improve nutrient management.
• Study the performance and effect of fertilizer. Detect and study environmental stressors.
• Checking the nutritional condition of plants.

Computing SPAD Meter Values

• SPAD readings are taken at 9-15 days intervals, starting from 14 DAT for transplanted rice and 21 DAS for wet direct seeded rice, Periodic readings continue up to the first (10%) flowering.
• The youngest fully expanded leaf of a plant is used for SPAD measurement.
• Readings are taken on one side of the midrib of the leaf blade
• A mean of 10-15 readings per field or plot is taken as the measured SPAD value.
• Whenever SPAD values fall below the critical values, N fertilizer should be applied immediately to avoid yield loss.
• Chlorophyll meter based N management in rice reported that chlorophyll based N application of N increase agronomic efficiency 6.97 % over fixed time N application and also save 25 % N as compared to fixed time N application.

Benefits of SPAD Meter

• The chlorophyll meter is faster than tissue testing for N.
• Samples can be taken often and can be repeated if results are questionable.
• Chlorophyll content can be measured at any time to determine the crop N status. • The chlorophyll meter allows "fine tuning" of N management to field condition.
• The Chlorophyll Meter would also help people who are not highly trained to make N recommendations.

Crop Canopy Sensor

Crop canopy sensors can be used to estimate crop growth in a population or community rather than individual plant or leaf. It was more efficient and suitable for large scale applications than leaf sensors. Crop canopy sensors are two types1) Green seeker 2) Crop circle

Green Seeker Sensor

Green seeker is emerging as a potential tool for efficient nitrogen management through monitoring crop growth with remotely sensed indices like NDVI (Normalized difference vegetation index).

The Green Seeker sensor measures normalized difference vegetative index (NDVI) by using a self-illuminated (active sensor) light source in the red and near infrared wavelengths, (660 ± 10 nm) and (780 ± 15 nm), respectively. The Green Seeker calculates NDVI using the following formula:

$NDVI = \rho NIR - \rho red \rho NIR + \rho red$

Where, ρNIR represents the fraction of emitted NIR radiation returned from the sensed area (reflectance) and ρred represents the fraction of emitted red radiation from the sensed area (reflectance). The Green Seeker has an area of measurement of 1 cm × 60 cm when used in a normal operating range of 60 cm to 100 cm over the top of the crop canopy. The model can be used to find out direct N deficiency in wheat in kg N required per hectare.

Slow-Release Nitrogen Fertilizer

A slow-release nitrogen fertilizer (SRNF) is a granulated fertilizer that releases nutrients gradually into the soil. Terms sometimes used synonymously are Controlled-release fertilizer or Delayed-release fertilizer.

Classification of Slow-Release Nitrogen Fertilizers

Uncoated, Slow-Release

Urea-formaldehyde reaction products like Isobutylidenediurea (IBDU).

Coated, Slow-Release

Sulfur-coated urea, Polymer-coated (or Poly-coated) urea, Neem coated urea

Bio-Inhibitors

Not really "slow-release" but inhibit microbial processes that convert N into plant available forms and slowly (or relatively slowly) parse N into soil environment like Urease and Nitrification inhibitors.

Conclusion

LCC, SPAD meter, SSNM, crop canopy sensor, crop stimulation models and slow-release fertilizers are effective tools of precision nitrogen management. Around 10-25 % nitrogen can save through precision nitrogen management.

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