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Green Seeker:

Tool for improving nitrogen use efficiency in rice

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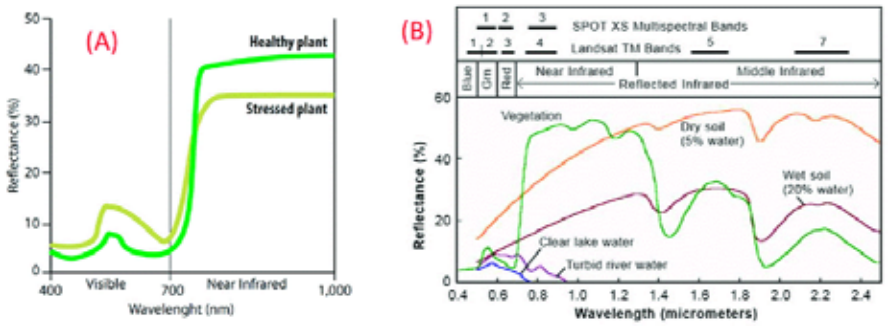
Nitrogen is most limiting nutrient in crop production in irrigated agro-ecosystem of cereal crops and an essential constituent of enzymes, chlorophyll, nucleic acids, storage proteins and cell walls. Nitrogenous fertilizer production is costly, high energy requiring and is subjected to various losses. Successful nitrogen management can optimize crop yields, increase profitability and minimize nitrogen losses to the environment. With the progress of science when thought of green-energy, sustainability and environmental safety, one should have a look at modern nitrogen management tools. Green Seeker is a non-destructive method for accurate estimation of required amount of nitrogen based on plant condition and site specific management of nitrogen at farmer's field.

Keywords: Crop production, Green Seeker, Nitrogen use efficiency.

INTENSIVE cultivation, growing of exhaustive crops, imbalanced and inadequate crop nutrition largely through chemical fertilizers has made soils not only deficit in nutrients, but also deteriorated soil health resulting in diminishing crop response to the recommended dose of nitrogenous fertilizer in the region. Non-judicious enhancement and bias N-fertilization further worsens situation. Demonstration of declining partial/total factor productivity is already becoming available. Decreasing soil fertility has also been reported as one of the major reasons for the decline in crop yield. Fertilizer use pattern for rice in the rice-wheat system (RWS) in Indo-Gangetic Plain (IGP) is region specific and diagnostic surveys have indicated that farmers are using more N than recommended levels of rice. Recovery of N fertilizer applied seldom exceeds 50% due to heavy losses through various means and lack of synchronization of crop requirement resulting in lower physiological efficiency. Food production is directly related to nutrient consumption, and N is a key element in RWS. Most of the farmers are not aware of N recommendation and are happy with their present N management practices in rice, which are subsequent cropping cycles which exhibit decreased yield level with control plot due to decline in inherent fertility.

Adoption of technological interventions to improve cropping intensity

Climate Resilient Agriculture (CRA) practices of the new futuristic cropping system relevant to the needs of resource poor farmers that can address climatic risks are being developed, validated, and deployed through a community-led approach to make farming relevant, remunerative and stable. Engagement model will work principles of convergence with multi-stakeholder, multi-disciplinary, and multi-institutional teams contributing to innovation and knowledge generation. CRA villages adopted an integrated social, biophysical, and economic approach to understand factors influencing adoption and impact of climate smart interventions. Once dynamics stabilize in local context, the CRA villages model is being progressively rolled out in other



Typical reflectance spectrum of (A); healthy plant and (B); stressed plant

Practicing Green Seeker in a paddy field at KVK Instructional Farm, Banka, Bihar

Green Seeker based nutrient management in paddy at Bhusiya, Banka, Bihar

villages. Based on existing climatic situations, different ecologies (low, mid, upland soil) and available resources, 14 different cropping systems (Rice–Wheat–Mungbean; Rice–Mustard–Mungbean; Rice–Wheat; Rice–Potato+Maize; Rice–Winter Maize;Rice–Lentil; Maize–Wheat–Mungbean; Maize–Mustard–Mungbean; Maize–Lentil–Mungbean; Soybean–Winter Maize; Soybean–Wheat–Mungbean; Pearlmillet–Mustard–Mungbean; Pearlmillet–Lentil–Mungbean; Pearlmillet–Wheat–Mungbean) were identified to demonstrate in 38 project district of Bihar.

Correlation with nitrogen and Green Seeker

Nitrogen is an essential constituent of protein, chlorophyll and other physiological processes. Nowadays, we all know that our Indian population is increasing gradually day-by-day, so food consumption is also expanding. Nitrogen consumption of cereals is 60% in the world and 72% in India. In Punjab and Haryana state, if farmer apply 100% dose of N, only 33% nitrogen is used by plants remaining 67% is lost. Traditionally, farmers would apply N uniformly as a blanket recommendation in the wheat crop. Mostly farmers apply N much higher than a blanket recommendation to get high crop yields. Despite this, soil N supply is highly variable over time, from field to field, making it difficult to use fertilizer efficiently. In this situation, site-specific N management can effectively replace blanket fertilizer N recommendations for achieving high N-use efficiency and reduced possibility of N fertilizer related environmental pollution. Field-specific N fertilizer management appears to improve fertilizer N-use efficiency. Fruitful strategies will comprise of management options based on location-specific N fertilizer necessities of crops, according to year-to-year variations in climate (solar radiation), spatial as well as transient variation of indigenous soil N supplies in which precision N management is one of the best methods.

There are various methods of N application through real time, viz. Green Seeker, leaf color chart (LCC) and soil-plant analysis, development meter/chlorophyll meter. Green Seeker is an integrated optical based sensor with variable rate of application and mapping system, measure crop N requirements. Oklahoma State University, USA developed this technology and licensed to N Tech Industries in 2001. The sensors use light emitting diodes (LED) to generate red light (660 nm) and near infrared light (780 nm). Red light is absorbed by plant chlorophyll as a source of energy during photosynthesis. Healthy plants absorb more red light and reflect more near-infrared (NIR) light. The biomass produced per day as estimated by measuring NDVI using an optical sensor is a reliable predictor of yield potential. It helps to reduce pollution and helps to increase NUE. N fertilizer that is applied at optimal time will maximize the plant uptake, which enables to reduce fertilizer use (without decreasing yield) and decreases N_2O emissions. As a rule, fertilizer should not be applied prior to the planting, application should be undertaken in the initial crop development phase (at planting time, or shortly thereafter). However, no study could be found on GHG and financial benefits by adopting this technology.

Traditionally, farmers in Bihar and elsewhere apply N uniformly as a blanket application based on a university recommendation for most of the crop. Such broad-based recommendations for N fertilizer limit efficient use of nitrogen and recovery of N fertilizers. Therefore, under and over application of N is a common phenomenon, which limits crop yields in agriculture. Current N fertilizer recommendations (amounts and timings) are based on large agro-ecological regions of rice and wheat growing tracts in the IGP and do not account for spatial and temporal variability of field. It is important to know the amount and variation in domestic N supply during cropping season to determine optimal timing and amount of N fertilizer application in any crop/cropping system. As domestic nitrogen supply is highly variable over time, both within the same field and across different fields, it is not easy to precisely manage crop N requirements in any given agro-ecological region. Innovative fertilizer management practices aimed at managing N efficiently, must integrate both preventive and corrective strategies, to sustain soil resource base, increase profitability of irrigated rice and wheat crops grown in IGP.

Uses of Green Seeker

Green Seeker is an integrated optical sensing and application system that offers a more efficient and accurate way to apply fertilizer immediately. Green Seeker is an affordable and innovative diagnostic tool that can be used to assess crop vigour. Green Seeker is based on reflectance measurements in the red (defined by chlorophyll content) and near-infrared (defined by living vegetation) regions of the electromagnetic spectrum to estimate crop N needs using estimates of early-season N uptake and potential yield. With this technology, yield potential of a crop is identified

using a vegetative index known as NDVI and an environmental factor. N is then recommended based on yield potential and responsiveness of crop to additional nitrogen. The combination of prescriptive N dose at the planting and crown root initiation stages, as well as corrective N dose led by Green Seeker optical sensor at various stages of crop development, shows promise for high output. Fertilizer NUE can be improved through Site Specific Nutrient Management (SSNM) using Green Seeker, as it takes care of both spatial and temporal variability. To target final dose of urea based on Green Seeker readings, schedule and amount of N should be augmented for first doses. In addition, the ZT uses precise water management technologies in conjunction with Green Seeker-guided N management methods to achieve maximum efficiency.

NDVI value

Reflectance is the ratio of the energy reflected from an object to the energy incident on an object. Spectral reflectance of a crop differs considerably in the near infrared region (λ = 700–1300 nm) and in the visible red range (λ = 550–700 nm) of electromagnetic spectrum. As chlorophyll absorbs blue and red light, plants often reflect less of these colours than green, which gives them the appearance of being green to the human eye. Near infrared radiant energy is strongly reflected from the plant surface and the amount of this reflectance is determined by the properties of leaf tissues and their cellular structure, and air-cell wall-protoplasm-chloroplast interfaces. Therefore, spectral reflectance data can be used to calculate various vegetative indices that correlate well with plant agronomic and biophysical parameters related to photosynthetic activity and plant productivity. As NDVI contains both near infrared/red light, this vegetation index is effective at forecasting photosynthetic activity. Chlorophyll content determine the photosynthetic activity of plants. Several factors have been connected to NDVI, including crop nutrient deficit, small grain yield at harvest, and long-term water stress.

Table 1. Yield and per cent enhancement of different crops under Green Seeker-based nutrient management

Name of technology	Grain yield (t/ha)		Increase yield (%)	Net returns (₹/ha)	
	Demo	Local check		Demo	Local check
Green Seeker-based nutrient management in paddy	4.39	3.67	16.4	55200	34400
Green Seeker-based nutrient management in wheat	4.19	3.64	13.1	44180	38280

However, NDVI must be viewed as a measurement of aggregated plant growth that includes numerous plant growth parameters, rather than solely reflecting effect of one component. Physical characteristics detected by the index are likely related to some measure of canopy density (leaf area or per cent cover) or total biomass (Table 1). Therefore, underlying factor for variability in a typical vegetation index cannot be blindly linked to a management input without knowledge of primary factor that limit growth. For example, in a field where N is limiting factor for growth, NDVI may show a strong correlation with soil N availability, however, in another area where water is the limiting factor, NDVI may be strongly correlated with plant-available soil moisture.

Way forward

Green Seeker is a state-of-the-art machine, which is used to measure amount of N fertilizer in paddy. Nowadays, farmers use urea indiscriminately in paddy fields. There is decrease in flowers and fruits in paddy field and soil fertility is also affected at the same time. By measuring amount of N through NDVI data of machine, less quantity of fertilizer is required by giving N as per requirement of crop. In context of modern agriculture, Green Seeker is providing to be a boon for nitrogen fertilization in paddy, as it uses balanced quantity for precision agriculture.

SUMMARY

Green Seeker is a non-destructive method for accurate estimation of required amount of nitrogen on the basis of plant condition as well as specific site. Innovative fertilizer management practices aimed at managing N efficiently must integrate both prescriptive/corrective strategies to sustain soil resource base and increase profitability of irrigated rice grown in Indo-Gangetic plains. This device has been shown to have strong potential to increase farmer profit by reducing N fertilizer costs without significantly affecting yields and has added social benefit of reducing N pollution, including nitrous oxide (N_2O) emissions, one of the largest direct contributors of GHG emissions from the agricultural sector. The biomass produced per day as estimated by measuring NDVI using an optical sensor is a reliable predictor of yield potential. Green Seeker helps to produce an expected yield than traditional methods for application of N.

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