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Leaf Colour Chart Based Nitrogen Management in Rice—Its Economic, Environmental and Technological Dimensions

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India today is world's third largest producer and consumer of chemical fertilizers with annual consumption of 24.09 MT in 2008–09. N based fertilizers constitutes nearly 60 percent of total fertilizers. Rice is the maximum consumer of nitrogenous fertilizer. India is the second largest producer of rice in the world with a production of 98.18 MT in 2008-09. Nitrogen plays an important role in increasing the productivity of rice. Worldwide, nitrogen use efficiency (NUE) for cereals including rice is as low as 33%. The unaccounted 67% represents an annual loss of nitrogen fertilizer worth up to Rs. 72,000 crore. Low use efficiency of nitrogen fertilizers in agriculture contributes to different environmental impact like eutrophication of surface water bodies, acidification of agricultural soil and increased concentration of nitrous oxides in atmosphere contributing to global warming. Split application of the nitrogen fertilizer to rice may reduce the rapid nitrous oxide emission and increase NUE. Leaf Color Chart (LCC) an ideal tool & ecologically-friendly to optimize Nitrogen use efficiency irrespective to N applied.

Keywords: Fertilizer, NUE, LCC, Rice

INTRODUCTION

India is currently the third largest producer and consumption of fertilizer usage is bound to increase with further intensification of agriculture. It contributes to 12% of world production of N & P nutrients and 12.6% of world consumption of NPK nutrients. India's production in terms of nutrients (N and P_2O_5) reached a level of 14.33 MT in 2008-09 from 38.7 thousand tonnes in 1951–52. In India consumption of fertilizers in terms of nutrients (NPK) has also grown from 65.6 thousand tons in 1951–52 to nearly 24.90 MT in 2008–09.Rice is the most heavily subsidized crop followed by wheat, sugarcane and cotton. These four crops account for about two-third of total fertilizer subsidy. Input subsidies can bring economic benefits to society but can also be a major cause of negative environmental externalities when they promote excessive use of fertilizers, agrochemicals and irrigation water (Sharma *et al*., 2009).The general Perception that about one-third of fertilizer subsidy goes to fertilizer Rice, wheat, sugarcane and cotton account for about two-third of total fertilizer subsidy. Rice and wheat are the major users of fertilizer subsidy accounting for over half of the total subsidy.

IMPORTANT OF N FERTILIZER AND N-LOSSES

Nitrogen (N) is necessary for all forms of life and is a crucial component for increasing production of food to feed the continuously increasing human population. 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 N_2, 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 fertilizer constitute a major fertilizers constitute a major fraction, nearly 60 percent, of the total fertilizer material. Worldwide, NUE 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 denitrification. 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 N_2O through denitrification 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 N_2O 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 (NAAS, 2006).Loss of N from soil plant system results from gaseous plant emission, denitrification, surface runoff, volatilization and leaching beyond rooting zones of crops. From agricultural perspective, N_2O emissions from soil represent a loss of N from the soil system and decreasing N use efficiency (Pathak, 1999).

ENVIRONMENTAL ASPECT FOR N_2O EMISSION

Agricultural soil was primarily responsible for the total global anthropogenic N_2O emission, which account for more than a third of all N_2O emission (IPCC, 1999). Nitrogen, not recovered by crops contributes to environmental problems including those of pollution of groundwater, eutrophication of surface water, green house gaseous emissions of nitrous oxides, ammonia etc. Emission of N_2O from rice fields is directly related to N-fertilizer application. Improvements in NUE should diminish N_2O emission. This can be done even while increasing the use of fertilizers if their use efficiencies are tightly managed. The Indian agricultural soils are contributing only 0.88% of the world's nitrous oxide emission. Some studies have shown leaching loss of N from soils in the Indo-Gangetic-Plains (IGP) as 10–15 kg N ha^{-1}, while ammonia volatilization loss is 20–30 kg N ha^{-1} with application of 120 kg N ha^{-1} in rice and wheat (Katyal *et al.,* 1987, Aulakh et al., 1997).Among all the fertilizers, urea application is responsible for contribution of more than 90% of these emissions. Other types of fertilizers like ammonium sulphate, calcium ammonium sulphate, diammonium phosphate, ammonium phosphate, nitrophosphate and NPK, have been estimated to contribute only a small amount of NH_3 emission.

N-MANAGEMENT STRATEGIES FOR RICE

India is the second largest producer of rice in the world with a production of 99.18 MT in 2008–09. Rice is the maximum consumer of nitrogenous fertilizer. In rice field, 10–40% of applied nitrogen is lost due to denitrification and adds nitrous oxide in the atmosphere which is a potential Green House Gas. Split application of N has been suggested to enhance its efficiency Split application of the N fertilizer may reduce the rapid N_2 emission (Majumdar, 2000). Relative recoveries and level of N loss can also be influenced by fertilizer composition and the rate and timing of application. Two major Strategies followed in N management are 1) blanket fertilizer N recommendations 2) Crop-need-based N management. Blanket-fertilizer N recommendations do not consider variability in soil N supply and changes in crop demand. Crop-need-based N management approach takes into account variability in soil N supply and crops' additional requirement for N fertilizer. Several techniques are used to measure greenness including near-infrared leaf N analysis, chlorophyll meters, leaf color charts, crop canopy reflectance sensors and remote sensing (Giller *et al*., 2004).Significant increases in Nitrogen use efficiency have been achieved through reductions in N use but increases in yield tend to be small. The leaf color chart (LCC) developed by IRRI, Manila, Philipines is simple and inexpensive tool to determine the time of N application in rice so as to synchronize with crop demand. It is an ideal tool & ecologically-friendly to optimize Nitrogen use efficiency irrespective to N applied. It is easy to use for real-time N management & measures leaf color intensity related to leaf N status in rice (Balasubramanian *et al*., 1999).

LEAF COLOR CHART FOR NITROGEN MANAGEMENT

LCC based N application at critical stages in ADT 36 rice varieties during kuruvai season result in saving of 15 kg N/ha as compared to the blanket recommendation of 120 kg N/ha. LCC-N management during Thaladi season for ASD 18 revealed that LCC measurement at critical growth stages resulted in the conservation of 70 kg N ha^{-1} compared to the blanket N of 150 kg N/ha in three splits (Thiyagarajan *et al*., 2000). Average saving in N was 25 kg ha^{-1} by using LCC method without any reduction in yield (Balasubramanian, 2002). LCC at 14 days interval or at critical growth stages of active, panicle initiation and 10 days after of active after PI would save 40 % of N as compared to blanket recommendation (Hussain *et al*., 2005). Higher nitrogen use efficiency of LCC based N management over blanked was reported by Maity and Das (2006). Chandrashekara (2009) reported that the application of 50 and 60 kg N ha^{-1} $dressing^{-1}$ coupled with LCC threshold 6 recorded higher cane yield (150.5 and 151.7 t ha^{-1} during I season and 123.8 and 125.0 t ha^{-1} during II season, respectively), CCS yield, juice, brix, pol and lesser reducing sugars, total N, P and K uptake than conventional practice.

Shukla *et al*. (2006) from Utter Pradesh noticed that in wheat, LCC threshold value 4 gave higher grain yield, N uptake and N use efficiency than with 120 N kg ha^{-1} applied in 3 fixed time splits. Alam *et al*. (2006) revealed that use of LCC for N management consistently increased the wheat grain yield and added net return as compared to the farmers' fertilizer practice, in the study conducted at south-western Bangladesh. Mohandas *et al*. (2003) noted that LCC threshold value of 5 for hybrids DRRH1 and ADTRH1 and 4.5 for inbred variety TRY-2 optimized rice yield and fertilizer use efficiency in saline sodic soils of Tamil Nadu, India. These studies indicated that for the crop need-based N management using chlorophyll meter or LCC was equally good for inbred and hybrid rice varieties to maximize their yield and N fertilizer use efficiency.

Leaf colour chart based N management reduced the N fertilizer use by 29 kg ha^{-1} and it also reduced the lodging, pest incidence and production cost of rice (Nguyen Nogoc De and Le Huu Hai, 1999).LCC based N management is suggested to be the optimal N fertilization strategy for rice, since it gives higher yields besides effecting saving of N as compared to blanket N recommendation or the soil-test based N recommendation under field specific situation. With the help of LCC and SPAD, N could be saved up to 50 and 60 kg ha^{-1}, respectively without yield decrement Maiti (2003). Maiti *et al*. (2004) reported the mean values of LCC and SPAD varied from 3.19–5.31 and 27.36–39.26, respectively, in rice. The results showed that the amount of N can be saved as 20–42.5 and 27.5–47.5 kg N ha-1 through the use of LCC and SPAD in rice over the fixed-timing N treatment T7 where 150 kg N ha^{-1} was applied in three 3 splits without reduction in the yield. Hussain *et al*. (2005) reported that in rice the nitrogen applied by studying the LCC value at 14 days after panicle initiation and 10 days after panicle initiation would save 40 per cent of N as compared to blanket recommendation. Shukla et al. (2004) found that NUE can be increased using LCC-based N management without basal N application, provided indigenous soil N supply is sufficiently high (50–60 kg N ha^{-1}). Shukla *et al*. (2004) reported a threshold LCC value of 4 for an inbred line (Saket 4) for an optimal yield and NUE in the western Indo-Gangetic plains of India.

Samson *et al*. (2005) from the field experiments conducted at IRRI and PhilRice (Philippines), where real-time N management through LCC in the dry season was carried out, reduced the N fertilizer use by 45 to 80% compared to the conventional N management with a fixed seasonal N rate of 210 kg N ha^{-1}, while achieving comparable or higher yields of 6–8 t ha^{-1}

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