



International Journal of Research in Agronomy

E-ISSN: 2618-0618
P-ISSN: 2618-060X
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NAAS Rating (2026): 5.20
www.agronomyjournals.com
2026; 9(1): 469-472
Received: 10-10-2025
Accepted: 14-11-2025

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Leaf color chart: An innovative approach to manage nitrogen application and pest incidence in kharif rice

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DOI: <https://www.doi.org/10.33545/2618060X.2026.v9.i1g.4708>

Abstract

A frontline demonstration on rice var. MTU-1010 was conducted with an objective to demonstrate the effectiveness of Leaf Color Chart (LCC) based nitrogen application in rice at Faridpur village, Ratua-I, Malda, West Bengal from July to October, 2021. The demonstrated technology showed 12.76% taller plants compared to farmers' practice i.e. blanket nitrogen application at harvest. The technology also provided 34% more leaves and 54.5% higher effective tiller than farmers' practice. Yield was 21.32% higher and pest incidence was 84.23% lower in LCC based practice than farmers' practice. This innovative approach also reduced the cost of cultivation up to 20.52% and increased gross return, net return and benefit-cost ratio by 20.29%, 73.45% and 122.1%, respectively over farmers' practice. The extension gap was 10.14 q/ha and technology gap was 4.87 q/ha in demonstrated plot which reverses the trend of huge extension gaps by teaching farmers via various extension techniques like Training FLD etc and also confirms superior results in demonstrated plot. Considering the effect of nitrogen application through Leaf Color Chart management on rice productivity, it is clear that LCC offers valuable chances to enhance nitrogen use efficiency, rice yield, and farmers' profits by reducing cost of cultivation and pest attack.

Keywords: Nanourea, Conventional Urea, Growth, LAI, Yield and Wheat.

Introduction

Rice being one of the most important staple crops, provides food to a major portion of the world's population. So, judicious management of nitrogen fertilizers is very crucial to meet the increasing demand for rice and ensure sustainable production, (Midya *et al.*, 2021) [15]. Nitrogen significantly influences the growth, development, and yield of rice (Jahan *et al.*, 2022) [11]. On the other hand, injudicious nitrogen application can cause to yield losses, environmental pollution through nitrogen runoff or leaching, and increased production costs of rice (Dinnes *et al.*, 2002) [6]. In traditional method, application of nitrogen fertilizer in rice has been based on agronomic practices, such as farmers' experience, soil testing, and crop growth stage based fertilizer application (Banayo *et al.*, 2018) [4]. But sometimes, there are some lacunas in precision and it fails to account for proper nitrogen requirements in crop throughout the growing season (Kivi *et al.*, 2022, Dinnes *et al.*, 2002) [12, 6]. Consequently, there is an emerging need to apply a reliable and efficient tool to optimize nitrogen fertilizer management in rice. Keeping this problem in mind, this novel approach was introduced in rice to reduce the cost of cultivation, improve soil health and curb the pest incidence in rice.

Importance of Leaf Color Chart (LCC)

Appropriate management of nitrogen fertilizer application is very essential to optimize rice production by reducing environmental impacts. The Leaf Color Chart (LCC) is an promising important device to manage nitrogen fertilizer in rice (Ali *et al.*, 2015) [2]. This method depends on visual evaluation of rice leaf color as a marker which indicates the status of nitrogen in plant (Tao *et al.*, 2020) [23]. LCC based nitrogen management approach can elevate nitrogen use efficiency, enhance yield, and lower nitrogen losses (Rao and Das, 2023) [19]. Appropriate time and dose of nitrogen fertilizer application can be determined by farmers and scientist by comparing the leaf color with this standardized color chart (Golicz *et al.*, 2021) [8]. This is a simple, cost-effective, non-destructive sampling method, and real-time monitoring indicator of nitrogen status in crop (Oláh *et al.*, 2022) [16].

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The LCC is a multipurpose approach which can be used apart from the source of nitrogen applied, including inorganic, organic, or bio-fertilizers. It facilitates the evaluation of canopy lushness as well as the green color of individual leaves (Gill *et al.*, 2023) [7]. By measuring the leaf color with this chart, critical color grades or LCC values can be found to direct the appropriate dose of nitrogen application.

Materials and methods

Site description

The field experiment was conducted at Faridpur village, Ratua-I, Malda district of West Bengal through frontline demonstration with 50 farmers during *kharif* (July to October) season of 2021. The soil of the experimental site was clay loam in texture with good water holding capacity, drainage facility with moderate fertility status. The experimental area is situated under subtropical humid climate. The soil was fertile with pH 6.98, low in organic carbon 0.43% and EC 0.42 dS m⁻¹ and high level of available nitrogen (480.32 kg/ha), phosphorus (98.07 kg/ha) and potash (213.6 kg/ha).

Description of LCC

The Leaf Color Chart is made of a 12-15-inch-long chart with a number of shades of green (Lindsay and Lindsay, 2017) [13]. The chart consists of sturdy, sunlight-defiant plastic and attributes various colored lines organized like leaf veins. The light colored shade is demarked as 1, while the darkest green one is demarked as 8. Primarily, the LCC had 8 shades of unnamed green color, but latest versions found by the International Rice Research Institute (IRRI, 2005) [10] attributed 7 or 6 shades of green color. This chart is regulated with a chlorophyll meter and helps as an indicator for top dressing of nitrogen fertilizer in rice. There is also a construction sheet written in local language, enlightening the optimal time for nitrogen fertilizer application to the farmers.

Description of Technology under demonstrated plot and farmers' practice

The frontline demonstration was carried out during July to October in *kharif* rice var. MTU-1010 with seed treatment with NPK (30:30:40 kg/ha and 30 kg N/ha at 3 split doses) along with carbendazim 50% WP @ 2 gm/kg of seed, soil treatment with well rotten cow dung manure @ 375 kg/ha and *Trichoderma viride* @ of 1.5 ton/ha and *Pseudomonas fluorescens* @ of 1.5 ton/ha, weed management with glyphosate @ 2.5 kg/ha, micronutrient treatments with boron 20% @ 450 g/ha and zinc @ 900 g/ha, insect management with one spray of novaluron 5.25% + emamectin benzoate 0.9% SC @ 900 ml/ha and disease management with one spray of captan 70% + hexaconazole 5% @ 900 gm/ha. The farmers' plot was treated with NPK (60:40:40 kg/ha as basal and 30 kg N/ha at 2 split doses) and boron and zinc as basal along with 7-8 sprays of insecticides and fungicides. Other intercultural operations like weeding and irrigation were done as and when required.

Collection of data

Leaf Color Chart is made of 6 colored shades varying from light yellowish green to dark green strips formulated with veins akin to rice leaves. 30 kg N/ha was applied as basal within 7 days after transplanting (DAT) and LCC readings were taken at 7 days intervals initiating from 15 DAT until commencement of flowering stage. 30 kg N/ha was applied as top dressing when color of 6 leaves out of 10 leaves of rice fell below a threshold of shade 4 on the LCC. For sampling, 10 insect free hills and most fully expanded leaf from each hill top were randomly

selected from the selected area in each plot. Readings on LCC were taken by placing the middle portion of the leaf on the chart and leaf color was observed by keeping blockage of the sun by body as sunlight influences leaf color reading. At 30, 45, 60, and 75 days after transplanting of rice, a plant with any hint of insect infestation was randomly selected from five 1 m² areas of demonstrated plots and recorded as infected. All data regarding yield components and yield were documented at 115 DAS.

$$\text{Per cent yield increase over control} = \frac{\text{Demonstration yield} - \text{Control yield}}{\text{control yield}} \times 100$$

The percentage of damage (disease incidence) was determined by the following formula:

$$\text{Insect incidence (\%)} = \frac{\text{No. of plants infected}}{\text{Total no. of plant/sq.m area}} \times 100$$

To determine the extension gap (EG) and technology gap (TG), the following formulae were used (Samui *et al.*, 2000) [20]:

$$\text{EG} = \text{Yield of demonstrated technology} - \text{farmers' yield (control)}$$

$$\text{TG} = \text{Potential yield} - \text{demonstration yield}$$

Results and Discussion

Effect on plant height

The average plant height observed for leaf color chart practice was 65.74 cm, while average plant height observed for farmers' practice was 58.3 cm during the time of harvest. Application of crop specific need of nitrogen fertilizer in split doses encourages plant growth, enhances the number and length of internodes of stem which eventually boosts the plant height (Amin, 2011) [2]. Nitrogen fertilizer management through Leaf Color Chart helps in plant growth enhancement, possibly by escalating the accessibility, uptake, and utilization of soil nutrients resulting from a elevated rate of split doses of nitrogen fertilizer.

Effect on leaf number

The maximum leaf number for leaf color chart practice was 87 at 75 DAT, while maximum leaf number for farmers' practice was 68 at 75 DAT. The higher leaf number was due to the balanced dose of nitrogen fertilizer application, which advanced the method of cell division and cell elongation, directing to amplification in both number and size of leaves (Om *et al.*, 1989) [17]. The reduction in leaf number recorded after 75 DAT was mainly due to the senescence of lower leaves (Subedi *et al.*, 2019) [22]. Chandrashekhar *et al.* (2001) opinioned that reduction of leaf size and number occurs after panicle initiation due to retransmission of stored metabolites from leaf sheath and stem to panicles.

Effect on tiller number

At 45, 60 and 75 DAT, LCC-based practice exhibited higher plant tillers than farmers' practice. This result may be due to proper split application of nitrogen fertilizer as nitrogen enhances cytokinin level within tiller nodes, which further encourages the germination of tiller primordium, thereby causing elevated tiller number (Liu *et al.*, 2011) [14].

Effect on Yield

Grain yield of rice in demonstrated plot was observed 60.13 q/ha, whereas it was recorded only 49.99 q/ha in farmers'

practice. The number of leaves is positively correlated with nitrogen assimilation rate in leaf. Effective use of nitrogen helped in increase of chlorophyll concentration in leaves and improved photosynthetic rate, ultimately resulting to a greater availability of photosynthates during grain development (Subedi *et al.*, 2019) ^[22]. Therefore, the application of nitrogen fertilizer based on the LCC value maintained the appropriate level of leaf nitrogen leading to improved crop growth and a higher yield of rice grains. This finding is also in conformity with Ahmad *et al.* (2016) ^[1] who found that nitrogen accelerates the accumulation of carbohydrates in the culms and leaf sheaths and in the grains during pre-heading and ripening stage of rice, respectively.

Effect on Economics

The gross and net economic returns for demonstrated plots were 20.29% and 73.45% higher, respectively, in contrast to farmers' practice during respective years. In comparison with farmers' practice, 122.1% higher benefit-cost ratios was observed, which confirm the viability of the LCC based nitrogen application in demonstrated plot to enhance the gross income of the farmers.

Effect on pest incidence

In demonstrated plots, the pest incidence was 84.23% lower than farmers' practice. High doses of nitrogen fertilizer make plant tissues more tender which can be easily be attacked by insects as reported by Singh and Sarkar (2021) ^[21] and Pramanick *et al.* (1995) ^[18].

Extension Gap and Technology Gap

The extension gap was 10.14 q/ha in demonstrated plot, altering the trend of extension gaps by teaching farmers through trainings for the acceptance of improved and innovative production and protection technologies (Bhowmik *et al.*, 2019) ^[5]. Technology gap was 4.87 q/ha, which confirms superior results in demonstrated plot. The obtained technological gap can be associated with the variations in soil fertility of the experimental plots and agricultural production techniques practiced by the farmers and also the prevailing weather circumstances of the locality as experienced by Bhowmik *et al.* (2019) ^[5].

Conclusion

The experiment revealed that nitrogen application based on Leaf Color Chart gave superior results in terms of plant height, leaf number, tiller number and yield of rice than farmers' practice. The better performance of LCC based nitrogen management is mainly due to more split application of nitrogen fertilizer during growing season along with balanced practice of fertilization. The technology of split application of nitrogen fertilizer after 45 days after transplanting when nitrogen demand is escalating in rice confirmed the elevated plant height. The yield in demonstration was also higher than the farmers' practice. Higher effective tiller number implied the increased yield which has confirmed the nitrogen requirement by measuring the leaf greenness with the help of low-cost devices like LCC (Hou *et al.*, 2020) ^[9]. So, it is suggested to adopt the Leaf Color Chart based nitrogen fertilizer application practice as it emphasizes on the need based application of slit doses of nitrogen fertilizers, thus reduces the loss of nitrogen, improves soil health and reduces cost of cultivation of rice up to 20.52%. It also provides way forward for how to use nitrogen fertilizer in a proper way that maintains the leaf nitrogen content at an optimal level, resulting in a thriving rice produce and effective nitrogen usage.

Acknowledgement

The authors are thankful to the ICAR-ATARI, Kolkata, Zone V, for their support and funding of the frontline demonstration programme.

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