# Need based fertilizer nitrogen management using leaf color chart in irrigated rice in Punjab, India

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## Abstract

General fertilizer N recommendation for rice does not take into account site-to-site variation in N supply capacity of soils to meet crop N demand. Leaf colour chart (LCC) is an ideal tool to optimize N use irrespective of soil N supply and source of N applied. It will help farmers realize high yields and achieve high N-use efficiency in rice. Several field experiments were conducted to evaluate need-based fertilizer N management in transplanted rice by using LCC in Punjab, India during 'kharif' season for three years (2000 to 2002). Application of N with LCC using a critical value of 4 produced rice grain yields, which were on a par with recommended N applied in three equal splits in the three years. There was no effect of applying 20 kg N $ha^{-1}$ compared with no fertilizer N applied at the time of transplanting on grain yield and N uptake of rice. On average, application of fertilizer N to rice using LCC 4 resulted in a saving of 26% fertilizer N as compared with the recommended practice of applying 120 kg N $ha^{-1}$. Agronomic efficiency and recovery efficiency of fertilizer N were higher when N was applied using LCC 4 as compared to the recommended practice of applying 120 kg N $ha^{-1}$ in three equal split doses on all soils.

## Media Summary

Leaf colour chart is an ideal tool for need-based N management for achieving high N-use efficiency in transplanted rice.

## Key Words

Agronomic efficiency of N, recovery efficiency of N

## Introduction

Rice is unquestionably the most widely grown cereal and staple food of Asia. Rice rotated with wheat is one of the most important rice-based systems in South Asia (Ladha et al., 2000). In the quest of achieving high yields of rice, farmers in northwestern India tend to apply N in excess of the crop requirements. In many field situations more than 60% of applied N is lost because of the lack of synchrony of plant demand with N supply (Bijay-Singh and Yadvinder-Singh 2003). The general recommendation of 120 kg N $ha^{-1}$ for rice is based on crop response functions developed from data for few soils. The general fertilizer N recommendation does not take into account site-to-site variation in N supply capacity of soils to meet crop demand. Matching N supply with crop demand will optimize N use efficiency and reduce N losses to the environments. There is thus, need to mange fertilizer N more efficiently by making its application based on actual needs of rice plant so that a large fraction of applied N is translocated into grain yield. To regulate the timing of N application in rice IRRI has introduced a plant-based decision tool, the leaf colour chart (LCC). The LCC is an ideal and inexpensive tool to optimize N use in rice (Yadvinder-Singh and Bijay-Singh 2003). The objective of the present investigation was to use leaf colour chart for improving N use efficiency in rice in northwestern India.

## Methods

Thirty-nine on-farm and on-station field experiments were conducted at several locations in Punjab (India) during three years (2000-2002). The soils of the experimental fields varied from loamy sand to sandy loam in texture, with pH ranging from 6.80 -8.70, electrical conductivity 0.12-0.48 $dSm^{-1}$, organic carbon 0.21-0.95%, available P 5.9-68.5 kg $ha^{-1}$, and available K 52-286 kg $ha^{-1}$. The four treatments included; (1) no- N control, (2) recommended N (120 kg $ha^{-1}$) in three equal splits, (3) LCC-4 (no basal N), and (4) LCC-4 (with 20 kg N $ha^{-1}$ as basal). A basal dose of 26 kg P $ha^{-1}$, 50 kg K $ha^{-1}$ and 10 kg Zn $ha^{-1}$ was

applied to all the plots at the time of transplanting. The LCC readings were taken at weekly intervals from the 10 randomly selected topmost fully expanded leaves starting at 7days after transplanting of rice until flowering. When the LCC value of six out of ten leaves fell below the critical level, 30 kg N $ha^{-1}$ was top dressed on the same day. Grain yields were corrected to 14% moisture content.

**Results and Discussion**

*Grain yield and nitrogen uptake*

Grain yields of rice in the no-N plots ranged from 1.61 to 7.88 t $ha^{-1}$ in the three years (Tables 1 and 2) and N uptake ranged from and 41 to 170 kg $ha^{-1}$. These data suggested a large site-to-site variation in N supplying capacity of soils. Rice grain yields obtained with both recommended N splits and LCC-based N management were 40 to 42% greater than that recorded on control plots in the three years. Application of N based on a LCC-4 produced rice yields on a par with recommended N applied in three splits in the three years. Mean grain yields of 6.64, 6.82 and 6.87 t $ha^{-1}$ in recommended three splits plots and 6.49, 6.88 and 7.05 t $ha^{-1}$ in the LCC-4 (with basal N) treatment were almost similar during 2000, 2001 and 2002, respectively. But the amount of N used was much lower in LCC plots (mean of 93 kg N $ha^{-1}$ in 2000; 95 kg N $ha^{-1}$ in 2001 and 80 kg N $ha^{-1}$ in 2002) as compared with 120 kg N $ha^{-1}$ applied in recommended practice (Tables 2 and 3). Thus, N application using LCC resulted in net saving of 26% of fertilizer N over the fixed timing N splits. It was also revealed that there was hardly any yield benefit of applying a basal dose of N to rice along with LCC based N management. Total N uptake by rice showed trends similar to the grain yield of rice

**Table 1. Effect of leaf color chart (LCC) guided N management on grain yield (t $ha^{-1}$) of rice in 2000 and 2001**

| Site | 2000 | | | | 2001 | | | |
|---|---|---|---|---|---|---|---|---|
| | N0 | N120 | LCC-4 (-B) | LCC-4 (+B) | N0 | N120 | LCC-4 (-B) | LCC 4 (+B) |
| 1 | 4.53 | 8.08 | 7.41 | 7.53 | 5.47 | 7.56 | 7.34 | 8.15 |
| 2 | 3.51 | 4.97 | 4.58 | 4.73 | 7.73 | 9.28 | 9.19 | 9.82 |
| 3 | 1.61 | 5.26 | 4.81 | 4.64 | 4.77 | 5.61 | 5.36 | 5.63 |
| 4 | 5.73 | 7.07 | 6.97 | 7.06 | 5.43 | 6.29 | 5.98 | 6.11 |
| 5 | 4.25 | 6.62 | 6.7 | 6.1 | 5.02 | 8.07 | 7.25 | 7.41 |
| 6 | 3.75 | 6.05 | 6.95 | 7.1 | 2.25 | 4.64 | 4.51 | 4.75 |
| 7 | 5.63 | 8.4 | | 8.25 | 4.15 | 6.32 | 6.31 | 6.29 |
| Mea | 4.14± | 6.64± | 6.24± | 6.49± | 4.97± | 6.82± | 6.56± | 6.88± |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ± s.d. | 1.41 | 1.32 | 1.22 | 1.39 | 1.64 | 1.58 | 1.53 | 1.71 |

-B= No fertilizer N was applied to rice at transplanting, +B= 20 kg N $ha^{-1}$ applied as basal

s.d. = standard deviation

**Table 2. Effect of leaf color chart (LCC) guided N management in rice on grain yield (t $ha^{-1}$) and amount of fertilizer N applied (kg $ha^{-1}$) during 2002.**

| Site | Grain yield (t $ha^{-1}$) | | | Fertilizer N applied (kg $ha^{-1}$) | |
|---|---|---|---|---|---|
| | N0 | N120 | LCC-4 | N120 | LCC-4 |
| 1 | 7.88 | 8.58 | 8.99 | 120 | 80 |
| 2 | 7.07 | 8.16 | 8.21 | 120 | 80 |
| 3 | 6.65 | 8.41 | 7.9 | 120 | 80 |
| 4 | 6.17 | 7.03 | 7.39 | 120 | 80 |
| 5 | 6.33 | 7.37 | 6.99 | 120 | 80 |
| 6 | 4.39 | 5.34 | 5.51 | 120 | 80 |
| 7 | 5.94 | 6.67 | 6.64 | 120 | 80 |
| 8 | 4.46 | 6.4 | 5.84 | 120 | 80 |
| 9 | 5.57 | 6.75 | 6.74 | 120 | 80 |
| 10 | 6.19 | 7.54 | 7.92 | 120 | 80 |
| 11 | 4.55 | 7.22 | 7.25 | 120 | 80 |
| 12 | 5.9 | 7.48 | 7.04 | 120 | 80 |
| 13 | 7.05 | 8.21 | 8.21 | 120 | 80 |
| 14 | 6.88 | 8.15 | 8.12 | 120 | 80 |

| | | | | | |
|---|---|---|---|---|---|
| 15 | 5.28 | 7.02 | 7.06 | 120 | 80 |
| 16 | 4.52 | 5.56 | 5.48 | 120 | 80 |
| 17 | 5.33 | 6.4 | 6.44 | 120 | 80 |
| 18 | 6.52 | 7.38 | 7.99 | 120 | 80 |
| 19 | 5.65 | 8.35 | 8.35 | 120 | 80 |
| 20 | 4.34 | 5.99 | 6.17 | 120 | 80 |
| 21 | 3.99 | 6.63 | 6.08 | 120 | 80 |
| 22 | 4.42 | 6.3 | 6.87 | 120 | 80 |
| 23 | 3.84 | 4.84 | 5.84 | 120 | 80 |
| 24 | 4.45 | 4.9 | 6.74 | 120 | 80 |
| 25 | 4.61 | 5.12 | 6.56 | 120 | 80 |
| Mean± s.d. | 5.52± 1.13 | 6.87± 1.13 | 7.05± 0.96 | 120 | 80 |

**Table 3. Amount of fertilizer N applied (kg ha$^{-1}$) to rice in different treatments during 2000 and 2001**

| Site | 2000 | | | 2001 | | |
|---|---|---|---|---|---|---|
| | N120 | LCC-4 (-B) | LCC-4 (+B) | N120 | LCC-4 (-B) | LCC-4 (+B) |
| 1 | 120 | 90 | 110 | 120 | 60 | 80 |
| 2 | 120 | 105 | 125 | 120 | 60 | 50 |
| 3 | 120 | 105 | 125 | 120 | 60 | 80 |
| 4 | 120 | 75 | 95 | 120 | 60 | 80 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 5 | 120 | 75 | 50 | 120 | 90 | 110 |
| 6 | 120 | 75 | 65 | 120 | 120 | 140 |
| 7 | 120 | - | 80 | 120 | 105 | 125 |
| Mean | 120 | 88 | 93 | 120 | 79 | 95 |

B= No fertilizer N was applied to rice at transplanting, +B= 20 kg N $ha^{-1}$ applied as basal

*Nitrogen use Efficiency*

Agronomic and recovery efficiencies of N were markedly higher with LCC-4 treatment in both with or without basal N application as compared with recommended N (120 kg $ha^{-1}$) treatment (Table 4). The average recovery efficiency of N with LCC-4 (20 kg N $ha^{-1}$ as basal) was 42, 45 and 58% compared to 31, 29 and 40% obtained in the recommended N treatment during 2000, 2001 and 2002, respectively. Similarly, agronomic efficiency was also higher under LCC-4 based N management than that of recommended N treatment in all the years.

**Table 4. Agronomic efficiency (AE) and recovery efficiency (RE) of fertilizer N in rice as influenced by N application using Leaf colour chart (LCC)**

| Year | No. of sites | Treatment | AE (kg grain/kg N) | | RE (%) | |
|---|---|---|---|---|---|---|
| | | | Range | Mean | Range | Mean |
| 2000 | 7 | 120 kg N $ha^{-1}$ | 11.2 - 30.4 | 20.8 | 15.0 - 48.2 | 30.9 |
| | | LCC 4 (no basal N) | 10.2 – 42.7 | 27.4 | 29.3 – 53.6 | 42.7 |
| | | LCC 4 (20 kg N $ha^{-1}$ as basal) | 9.8 – 51.5 | 28.1 | 21.1 – 51.1 | 42.1 |
| 2001 | 7 | 120 kg N $ha^{-1}$ | 7.0 – 25.4 | 15.4 | 18.2 – 50.8 | 29.1 |
| | | LCC 4 (no basal N) | 9.2 – 31.2 | 19.8 | 18.9 – 58.3 | 38.9 |
| | | LCC 4 (20 kg N $ha^{-1}$ as basal) | 8.5 – 41.8 | 21.6 | 18.2 – 56.3 | 45.4 |
| 2002 | 25 | 120 kg N $ha^{-1}$ | 3.8 – 22.5 | 11.3 | 16.7 – 61.7 | 39.8 |

| | | | | |
|---|---|---|---|---|
| LCC 4 (20 kg N $ha^{-1}$ as basal) | 8.3 - 33. 8 | 19.2 | 26.3 – 88.8 | 58.3 |

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