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Standardisation of Leaf Colour Chart Based Nitrogen Management in Direct Wet Seeded Rice (*Oryza sativa* L.)

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Abstract: Field experiment was conducted at the wetlands, Tamil Nadu Agricultural University, Coimbatore in Noyyal series deep clay soil (*Vertic ustochrept*), to standardise the Leaf Colour Chart critical value (LCC cv.) and the rate of nitrogen application in CO 47 rice variety. The study was conducted in factorial randomized block design with three replications. The treatments included three levels of LCC cv. (LCC cv. 3, 4 and 5) with different rates of N application (20, 25, 30 and 35 kg ha^{-1} at a time) along with three checks (control, blanket N (150 kg N ha^{-1} in four equal splits) and manage N practices (150 kg N ha^{-1} in four unequal splits)). LCC readings were measured every week from 21 Days After Sowing (DAS) to 84 DAS and nitrogen fertilizer was applied as per treatment schedule. The performance of blanket N and manage N were almost comparable among themselves in all aspects. Grain yield and straw yield increased with increasing LCC levels. The physical and economic optimum doses were found to be 141 and 139 kg N ha^{-1} to get the grain yield of 5356 and 5350 kg ha^{-1} respectively. LCC cv.5 which received 30 kg N ha^{-1} each time with a total dose of 150 kg N ha^{-1} recorded a grain yield of 5045 kg ha^{-1} was in corroboration to the predicted optimum dose and yield and also it gave a higher net income than blanket N. LCC cv.4, which received 20 kg N ha^{-1} each time with a total dose of 60 kg ha^{-1} recorded comparable yield with blanket N with a saving of 50% fertilizer nitrogen. Hence, under direct wet (drum) seeded condition, L_5N_{30} (LCC cv.5 at the rate of 30 kg N ha^{-1} each time) can be recommended for a high resource farmer to get higher net income and L_4N_{20} (LCC cv.4 at the rate of 20 kg N ha^{-1} each time) can be recommended for a low resource farmer to get 50% fertilizer N saving and comparable rice yields with the blanket N.

Key words: Leaf colour chart, rice, nitrogen, standardisation

INTRODUCTION

The world of rice plant is completely composed of the regularity, order and rules, though many of them are still too complicated for us to comprehend (Seizo Matsushima, 1976). Rice is a major crop of 89 countries in the world and is the staple food for half of the world population. World wide, rice is harvested in 150.2 million hectare. In the global rice scenario, there is a total production of 606.3 million tons of unmilled, rough rice with an average productivity of 4.03 tonnes ha^{-1} (FAO, 2004). Asia contributes 59% of world population and accounts for 92% of global rice production (FAO, 2001).

Irrigated rice occupies 50% of total rice area and produces 75% of total rice output (Balasubramanian, 2004). Further intensification of irrigated rice ecosystem is necessary to feed the growing population and maintain food security in coming years (Dobermann *et al*., 2004). Rice crop usually take half of the applied N to yield above ground biomass. The other half of the N is dissipated in the wider environment causing a number of environmental and ecological problems (Balasubramanian, 2004). The efficient N use is critical to produce enough food for feeding the growing population and avoid large scale degradation caused by excess N (Tilman *et al*., 2001).

Monitoring plant nitrogen status is important in improving the balance between crop N demand and N supply from soil and applied fertilizer (Cassman *et al*., 1994). As leaf N content is closely related to photosynthetic rate (Peng *et al*., 1995) and biomass production (Kropff *et al*., 1993) it is a sensitive indicator of the dynamic changes in crop N demand within a short season. The direct measurement of leaf N concentration by laboratory procedure is laborious, time consuming and costly. Such procedures have limited use as a diagnostic tool for optimizing N topdressing because of the extensive time delay between sampling and obtaining results (Yang *et al*., 2003).

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Table 1: Treatment details of the field experiment

Treatment No.	Notation	Treatment details	N dose (kg ha^{-1})	No. of splits
T_1	C	Control (zero-N)	0	0
T_2	BN	Blanket N (120 kg N ha^{-1} in four equal splits from 21 DAS)	120	4
T_3	MN	Manage N practice (120 kg N ha^{-1} in four splits - 1/6, 1/3, 1/3 and 1/6 from 21 DAS)	120	4
T_4	L_3N_{20}	LCC cv. 3 with 20 kg N ha^{-1} each time	40	2
T_5	L_3N_{25}	LCC cv. 3 with 25 kg N ha^{-1} each time	25	1
T_6	L_3N_{30}	LCC cv. 3 with 30 kg N ha^{-1} each time	30	1
T_7	L_3N_{35}	LCC cv. 3 with 35 kg N ha^{-1} each time	35	1
T_8	L_4N_{20}	LCC cv. 4 with 20 kg N ha^{-1} each time	60	3
T_9	L_4N_{25}	LCC cv. 4 with 25 kg N ha^{-1} each time	50	2
T_{10}	L_4N_{30}	LCC cv. 4 with 30 kg N ha^{-1} each time	60	2
T_{11}	L_4N_{35}	LCC cv. 4 with 35 kg N ha^{-1} each time	70	2
T_{12}	L_5N_{20}	LCC cv. 5 with 20 kg N ha^{-1} each time	120	6
T_{13}	L_5N_{25}	LCC cv. 5 with 25 kg N ha^{-1} each time	150	6
T_{14}	L_5N_{30}	LCC cv. 5 with 30 kg N ha^{-1} each time	150	5
T_{15}	L_5N_{35}	LCC cv. 5 with 35 kg N ha^{-1} each time	210	6

A small portable chlorophyll meter (SPAD 502) could make instant non destructive and quick chlorophyll readings of plant leaves for estimating the chlorophyll content (Watanabe *et al*., 1980). The ability to predict the chlorophyll content on a leaf area basis from SPAD readings was demonstrated in corn (Dwyer *et al*., 1991) and rice crops (Jiang and Vergara, 1986; Takebe and Yoneyama, 1989). Because chlorophyll content in a leaf is closely correlated with leaf N concentration (Blackmer and Schepers, 1994; Evans, 1983) the measurement of chlorophyll provides an indirect assessment of leaf N status.

The high price of SPAD limits its use by individual income-poor farmers (Balasubramanian *et al*., 2003). Another simple, quick and non destructive tool for estimating leaf N status is Leaf Colour Chart (LCC). Even though LCC has been tested for real time N management in the farmers' fields in several countries (Balasubramanian *et al*., 1999), very limited information is available on the accuracy of LCC in estimating leaf N status of rice plants. The use of LCC for scheduling N application may not be uniformly applicable to all varieties that differ in inherent leaf colour, thereby necessitating individual or group standardization (Sheoran *et al*., 2004). Hence, the present investigation was focused on standardizing the LCC cv. for short duration rice (var. CO 47) under direct wet (drum) seeded condition.

MATERIALS AND METHODS

Experimental site and initial soil characteristics: Field experiment was conducted at wetlands, Agricultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore during kuruvai (August-November) 2002, to standardize the Leaf Colour Chart critical value (LCC cv.) and the rate of nitrogen application in CO 47 (115 days duration) rice. The farm is situated in Western agro-climatic zone of Tamil Nadu at 11° N latitude and 77° E longitudes at an elevation of 426.7 m above the mean sea level. The soil of the experimental site was clay textured (68.7% clay, 18.1% silt, 7.3% coarse sand, 5.9% fine sand) belonging to Noyyal series, (Vertic Ustochrept).

The initial analysis of the soil of the experimental site revealed that soil was neutral (pH -7.87) with low soluble salts (EC- 0.79 dS m^{-1}), medium organic carbon content (0.72%), medium in $KMnO_4$-N (290 kg ha^{-1}), high in Olsen-P (41 kg ha^{-1}) and NH_4OAc-K (796 kg ha^{-1}).

Experimental design, sowing and fertiliser schedule: The study was conducted in factorial randomized block design (FRBD) with three replications. The treatments (Table 1) included three levels of LCC (LCC cv. 3, 4 and 5) with different rates of N application (20, 25, 30 and 35 kg ha^{-1} at a time) along with three checks viz., control (zero-N), blanket N (120 kg ha^{-1} in four equal splits from 21 Days After Sowing (DAS)) and manage N practice (120 kg N ha^{-1} in four unequal splits - 1/6, 1/3, 1/3 and 1/6 from 21 DAS). Sprouted seeds were sown at the rate of 80 kg ha^{-1} using a drum seeder at 20 cm row spacing. Nitrogen was applied in the form of urea as per treatment schedule based on the LCC cv. assessed at weekly intervals from 21 DAS as per treatment schedule. A uniform dose of 38 kg P_2O_5 ha^{-1} (all basal), 38 kg K_2O ha^{-1} in two equal splits at 21 and 56 DAS, 25 kg $ZnSO_4$ ha^{-1} (all basal) and 500 kg gypsum ha^{-1} (all basal) were applied to all the treatments. Yield and agronomic efficiency were worked out for different N regimes.

Leaf Colour Chart (LCC) measurement: The LCC was developed from a Japanese prototype by the Crop and Resource Management Network (CREMNET) at IRRI and

Fig. 1: Leaf colour chart with six colour shades (ranging from 1 to 6 with leaf on number 4)

the Philippine Rice Research Institute, Philippines (Philrice). LCC is made of high quality plastic material. It consists of six colour shades ranging from light yellowish green (No. 1) to dark green (No. 6) colour strips fabricated with veins resembling those of rice leaves.

LCC readings were taken at weekly intervals from 21 DAS. At least 10 disease free healthy rice plants were selected at random for each plot. The colour of the index leaf (fully opened third leaf from top upto panicle emergence and boot leaf after panicle emergence) of selected plants was compared with the colour strips of the chart. If six or more leaves read below the set critical value, fertilizer N was applied in the form of urea as per treatment schedule. LCC readings were measured under the body shade in the morning time. LCC readings were taken upto 84 DAS.

Harvesting and thrashing: Sampling rows of all plots and the net plot area were harvested, thrashed and winnowed separately. The grain yield was recorded for each plot at 14% moisture content and the straw yield was recorded after oven drying.

Optimisation of applied N and agronomic efficiency: The data on the grain yields of rice under the various treatments were fitted into the appropriate response function following statistical procedures (Snedecor and Cochran, 1967). In cases where the response function was quadratic type, the physical optimum dose of N was calculated by equating the first order derivative of the response function to zero

$$\frac{dy}{dx} = 0$$

The economic optimum dose was calculated by equating the first order derivative of the response function to the price ratio (pxpy).

$$\frac{dy}{dx} = \frac{px}{py}$$

Taking into account the unit cost of N kg^{-1} as 10.4 and price of rice grain as Rs. 5.75 (INR) kg^{-1}

The response of rice (increase in grain yield per kg of fertilizer N applied) in different treatments were calculated is presented as agronomic efficiency (AE)

$$AE = \frac{Y_t - Y_0}{X}$$

Where:

Y : Grain yield (kg ha^{-1}) in treated plot
Y_0 : Grain yield (kg ha^{-1}) in control plot
X : Total N applied in (kg ha^{-1})

Statistical analysis: The observations collected from the field experiment and the data on the results of analysis of soil and plant samples were subjected to statistical scrutiny as per the procedure of Gomez and Gomez (1984). The treatments T_4 to T_{15} were treated as FRBD along with three checks (control, blanket N and manage N) and statistically analysed.

RESULTS AND DISCUSSION

Grain and straw yield: Almost all the treatments had recorded significantly higher grain yield over control plot. None of the treatment combination could out yield the existing blanket recommendation. The treatment L_5N_{35} (LCC cv.5 applied with 35 kg N ha^{-1} each time which received a total of 210 kg N ha^{-1}) has recorded 87% higher grain yield over control. Blanket N dose and manage N dose being on a par among themselves recorded 81 and 73% higher grain yield respectively over control (Table 2).

Among the different rates of N applied to maintain LCC cv.4, L_4N_{20} viz., 20 kg N ha^{-1} each time, with a total application of 60 kg N ha^{-1} and L_4N_{35} viz., 35 kg N ha^{-1} each time with a total dose of 70 kg N ha^{-1} had recorded comparable yield (4703 and 4568 kg ha^{-1}, respectively) with that of the blanket N (4926 kg ha^{-1}) with a saving of about 40-50% N compared to blanket N (120 kg ha^{-1}). Higher nitrogen use efficiency of LCC based N management over blanket N has been reported by Maiti and Das (2006).

The higher grain and straw yield trend to a tune of 87 and 135% respectively over control under L_5N_{35} emphasized the essentiality of N to achieve higher yield

Table 2: Grain yield and straw yield (kg ha^{-1}) of rice (variety CO 47) as influenced by different N regimes

Treatment No.	N dose (kg ha^{-1})	No. of splits	Grain yield	Straw yield
T_1	0	0	2723	3917
T_2	120	4	4926	7614
T_3	120	4	4702	8103
T_4	40	2	4315	6308
T_5	25	1	4182	5806
T_6	30	1	4315	6395
T_7	35	1	4077	6174
T_8	60	3	4703	6871
T_9	50	2	4405	6415
T_{10}	60	2	4226	5920
T_{11}	70	2	4568	6609
T_{12}	120	6	4702	7152
T_{13}	150	6	4688	8705
T_{14}	150	5	5045	7667
T_{15}	210	6	5104	9194
Mean			4445	6857
SEd			189	385
LSD (0.05)			386	788

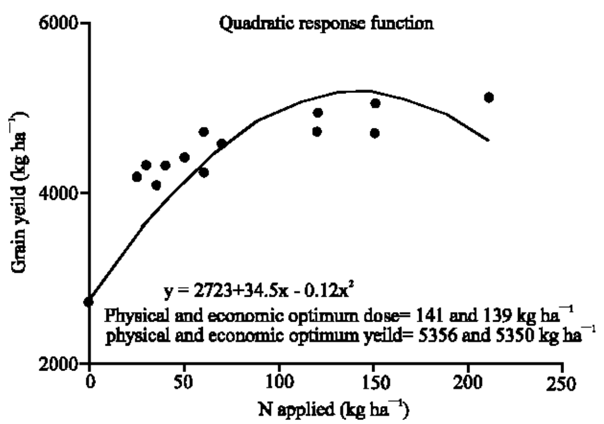

Fig. 2: Yield of rice (variety CO 47) to applied doses of N

potential. The perusal of the data for different N regimes comprehended that the short duration rice variety CO 47 responded upto 150 kg N ha^{-1}, since the difference in and failed to attain statistical significance. The report of yield between 150 and 210 kg N ha^{-1} was only marginal the network experiments on the response of direct seeded rice varieties under varied agro-climatic zones and soil types of South India has indicated the positive response of rice upto 120 kg N ha^{-1} and LCC cv.4 was found to be optimum (Anonymous, 2002; Budhar and Tamilselvan, 2003). Porpavai *et al.* (2002) observed best performance of LCC cv.5 during wet season and LCC cv.4 during dry season on a sandy loam soil. Use of the LCC for N management without any other change in the farmer's fertilizer or crop management increased the average grain yield by 0.1 to 0.7 t ha^{-1} across villages and seasons in Bangladesh (Alam *et al.*, 2005).

Increase in grain yield with increasing LCC levels was an expected one, as the cumulative dose of applied N was high at higher LCC levels (Table 2). Different rates of applied N failed to influence the grain yield under each level of LCC. This might be due to less variation in cumulative dose of applied N at each level except LCC cv. 5 where 120-210 kg N ha^{-1} was applied.

The quadratic response function (Fig. 2) of grain yield for applied N indicated that physical and economic optimum doses were 141 and 139 kg ha^{-1} to achieve grain yield of 5256 and 5350 kg ha^{-1} respectively. The performance of the treatment L_5N_{30} with respect to the yield as well as applied N dose (150 kg ha^{-1}) was almost close to the predicted optimum N dose and optimum yield. The highest grain yield recorded under LCC cv.5 could be anticipated since there existed a positive correlation between N uptake at harvest and grain yield (r^2 = 0.76).

Matching the N application with crop demand by real time N management is one among the efficient N management strategies for irrigated rice in Asia and LCC could be adopted for the same as it is attractive to farmers (Balasubramanian, 2004). Thus adoption of LCC cv. 5 with 30 kg N ha^{-1} each time can be recommended to get an optimum yield. This holds good for a farmer who can afford higher fertiliser cost, as the N input in the above treatment is slightly higher than existing recommendation of 120 kg ha^{-1}. India is a country with large number of small farm holdings and large number of farming group live below the poverty line. A poor farmer has much less resource allocative efficiency and he always search for an input system with less investment. In such a case, the farmer can adopt LCC cv.4 at the rate of 20 kg N each time, since L_4N_{20} (60 kg N ha^{-1}) was comparable with Blanket N (120 kg N ha^{-1}) in grain yield with a saving of 50% fertilizer nitrogen. Similar study to standardize the LCC for N management of different cultivars has shown that LCC cv. = 3 for Basmati 370, 4 for Saket 4 and 5 for Hybrid 6111/PHB-71 produced higher yield and nitrogen use efficiency than recommend N splits (Shukla *et al.*, 2004).

Agronomic efficiency: The Agronomic Efficiency (AE) of blanket and manage N were almost closer to different rates of applied N under LCC cv.5 except L_5N_{35}. Since the total dose of N applied for L_5N_{20}, L_5N_{25} and L_5N_{30} (around 120-150) were very closer to BN and MN. LCC cv.3 recorded the highest AE than by LCC cv. 4 and 5 (Fig. 3). Budhar and Tamilselvan (2003) observed highest AE under LCC cv. 4 which was due to highest yield under LCC cv. 4. L_4N_{20} and L_4N_{30} though received similar N doses; the AE of L_4N_{20} was higher than L_4N_{30} which was due to increased number of N splits. The results observed under L_5N_{25} and L_5N_{30} confutes with the above observation. Rao and Moorthy (1997) observed highest

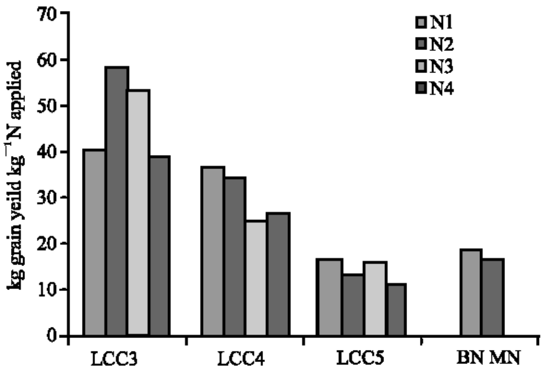

Fig. 3: Agronomic efficiency of rice (variety CO 47) as influenced by different N regimes (LCC 3, 4 and 5 indicates the critical value maintained, N_1, N_2, N_3 and N_4 represents N applied @ 20, 25, 30 and 35 kg ha^{-1} under each level of LCC. BN and MN are Blanket N and Manage N, respectively)

N response (kg grain kg^{-1} N applied) at 30 kg N ha^{-1} level (24.3-27.3) than 60 (22.5) and 90 kg N ha^{-1} (19.4-20.0). This fact was also supported by Bindhu (2002). The higher N response at lower N dose could be expected in cereal crop like rice wherein a linear response at low fertilizer input and a quadratic response thereafter has been normally reported.

In general, LCC cv.3 and LCC cv.4 has recorded higher AE and that of LCC cv.5 has recorded comparable AE over BN and MN (Table 2), suggesting that higher AE and sustained productivity could also be achieved with LCC based N management technology. Kumar *et al.* (2001) and Velu *et al.* (2002) observed higher AE for SPAD based N application compared to the conventional method of N fertilization. Since N was supplied based on crop demand as indicated by leaf greenness (Plant N concentration), a better AE could be achieved under LCC based N management over the existing blanket recommendation. This was evident from the performance of L_4N_{20} which recorded a comparable grain yield with that of the blanket N, while the AE of the same was almost double (36.5) over BN (18.4). This trend of results once again urges the need for adopting the LCC based N management for higher AE and sustained rice productivity.

CONCLUSIONS

Thus under the similar soil type (clay) and climatic conditions (tropical) in South India, a farmer who can afford higher fertiliser cost could adopt LCC cv 5 @ 30 kg N ha^{-1} each time to get the highest yield and net return and a farmer with low resource allocative efficiency could adopt LCC cv 4 at the rate of 20 kg N ha^{-1} each time to get a yield comparable to that of the blanket N with a saving of 50% nitrogen.

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