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Relative performance of neem coated urea on the basis of need based nitrogen management using customized leaf colour chart in low land rice (*Oryza sativa*) of eastern India

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ABSTRACT

An experiment was conducted during the Kharif season, of 2018 to study the effect of NCU in conventional and customized leaf colour chart (CLCC) based approach on rice (Oryza sativa). The eight treatments were evaluated in randomized block design with three replications. It has been found that application of NCU based on CLCC recorded higher yield i.e. by 7.74% in comparison with conventionally applied NCU and 12.5% in comparison with conventionally applied OU. The N_2O emission ranged from 14.1–91.6 µg N_2O-N m^{-2} hr^{-1} and the total N_2O-N emission during the season ranged from 0.38 to 0.61 kg ha^{-1}. The loss of N through N_2O emission was recorded in the range of 19-23% under NCU applied based on CLCC than those applied under conventionally. 75% RDN in form of NCU based on CLCC recorded the highest N recovery efficiency (REN) (49.62%). CLCC based NCU application recorded notable performance in most of the yield attributing characters such as number of panicles m^{-2}, panicle length, number of grains $panicle^{-1}$, number of filled grains $panicle^{-1}$ and harvest index. It also recorded the highest yield (4.59 t ha^{-1}) amongst all the treatments and increases the yield by 7.74% in comparison with conventionally. The results acknowledged that N can be saved by following CLCC approach.

Keywords: Neem coated urea; CLCC; Nitrogen recovery efficiency; Rice.

INTRODUCTION

Rice (*Oryza sativa*) is one of the foremost staple food crops of South and South East Asia, usually grown in lowland rainfed environment. To secure a certain target yield in rice, the major prerequisite is to have adequate number of grains per unit land area, which can be possible with application of nitrogenous fertilizer as there exists a close relationship among the quantity of grain per unit land area and the amount of nitrogen absorbed by rice plants. An adequate amount of nitrogenous fertilizer enhances photosynthesis in rice crop, increases resistance to biotic strain (Guo *et al.* 2016), improves dry matter buildup and nutrient uptake (Barlog and Grzebisz, 2004). The management of N nutrition of rice crop is complicated because lowland rice cultivation favors losses of soil N (more than 60%) through leaching of nitrate-nitrogen, volatilization of ammonia, surface runoff and de-nitrification. So, the quick transformation is the major grounds of poorer use efficiency of both applied and soil nitrogen. These losses can be minimized if it is conserved in ammonium form for a reasonably long period of time. Neem coated urea which is an indigenous slow-release N fertilizer as well as nitrification inhibitor and have been reported to boost the growth, yield, uptake and use efficiency of applied nitrogen fertilizer in rice (Thind and Gupta, 2010). Farmers in general apply nitrogen fertilizer in split doses in predetermined time without taking into consideration the plant's need for nitrogen at that point in time which leads to a range of losses. The best promising use of nitrogen can be achieved by harmonizing its supply with the crop demand. Synchronization of N fertilizer application with the crop requirement following need-based nitrogen management is one more approach for superior yields, reduced nitrogen losses and superior nitrogen use efficiency (Thind and Gupta, 2010). For this, chlorophyll meter or leaf colour chart (LCC) can be used to estimate the actual plant nitrogen status. Leaf colour chart is a high-class plastic strip. It consists of diverse shades of green colour ranging from light yellowish green to dark green. The foremost Leaf colour chart was developed in Japan. The customized leaf colour chart is based on a fixed-dose approach. The CLCC recommendation concerned with the application

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of 33% of N as basal dose followed by two top dressings of 33% each, as and when CLCC reading is ≤ 3 ensuring greater synchrony between supply and demand of nitrogen. Taking into account these facts, this trial was conducted to estimate growth and yield of low land rice under CLCC based real time nitrogen management.

MATERIALS AND METHODS

A field experiment was conducted at the experimental farm ICAR-NRRI, Cuttack, Odisha, India (20° 25′ N, 85° 55′ E; elevation 24 m above mean sea level) during the *Kharif* season in 2018. The experimental soil was sandy clay loam having pH, EC and organic carbon as 6.23, 0.19 dSm^{-1} and 6.17 g kg^{-1} respectively. The available N, P and K content of the soil were recorded as 328, 21.19 and 189 kg ha^{-1} respectively and rated as medium status on major nutrients. The experiment was arranged in Randomized block design, comprised of eight treatments and were replicated thrice. Treatments comprised of T1: control with no nitrogen applied; T2: 100% RDN (Recommended dose of N) as NCU in conventional method; T3: 75% RDN as NCU in conventional method; T4: 50% RDN as NCU in conventional method; T5: 100% RDN as NCU with CLCC recommendation; T6: 75% RDN as NCU with CLCC recommendation; T7: 50% RDN as NCU with CLCC recommendation; T8: 100% RDN as prilled urea (PU) in conventional method. Naveen rice variety was taken as test crop and was planted in July 2018.

Biometrical observations on the number of tillers, leaf area index (LAI), crop growth rate, above-ground dry matter production, total N uptake were measured and recorded at different growth stages of the crop. The leaf area index was calculated by the following formula given by (Watson, 1952). In CLCC based treatments, nitrogen was applied through urea based on average LCC readings taken from 21 days after sowing (DAS) to heading at every 10 days interval. If the colour of a rice leaf (taken from 10 randomly selected upper healthy leaves) was in between two shades, then the average of the two values was taken as the reading. If the colour was 3.5 or less, N fertilizer was applied. For the above-ground dry matter, destructive sampling was done following oven drying at a temperature of 70°C for 72 hours until the constant weight. Likewise, grain and straw yields were calculated in kg ha^{-1}. Harvest index (HI) was calculated by the following formula as described by Donald *et al.* (1976). Nitrogen recovery efficiency (RE_N) was calculated by using the following formula described by Yan *et al.* (2014). Nitrate nitrogen in soil was determined by following the copperized cadmium method given by Huffman *et al.* (1981). Total N_2O emission was recorder by manual closed chamber technique (Bhattacharyya *et al.*, 2013).

The data were statistically analyzed with the SAS (version 9.2 English) software package (SAS institute 2011) software programs. One way ANOVA was performed to analyze the effect of treatments and differences between treatment means were compared using Duncan's new multiple range test (DMRT). The statistical testing was done at a significance level of 0.05.

RESULTS AND DISCUSSION

Growth Parameters

The results revealed that plant height, dry matter buildup at different growth stages and crop growth rate were found significantly influenced by the N management practices. In general, CLCC based treatments showed greater plant heights and dry matter accumulation as compared to the suggested practice of three split applications and control at different growth stages. Dry matter buildup of the crop increased with the advancement of crop growth and increase in the doses of nitrogen fertilizers which increased the height and growth of the plant (Table 1). However, the crop growth rate increased up to 30-60 DAT and declined thereafter. CGR of rice under 100% RDN in form of NCU applied based on CLCC readings (T5) recorded the highest among all other treatments at both 0-30 DAT and 30-60 DAT presented in Table 3.Higher dry matter accumulation might be due to higher accessibility and translocation of nutrients predominantly nitrogen during the growth and development stages which facilitate more photosynthesis and stimulate the uptake and consumption of other nutrients including phosphorous, potassium and controls by and large growth of the plant (Bloom *et al.* 2015). Application of 100% recommended dose of N in the form of NCU in combination with CLCC enhanced the plant height and dry matter accumulation of crop. Houshm *et al.* (2011) described considerable prospect to enhance yield and N use efficiency (NUE) levels through superior N management using CLCC in rice crop. Synchrony of N supply with crop requirement is necessary in order to make sure sufficient measure of uptake and exploitation, quality, best possible yield and avoiding negative environmental impacts. Increase in CGR up to 30-60 DAT was due to rapid vegetative growth with the increased number of leaves and tillers while the decrease in CGR at later stage of crop growth was due to senescence of leaves near to maturity. Higher CGR during panicle initiation to flowering stage may be owed to higher dry matter accumulation at flowering in different plant organs hence elevated growth rate (Chaudhari *et al.* 2017). The reason behind higher CGR in 100 % RDN under NCU based on CLCC could be due to synchronization demand of crops and supply of N.

Table 1: Effect of different nitrogen management practices on plant height, dry matter accumulation and nitrogen use efficiency

Treatments	Plant height at harvest (cm)	Dry matter at harvest (g m^{-2})	N Content (%)		N uptake (Kg ha^{-1})		NUE (g Kg^{-1})
			Straw	Grain	Straw	Grain	
T_1	104.5d	701.8d	0.24b	1.12abc	9.60b	30.79d	-
T_2	116.8a	995.37a	0.49a	1.08c	24.77a	45.63b	19.03ab
T_3	112.8b	960.94ab	0.39a	1.12abc	19.95a	44.92b	20.8ab
T_4	115.7a	860.7ab	0.47a	1.19a	20.57a	36.90c	9.07d
T_5	116.1a	1028.03a	0.44a	1.11bc	24.10a	50.90a	23.21a
T_6	111.6bc	1023.7a	0.41a	1.16ab	21.85a	48.50ab	23.93a
T_7	109.85c	850.33c	0.46a	1.16ab	20.67a	37.68c	12.63cd
T_8	110.3bc	1011.63a	0.39a	1.14ab	19.15a	46.81b	16.86bc
L.S.D. (P<0.05)	2.02	100.53	0.093	0.06	6.68	4.04	5.00

Nitrate nitrogen in soil

Nitrate nitrogen (NO_3^--N) content data recorded during the crop growth period are depicted through Fig. 1. It ranged from 1.65 to 12.53 kg ha^{-1}. Nitrate nitrogen content confirmed an asymmetrical pattern except for peaks formed which overlapped with the application of N fertilizer. Amongst all the treatments the maximum NO_3^-N absorption was witnessed in T2 following the application of fertilizer. The concentration of NO_3^-N in soil was higher at primary growth stages in treatments where 50% of nitrogen was applied in an only initial split. Only peaks were obtained where ever there was fertilization. Less NO_3^-N concentration in soil was observed in NCU applied plots as compared to ordinary urea.

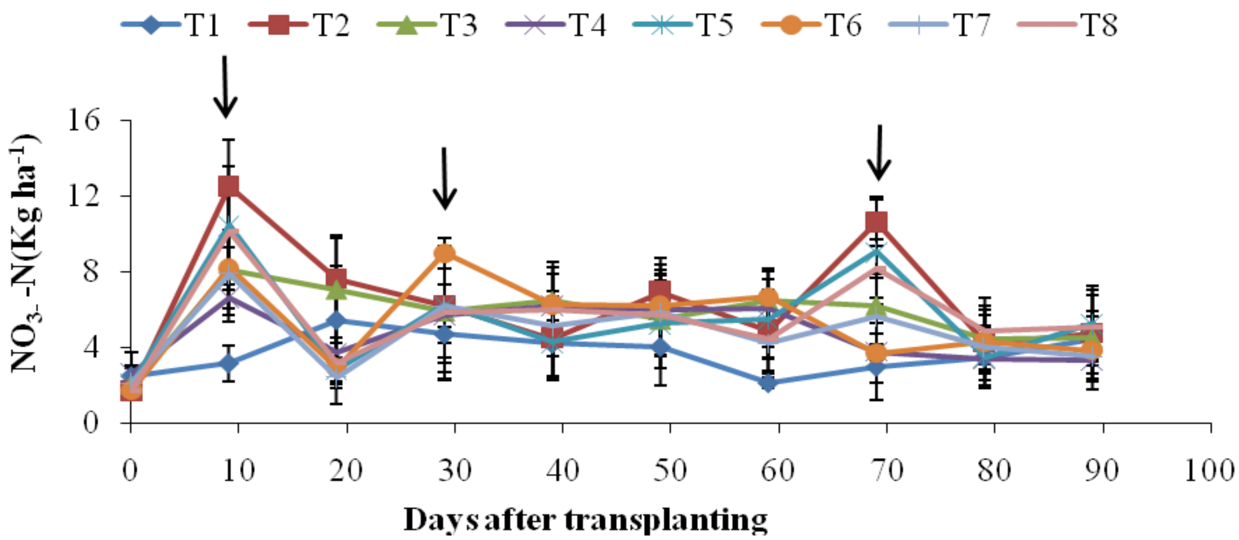

Fig 1: NO_3^--N content in soil during the crop growing period in rice under different N management strategy

NO_3^--N content showed an irregular pattern and the peaks were obtained at the time of fertilizer application. Less NO_3^-N concentration in soil were observed in NCU applied plots in comparison with plots where ordinary urea has been applied, because neem coated urea which acted as a slow release fertilizer, in addition to that coating of neem oil emulsion includes active ingredients that hold back nitrification action, and standardize the pattern of NO_3^-N in soil (Suri *et al.* 2004). The allocation of NO_3^-N was observed to be homogeneous all through the soil in the later stages of growth (panicle initiation and flowering stages) as plant grows, demand for N augmented which also boosts the uptake of nitrogen (Mohanty *et al.* 2017).

Table 2: Effect of nitrogen management practices on crop growth rate

Treatments	CGR ($g\ m^{-2}\ d^{-1}$)		
	0-30days	30-60days	60-90days
T_1	2.18b	11.46c	5.55a
T_2	2.98ab	17.74ab	7.92a
T_3	3.01ab	17.29ab	6.91a
T_4	2.60ab	14.44cb	7.38a
T_5	3.49a	19.28a	8.11a
T_6	2.94ab	15.91ab	7.89a
T_7	3.05ab	14.05cb	7.09a
T_8	3.32a	17.68ab	7.26a
L.S.D. (P<0.05)	0.81	3.9	4.01

Nitrogen loss and percentage recovery

Nitrous oxide (N_2O) emission data recorded during the crop growth period and ranged from 14.1–91.6 µg N_2O-N m^{-2} hr^{-1}. The utmost peak was witnessed in the treatment wherever 100% of nitrogen was applied as basal through normal urea (T8). Total N_2O-N release throughout the season ranged from 0.38 to 0.61 kg ha^{-1} (Table 4). The N_2O emission ranged from 14.1–91.6 µg N_2O-N m^{-2} hr^{-1}. The utmost peak was recorded in the treatment where 100% of N was applied as basal through PU (T8) and a significant amplification in the emission with peak observed on 1–2 days subsequent to application of N-fertilizer was observed in different N management, followed by a gradual decrease after 3 days (Fig. 2). Cumulative N_2O emission during the season was given in (Table 4) and the variation was noteworthy ($p \leq 0.05$). The highest collective N_2O emission was recorded in T8. Nitrogen recovery efficiency was estimated based on the N uptake from the total fertilizer N applied. Results presented in table 5 indicate that nitrogen efficiency was higher at a low level of fertilizer N applied and efficiency decreased with increase in fertilizer N level. Although almost all treatments showed statically *at par* results except T8 treatment which received 100 % RDN through ordinary urea applied as conventional method and recorded the lowest RE_N (33.81%). 75% RDN in form of NCU based on CLCC (T6) recorded the highest (49.62%).

Table 3: Nitrogen management practices on crop N_2O emission and percentage N recovery

Treatments	N_2O emission	RE_N
	(Kg ha^{-1})	(%)
T_1	0.38g	-
T_2	0.58ab	42.25b
T_3	0.55cb	43.28ab
T_4	0.51ed	46.44ab
T_5	0.53cd	45.11ab
T_6	0.47ef	49.62a
T_7	0.43f	48.61ab
T_8	0.61a	33.81c
L.S.D. (P<0.05)	0.04	6.64

Urea application significantly increased the N_2O flux as extended submergence in puddle transplanted rice produced a highly anoxic environment that facilitates the formation of N_2O, and most of N applied was lost in the form of N_2 (Ruser *et al.* 2006). The control plots with no fertilization, nitrous oxide emitted is much less than the rest of the treatments as the formation of nitrous oxide depend on the presence of substrate (urea) in the soil. The highest N_2O-N emission rate was recorded in T_8, a day after application of 50% N as basal in which can be attributed to increasing IPSITA concentrations of nitrate nitrogen in soil (Figure 1) with the application of N a quick rise in the N_2O emission was observed and the utmost peak was obtained when 50% of nitrogen was applied as basal dose. N_2O in soil is produced as the by-product of nitrification and/or de-nitrification processes which mostly depends upon the aeration status of the soil (Zhu *et al.*, 2013). The CLCC based treatment T_5, T_6 and T_7 Show lesser emission as compared to conventional N management practice. Use of CLCC reduced the amount of nitrogen applied as compared to conventional calendar which leads to significant drop in N_2O emission. 75% RDN in form of NCU based on CLCC (T_6) recorded the highest (49.62%) where as application of ordinary urea resulted in lowest percentage recovery due to more loss of nitrogen in the form of N_2O which resulted in lesser uptake. The treatment in which NCU applied based on CLCC recommendation showed better crop growth as compared to N applied in conventional way and was reported to have superior N utilization efficiency as compared to ordinary urea applied conventionally (Thind and Gupta, 2010).

Table 4: Effect of yield attributes on different nitrogen treatments

Treatment	No of panicles m^{-2}	panicle length (cm)	No of grains per panicle	Harvest index	Test weight	Grain yield (t ha^{-1})	Biomass yield at harvest (t ha^{-1})
T_2	210.1a	25.47a	125.56a	0.45a	24.8a	4.26b	9.35b
T_3	209a	23.52a	122.78ab	0.43a	24.7a	3.98b	9.08b
T_4	192.5b	21.48ab	117.44c	0.41a	25.3a	3.10c	7.50c
T_5	211.2a	23.97a	122.56ab	0.45a	23.7a	4.59a	10.09a
T_6	210.1a	21.12ab	121.33cab	0.43a	24.2a	4.17b	9.48ab
T_7	190.3b	18.67cb	119.33cb	0.41a	24.6a	3.24c	7.08c
T_8	209a	22.37ab	123.78ab	0.45a	24.8a	4.08b	8.99b
L.S.D (P<0.05)	11.05	4.26	4.52	NS	NS	0.281	0.67

Grain Yield, Yield Attributes and Harvest Index

Application of 100% RDN based on CLCC recorded notable performance in most of the yield attributing characters such as number of panicles m^{-2}, panicle length, number of grains panicle^{-1}, number of filled grains panicle^{-1} and harvest index. It also recorded the highest yield (4.59 t ha^{-1}) amongst all the treatments and increases the yield by 7.74% in comparison with conventionally applied NCU and 12.5% as compared to ordinary urea applied through conventional way depicted in Table 5.

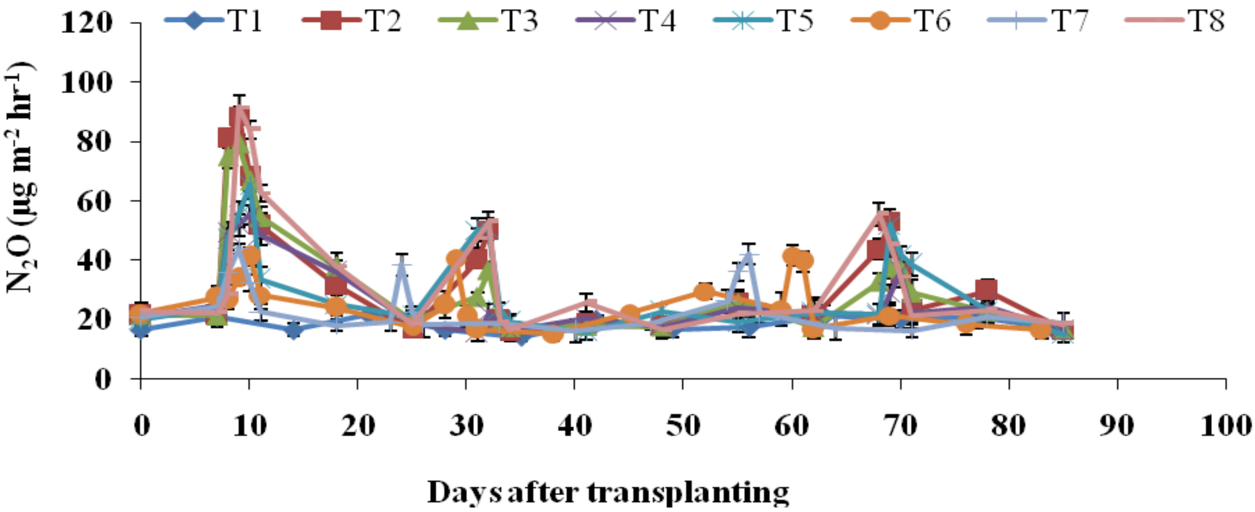

Fig 2: Nitrous oxide emission during the crop growing period in rice under different N management strategy

Application of 100% RDN based on CLCC recorded notable performance in most of the yield attributing characters such as panicle length, number of panicles m^{-2}, number of grains $panicle^{-1}$, number of filled grains $panicle^{-1}$ and harvest index. This was largely due to higher net assimilation and photosynthetic effectiveness which helped in enhancing by and large the growth of the plant. Sannigrahi and Nayak (2000) reported that the application of neem coated urea in splits at panicle initiation stage might have maintained a good supply of ammonium-N up to the flowering point which resulted in better yield characteristics and the highest yield (4.59 t ha^{-1}) was recorded in this among all the treatments which increased the yield by 7.74% as compared to NCU applied in conventional method and 12.5% yield increased as compared to ordinary urea applied conventionally. It was most likely due to improved growth and maturity of the plant due to harmonization of demand and supply which augment the uptake of nutrients and healthier nourishment of the grains ensuing increase in the size of the grain, which in due course improved the number of grains per panicle and better grain yield (Banerajee and Pal, 2011). Considerably higher grain yield observed in treatments based on CLCC recommendation were attributed to the harmonization of nitrogen supply and further proficient consumption by the crop. In suggested practice, fixed rate of nitrogen was applied in the predetermined time irrespective to the requirement of the crop which lead to various losses of applied nitrogen through various processes taking place in the soil. Therefore, predetermined three equal splits of N under the recommended practice were less efficient and caused lower grain yield. As compared to ordinary urea, NCU augmented the crop yield by 6% while applied through traditional way and increased the yield by 21% when neem coated urea applied on the basis of CLCC reading (Mohanty *et al.* 2017).

It may be concluded from the result that the application of neem coated urea according to CLCC recommendation is more realistic and capable in dropping the nitrous oxide emission which is a major contributor towards global warming. Moreover, superior performance was observed in treatments based on CLCC in terms of growth and yield characteristics with better N recovery by the crop in comparison to ordinary urea. It is concluded that the application of NCU according to the CLCC recommendation can save nitrogen without affecting the economic yield of the crop.

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