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Leaf Colour chart-based nitrogen management-Impact on soil properties and nutrient uptake of short duration transplanted rice

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Abstract
A field experiment was conducted during *Kharif,* 2018 to study the effect of LCC based nitrogen management on growth of short duration transplanted rice. Treatments included two doses of nitrogen (120 and 150 kg ha^{-1}) applied on basis of two critical LCC values- 3 and 4. In turn Nitrogen was applied in 3 equal splits @ 120 kg N ha^{-1} and (3 and 4) splits with half as basal, remaining @ 150 Kg ha^{-1}. LCC based treatments were evaluated against control, recommended method and Farmers practice. Results revealed that, LCC -4 was more beneficial in enhancing yield and nutrient uptake of rice. Physico-chemical properties and nutrient status of soil were not unaffected by treatments. LCC-4 with 150 kg N ha^{-1} was superior in uptake of N, P and K (112.5, 46.8 and 115.2 kg ha^{-1} respectively). LCC based nitrogen application was effective in improving uptake of nutrients thus resulting in satisfactory yields.

Keywords: LCC, nitrogen, Short duration transplanted rice, nutrient uptake, soil properties.

Introduction
In low land ecology, poor management practices, especially the fertilizer management is the key factor for the poor productivity of rice in India. Among all the reasons for lower productivity, inefficient utilisation of nitrogen is considered as an important one. Monitoring plant N status is important for improving the balance between crop N demand and N supply from soil and applied fertilizer. Since farmers generally prefer to keep leaves of the crop dark green and in a need to achieve high yields of rice, they have developed a tendency to apply fertilizer N in excess of crop requirements resulting in poor efficiency of applied Nitrogen. Advances in N management for rice include adjustment of the early N application to match the relatively low demand of young rice plants and varying rates and distribution of fertilizer N within the growing season to match crop demand for supplemental N. In this respect, the leaf N status of rice, which is closely related to photosynthetic rate and biomass production, serves as a sensitive indicator of the crop demand for N during the growing season (Singh *et al*., 2012) [1]. Precise application of nitrogen fertilizer based on plant need and location in the field will greatly help in improving the fertilizer use efficiency in rice. The LCC emerged as economical and potential tool for synchronizing in-season demand and supply in field crops. Leaf Colour Chart will provide indirect assessment of leaf nitrogen status, which is closely related to photosynthetic rate and biomass production (Kropff *et al*., 1993) [2]. Leaf color chart has been used successfully to guide fertilizer N application in rice, wheat and maize (Ali *et al.*, 2014) [3].

Material and methods
A field experiment was conducted during *Kharif,* 2017 to study the effect of LCC based nitrogen management on growth, yield and nitrogen use efficiency of short duration transplanted rice at College farm, College of Agriculture, Rajendranagar, Hyderabad (17°19' N and 78°24' E). The soil was moderately alkaline in pH (7.8), non-saline in EC (0.32 dS m^{-1}), low in organic carbon (0.42%), low in available N (210 kg ha^{-1}), medium in available P (44.3 kg ha^{-1}) and high in available K (351 kg ha^{-1}). The experiment was laid out in RBD with three replications. Treatments included two doses of nitrogen (120 and 150 kg ha^{-1}) applied on basis of two critical LCC values- 3 and 4. In turn N was applied in 3 equal splits incase of 120 kg

N ha^{-1} and with 150 kg N ha^{-1} it was applied in 3 and 4 splits with half as basal. These LCC based treatments were evaluated against control with no nitrogen, Recommended method and Farmers practice with (120-60-40), (180-80-40) RDF respectively applied at fixed time intervals. Rice variety selected for the study was KNM-118 (Kunaram sannalu). All agronomic practices were carried out as per the recommendations.

Nutrient management

The recommended dose of fertilizer @ (120-60-40) and (180-80-40) N, P_2O_5 and K_2O kg ha^{-1} were applied to T_2 and T_3 treatments respectively. NPK were applied through urea, single super phosphate and Muriate of potash (single super phosphate for control) sources respectively. Half of the recommended dose of N was applied as basal for all treatments except for T_4 and T_7. Entire dose of P as basal and K applied in 2Osplits (basal + at 1st top dressing of Nitrogen) for all treatments. RDN was applied at 0, 18, 35 DAT for T_2 and T_3. For treatments T_4 to T_9, nitrogen was applied based on their respective LCC critical values using RDN of 120 kg ha^{-1} for T_4 and T_7 and RDN of 150 for T_5, T_6, T_8 and T_9 treatments.

LCC observation

The topmost fully expandedoleaf from each hill was selected and leaf colour was compared by placing the middle part of the leaf on LCC and the leaf colour was observed. Whenever the green colour of more than 5 out of 10 leaves were observed equal to or below a set critical limit of LCC score, nitrogen was applied as per the treatment. The leafowas not detached or destroyed. The average LCC reading were determined for each treatment. Readings were taken in the morning (8-10 AM) underothe shade of body in order to avoid the influence of sun light as it may reflect the LCC colour.

Soil analysis and nutrient uptake studies

Soil samples collected from each plot up to depth 15 cm after harvest of the crop were shade dried, pounded and sieved through 2 mm mesh. A representative sample was prepared each treatment and preserved in polythene bags. Samples are analyzed for physico-chemical, physical and chemical properties following standard procedures. Available nitrogen in soil was determined by alkaline potassium permanganate method. Available phosphorus using Olsen's reagent (0.5 N $NaHCO_3$, pH 8.5) in ascorbic acid method given by Watanabe and Olsen. Available potassium was extracted from soil with Neutral normal ammonium acetate at p*H* 7.0 was determined by using flame photometer (Elico CL 378).

Plant samples collected at 30, 60, 90 DAT and at harvest. Samples were analyzed for N, P and K content by adapting standard procedures i.e., (Modified Kjeldhal's method), (Di-acid digestion method and colorimetric estimation) and (Di-acid digestion method followed by Flame photometer method) respectively given by Piper. 1966 [4]. The values of NPK contents for grain and straw were recorded treatment wise and then N, P and K uptakes were determined for grain and straw yields of each treatments.

Results and discussion

Effect of LCC based N management on soil physico-chemical properties and nutrient availability

An overview of the data presented in Table.1 indicated that, physico-chemical properties like pH, EC and OC in post harvest soil were close to the initial soil status. Post-harvest nutrient status of soil i.e., available N, P and K were not significantly influenced by LCC based Nitrogen management. All the treatments were on par with nitrogen dose and LCC critical value. Initially soil was moderately alkaline with pH 7.81. After the experimentation, soil pH ranged from 7.71 to 7.76 in various treatments. Lowest pH (7.71) observed in T_3 (Farmers practice) might be due to, application of excess nitrogen (ammonium based) which have acidifying property in soil. While highest (7.76) was recorded in T_1. Initial soil has EC of 0.32 dS m^{-1}. Highest EC (0.36) at harvest was recorded with T_7. While lowest (0.31) was recorded with T_3. Initially soil was low (0.42%) in organic carbon. Highest OC (0.41) at harvest was recorded withT_3, T_5, T_8 and T_9. While lowest (0.40) was recorded with T_1, T_2, T_4, T_6 and T_7.

The available nitrogen status in the initial soil was low (210 kg ha^{-1}). Highest available nitrogen (208.4 kg ha^{-1}) in post harvest soil was recorded with T_3 (Farmers practice) which might be due to the application of large amounts of nitrogen (Johnkutty *et al.*, 2000) [5]. While lower N availability in T_1 might be due to insufficient N application that was utilized for crop growth and uptake. These results were similar to the findings of Arvind *et al.* (2006) [6]. The available phosphorous status in the initial soil was medium (44.3 kg ha^{-1}). Highest available phosphorous (43.4 kg ha^{-1}) in post harvest soil was recorded with T_4. While lowest (39.7 kg ha^{-1}) was recorded with T_1 {No Nitrogen}. The higher soil P availability in T_4 {120 kg RDN at LCC 3 -RDN applied as 3 equal splits (1/3rd basal + 1/3rd + 1/3rd)} and farmers practice with 180 kg N ha^{-1} might be due to less uptake of P by plant. The available potassium status in the initial soil was high (351.0 kg ha^{-1}). Highest available potassium (345.4 kg ha^{-1}) in post harvest soil was recorded with T_2. While lowest (328.1 kg ha^{-1}) was recorded with T_1 {No Nitrogen} (Table 1). Application of N in larger quantities might have decreased available P and K. As the applied N being the primary nutrient factor, the rice biomass and P and K uptake increased considerably with increasing rate of N application and LCC levels, that might be lead to a proportional decline in soil available P and K (Nachimuthu *et al*., 2007) [7].

Table 1: Soil physico-chemical properties and nutrient availability as influenced by LCC based nitrogen management in rice

Treatments		Soil physico-chemical properties			Nutrient availability		
		pH	EC (dSm^{-1})	OC (%)	Available N (kg ha^{-1})	Available P (kg ha^{-1})	Available K (kg ha^{-1})
T_1	No Nitrogen	7.76	0.32	0.40	192.1	39.7	328.1
T_2	RDF (120-60-40 Kg N, P_2O_5, K_2O ha^{-1}) - RDN applied as 1 basal+ 2 equal splits (½ basal + 1/4th + 1/4th)	7.74	0.34	0.40	201.3	41.7	345.4
T_3	Farmers practice (180-80-40 Kg N, P_2O_5, K_2O ha^{-1}) - RDN applied as 1 basal + 2 equal splits (½ basal + 1/4th + 1/4th)	7.71	0.31	0.41	208.4	40.4	335.3
T_4	120 kg RDN at LCC 3 – RDN applied as 3 equal splits (1/3rd basal + 1/3rd + 1/3rd)	7.75	0.35	0.40	202.3	43.4	343.2
T_5	150 kg RDN at LCC 3 - RDN applied as 1 basal + 2 equal	7.73	0.34	0.41	205.8	43.3	342.5

	splits (½ basal + $1/4^{th}$ + $1/4^{th}$)						
T_6	150 kg RDN at LCC 3 - RDN applied as 1 basal + 3 equal splits (½ basal + 25 kg + 25 kg + 25 kg)	7.73	0.34	0.40	205.3	41.7	341.6
T_7	120 kg RDN at LCC 4 – RDN applied as 3 equal splits ($1/3^{rd}$ basal + $1/3^{rd}$ + $1/3^{rd}$)	7.74	0.36	0.40	203.7	41.1	340.6
T_8	150 kg RDN at LCC 4 - RDN applied as 1 basal+ 2 equal splits (½ basal + $1/4^{th}$ + $1/4^{th}$)	7.72	0.34	0.41	207.9	40.8	337.7
T_9	150 kg RDN at LCC 4 - RDN applied as1 basal + 3 equal splits (½ basal + 25 kg + 25 kg + 25kg)	7.72	0.33	0.41	206.5	40.6	336.8
	Initial	7.81	0.32	0.42	210.0	44.3	351.0
	SE(m) ±	0.01	0.01	0.01	6.87	1.47	11.91
	CD (p=0.05)	NS	NS	NS	NS	NS	NS
	CV %	0.22	6.96	5.85	5.8	6.1	6.1

Effect of LCC based N management on nutrient uptake by Rice:

Nitrogen uptake differed significantly at 30, 60, 90 DAT and Harvest by LCC based Nitrogen management (Table 2). It was observed that, at 30 DAT, highest nitrogen uptake (56.8 kg ha^{-1}) was recorded with T_3 (Farmers practice) and was on par with T_9 {150 kg RDN at LCC 4 - RDN applied as 1 basal+ 3 equal splits (½ basal + 25 kg + 25 kg + 25kg)}. While lowest (14.1 kg ha^{-1}) was recorded with T_1 {No Nitrogen} which was significantly inferior to all other treatments. At 60 DAT, highest nitrogen uptake (121.6 kg ha^{-1}) was recorded with T_9 which was on par with T_3 {Farmers practice}. While lowest (38.2 kg ha^{-1}) was recorded with T_1 {No Nitrogen}. Similar trend was observed at 90 DAT. Where highest nitrogen uptake (115.1 kg ha^{-1}) was recorded with T_9 which was on par with T_2 (Recommended practice), T_3 and T_8. Lowest (52.1 kg ha^{-1}) was recorded with T_1 {No Nitrogen}. At Harvest, Nitrogen uptake was analyzed in both grain and straw separately. Highest nitrogen uptake (81.4 kg ha^{-1}) in grain was recorded with T_9 which was on par with T_3 {Farmers practice}, T_7 and T_8. While lowest (25.4 kg ha^{-1}) was recorded with T_1 {No Nitrogen} which was significantly inferior to all other treatments. Highest nitrogen uptake (31.3 kg ha^{-1}) in straw was recorded with T_3 {Farmers practice which was on par with T_2, T_7, T_8 and T_9. Lowest N-uptake by straw (14.2 kg ha^{-1}) was recorded with T_1 {No Nitrogen}. It was found that, maximum absorption of nitrogen occurred between maximum tillering and flowering stage. This findings are in close conformity with Duan *et al.* (2005) [8]. Treatments imposed based on LCC-4 resulted in more N-uptake than farmers practice and recommended method. Since nutrient uptake is a function of biomass production, the rapid increase of biomass in T_9 {150 kg RDN at LCC 4 - RDN applied as1 basal + 3 equal splits (½ basal + 25 kg + 25 kg + 25kg)} might have demanded more nutrients, thus resulting in higher rate of N uptake (Zaman, 1999) [9]. Nitrogen uptake was more at higher rate of nitrogen (150 and 180 kg N ha^{-1}) due to increased nitrogen content in plant tissue and crop yield probably because of adequate nitrogen available to plant for vegetative and reproductive growth (Reena *et al.*, 2017) [10].

Table 2: Nitrogen uptake (kg ha^{-1}) as influenced by LCC based nitrogen management in rice.

Treatments		**Nitrogen uptake (kg ha^{-1})**					
		30 DAT	**60 DAT**	**90 DAT**	**Harvest**		
					Grain	**Straw**	**Total**
T_1	No Nitrogen	14.1	38.2	52.1	25.4	14.2	39.6
T_2	RDF (120-60-40 Kg N, P_2O_5, K_2O ha^{-1}) - RDN applied as 1 basal + 2 equal splits (½ basal + $1/4^{th}$ + $1/4^{th}$)	32.7	91.2	105.7	67.8	28.0	95.8
T_3	Farmers practice (180-80-40 Kg N, P_2O_5, K_2O ha^{-1}) - RDN applied as 1 basal + 2 equal splits (½ basal + $1/4^{th}$ + $1/4^{th}$)	56.8	110.2	112.8	76.9	31.3	108.2
T_4	120 kg RDN at LCC 3 – RDN applied as 3 equal splits ($1/3^{rd}$ basal + $1/3^{rd}$ + $1/3^{rd}$)	26.0	62.1	80.8	44.2	19.1	63.3
T_5	150 kg RDN at LCC 3 - RDN applied as 1 basal + 2 equal splits (½ basal + $1/4^{th}$ + $1/4^{th}$)	24.9	64.1	85.8	52.5	22.6	75.1
T_6	150 kg RDN at LCC 3 - RDN applied as 1 basal+ 3 equal splits (½ basal + 25 kg + 25 kg + 25 kg)	26.9	68.4	88.9	59.7	24.3	84.0
T_7	120 kg RDN at LCC 4 – RDN applied as 3 equal splits ($1/3^{rd}$ basal + $1/3^{rd}$ + $1/3^{rd}$)	32.9	85.6	102.4	71.2	28.2	99.4
T_8	150 kg RDN at LCC 4 - RDN applied as 1 basal+ 2 equal splits (½ basal + $1/4^{th}$ + $1/4^{th}$)	33.3	89.4	103.8	72.4	29.0	101.4
T_9	150 kg RDN at LCC 4 - RDN applied as1 basal + 3 equal splits (½ basal + 25 kg + 25 kg + 25kg)	47.8	121.6	115.1	81.4	31.1	112.5
	SE(m) ±	4.5	8.3	7.1	3.4	1.6	2.6
	CD (p=0.05)	13.4	24.9	21.4	10.3	4.7	7.8
	CV %	23.6	17.7	13.1	9.7	10.9	5.2

Phosphorous uptake at harvest differed significantly by LCC based Nitrogen management (Table 3). Phosphorous uptake was analyzed in both grain and straw separately. Highest Phosphorous uptake in Grain (29.4 kg ha^{-1}) was recorded in T_9 which was on par with T_3, T_7 and T_8. While lowest (10.4 kg ha^{-1}) was recorded with T_1 {No Nitrogen} which was significantly inferior to all other treatments. Highest Phosphorous uptake in Straw (17.9 kg ha^{-1}) was recorded in T_3 {Farmers practice} which was on par with T_2, T_7, T_8 and T_9. While lowest (7.2 kg ha^{-1}) was recorded with T_1. Highest total Phosphorous uptake (46.8 kg ha^{-1}) was recorded with T_9 which was on par with T_3. While lowest (17.6 kg ha^{-1}) was recorded with T_1. Similar were reported by Marahatta *et al.* (2017) [11] and Ravi *et al.* (2007) [12]. Treatments imposed based on LCC-4 resulted in more P-uptake than farmers practice and recommended method. This might be due to ready availability of nitrogen for the crop that helped in enhanced absorption of phosphorous. More P-uptake was recorded with higher doses of nitrogen (150 and 180 kg ha^{-1}). Increase in P uptake with increased dose of N added evidence to the fact that, N application has synergistic effect on the uptake of other nutrients like P and K (Nachimuthu *et al.*, 2007) [13].

Potassium uptake at harvest was significantly influenced by LCC based Nitrogen management (Table 3). Highest potassium uptake in Grain (27.4 kg ha^{-1}) was recorded in T_9 which was on par with T_3, T_7 and T_8. While lowest (9.3 kg ha^{-1}) was recorded with T_1. Highest potassium uptake in Straw (90.6 kg ha^{-1}) was recorded in T_3 {Farmers practice} which was found to be on par with T_8 and T_9. Lowest (26.3 kg ha^{-1}) was recorded with T_1 {No Nitrogen}. Highest Total potassium uptake (116.3 kg ha^{-1}) was recorded with T_3 {Farmers practice} which was on par with T_9. While the lowest (35.6 kg ha^{-1}) was recorded with T_1 {No Nitrogen}. The results are in agreement with Bai *et al.*, 2013 [14] and Sui *et al.*, 2013 [15]. K-uptake was higher in treatments imposed based on LCC-4 rather than recommended practice. This might be due to ready availability of nitrogen for the crop helped to enhanced absorption of potassium. Farmers practice with 180 kg N ha^{-1} and treatments with 150 kg N ha^{-1} were superior in terms of K-uptake. This increase in K uptake with increased dose of N was due to fact that, N application has synergistic effect on the uptake of other nutrients like P and K.

Table 3: Phosphorous and Potassium uptake (kg ha^{-1}) at harvest as influenced by LCC based nitrogen management in rice.

Treatments		P-Uptake (kg ha^{-1})			K-Uptake (kg ha^{-1})		
		Grain	Straw	Total	Grain	Straw	Total
T_1	No Nitrogen	10.4	7.2	17.6	9.3	26.3	35.6
T_2	RDF (120-60-40 Kg N, P_2O_5, K_2O ha^{-1}) - RDN applied as 1 basal+ 2 equal splits (½ basal + 1/4th + 1/4th)	24.7	15.8	40.5	21.9	78.5	100.4
T_3	Farmers practice (180-80-40 Kg N, P_2O_5, K_2O ha^{-1}) - RDN applied as 1 basal + 2 equal splits (½ basal + 1/4th + 1/4th)	28.4	17.9	46.3	25.7	90.6	116.3
T_4	120 kg RDN at LCC 3 – RDN applied as 3 equal splits (1/3rd basal + 1/3rd + 1/3rd)	16.2	10.7	26.9	15.0	54.9	69.9
T_5	150 kg RDN at LCC 3 - RDN applied as 1 basal + 2 equal splits (½ basal + 1/4th + 1/4th)	18.5	12.5	31.0	17.5	63.2	80.7
T_6	150 kg RDN at LCC 3 - RDN applied as 1 basal+ 3 equal splits (½ basal + 25 kg + 25 kg + 25 kg)	21.4	13.3	34.7	20.3	67.8	88.1
T_7	120 kg RDN at LCC 4 – RDN applied as 3 equal splits (1/3rd basal + 1/3rd + 1/3rd)	26.3	16.1	42.4	24.1	79.6	103.7
T_8	150 kg RDN at LCC 4 - RDN applied as 1 basal+ 2 equal splits (½ basal + 1/4th + 1/4th)	26.5	16.2	42.7	24.1	82.9	107.0
T_9	150 kg RDN at LCC 4 - RDN applied as1 basal + 3 equal splits (½ basal + 25 kg + 25 kg + 25kg)	29.4	17.4	46.8	27.4	87.8	115.2
	SE(m) ±	1.3	0.8	0.9	1.2	3.0	2.3
	CD (p=0.05)	4.0	2.5	2.7	3.7	9.1	6.9
	CV %	10.4	10.2	4.3	10.4	7.4	4.4

Conclusion

Most of applied N in fields is lost due to lack of synchrony of plant N demand with N supply. LCC is a simple and easy-to-use tool which helps farmers in avoiding excess application of N in rice crop. Also improves the balance between crop N demand and N supply from soil and applied fertilizer. The LCC based management in rice suggests that, availability and uptake of nutrients in soil and plant can be enhanced. Moreover, there can be considerable opportunity to increase farmers yield and N application can be saved with no yield loss by revising the fertilizer recommendation.

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