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Use of leaf colour chart for nitrogen management as a tool in bridging the yield gap in rainfed rice (*Oryza sativa* L.) production

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ABSTRACT : Nitrogen is the major nutrient that limits the yields of rice cultivars but application of higher level of nitrogen fertilizers is very common among Indian farmers, who attribute the rice crop greenness and growth to nitrogen application. As a result of application of higher levels of nitrogen the crop suffers from high incidence of pest and diseases and also from lodging. Therefore, there is need to synchronise N fertilizer application with plant needs to optimise the nutrient use and minimise the environmental pollution. Appropriate diagnosis of N status in leaves is necessary to decide the need for top dressing fertilizer N. So, recently introduced leaf colour charts (LCC) is a farmer friendly tool that offers substantial opportunities for farmers to estimate plant nitrogen (N) demand in real time for efficient fertilizer use and high rice yields. A field experiment was conducted to study the "use of leaf colour chart for nitrogen management as a tool in bridging the yield gap in rainfed rice (*Oryza sativa* L.) production". LCC readings were measured every week from 21 days after seeding (DAS) until the first flower appeared and nitrogen fertilizer was applied as per treatment schedule. The N management at LCC 3 with sunhemp green manuring registered higher grain yield as result of higher available N in the soil, higher net returns and B:C followed by green leaf manuring with eupatorium with N management at LCC 3. Significant positive correlation was observed between grain yield and growth and yield attributes whereas, per cent chaff, straw yield and lodging index were significantly negatively correlated with grain yield. Thus, the results of the experiment provide an appropriate and economic package to the farmers in judicious and conjunctive use of N fertilizer on the basis of LCC management practice.

KEY WORDS : LCC, Green manuring, Yield, NUE, B:C , Lodging

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Nitrogen management plays a crucial role in achieving the potential yields of rice cultivars. Increase in fertilizer nutrient input, especially N fertilizer, contributes significantly to the improvement of crop yields in the world (Peng *et al.*, 2010). Blanket fertilizer recommendations are not efficient as it does not consider variability of soil N supply and changes in crop demand. It is more beneficial if N inputs could be adjusted to actual crop conditions and nutrient requirements. Farmers generally apply too much N (and little P and K and other nutrients) that results in high pest and disease incidence and serious lodging. The consequence of high N application is associated with the high pesticide use to control pests, more expenditure on pesticides and reduced yield and poor grain quality due to lodging (Alam *et al.*,2005). Site specific nitrogen management has the potential to increase fertilizer use efficiency as well as grain yield in the farmers' fields (Nath *et al.*,2013). The need for precise and responsive management of N fertilizer in rice is compelling for both economic and environmental reasons.

The leaf colour chart (LCC) is an innovative cost effective tool for real-time or crop-need-based N management in rice. LCC is a visual and subjective indicator of plant nitrogen deficiency and is an inexpensive, easy to use and simple alternative to chlorophyll meter / SPAD meter (soil plant analysis development). It measures leaf colour intensity that is related to leaf N status. LCC is an ideal tool to optimize N use in rice at high yield levels, irrespective of the source of N applied, *viz.*, organic manure, biologically fixed N, or chemical fertilizers and the precise application of nutrients through the use of such tool can raise the profitability of the production system and may reduce environmental pollution (Ravi *et al.*, 2007). Thus, it is an eco-friendly tool in the hands of farmers. The present study was, therefore, undertaken to compare farmers' and recommended nitrogen fertilizer use practices with the LCC based N management along with use of different organic sources, to improve understanding of farmer's fertilizer management decisions, to increase nitrogen use efficiency, the effect of LCC on minimizing lodging incidence and the correlation of grain yield with growth and yield parameters, leaf N content, available N of soil, nitrogen uptake, NUE and lodging index.

Research Procedure

The experiment was carried out at Agricultural Research Station, Mugad, UAS, Dharwad which is situated between 25°18'N latitude, 74°40'E longitude and at an altitude of 697m above mean sea level. The station lies in Northern transitional tract (Zone 8) of Karnataka representing the rainfed drill sown rice belt. The average annual rainfall is 1013 mm, major part of which is received during the later part of June to mid October. The soil of the experimental site was clayey soil with pH of 7.2 and organic carbon of 0.44 per cent. The soil was medium in N (465 kg ha^{-1}) and P (31 kg ha^{-1}) and high in K (500 kg ha^{-1}).

The variety Intan (165 days) was raised during *Kharif* season (June - December). The experimental plot was ploughed and harrowed twice to attain a fine soil tilth condition. The soil surface was compacted by passing the wooden plank. After preparing the field the treatments were imposed as per the plan.

Treatment details:

The experiment was laid out in a Randomized Block Design with factorial concept and was replicated four times with 13 treatment combinations and treatment details are as follows :

Factor I : Organics (M) :

M_1: Farm yard manure (FYM) @ 10 t ha^{-1}

M_2: *In situ* green manuring with sunhemp (*Crotolaria juncea*) @ 10 kg seeds ha^{-1} by seed mixing method

M_3: Green leaf manuring with eupatorium (*Eupatorium odorata*) @ 5 t ha^{-1}

M_4: No organics.

Factor II : Nitrogen management (F) :

F_1: Nitrogen application at LCC threshold value of 3

F_2: Nitrogen application at LCC threshold value of 4

F_3: Recommended practice (100 kg N ha^{-1}- 20% N and entire 50 kg P and 50 kg K) were applied at sowing and 40 per cent N each at maximum tillering and just before panicle initiation stage)

F_4: Farmers' practice (FYM 5 tha^{-1} + 100: 50 kg N and P_2O_5 ha^{-1}- 20 % N and entire P at sowing and 80 % N at panicle initiation stage).

Note:

In all the treatments 20 per cent N and entire P were applied basally at sowing in the form of diammonium phosphate. Whereas K was applied basally at sowing in the form muriate of potash in all the treatments except farmers' practice.

Thus, making thirteen treatment combinations, which were replicated thrice and was laid out in Factorial Randomized Block Design (FRBD). The crop was raised following standard package of practices for water management, weed management and plant protection.

Layout of the field experiment :

The field was divided into 52 plots of 16 m^2 size with adequate drainage channels with clear demarcation of boundary for the four replications. The treatments were allotted to plots using Fisher's random numbers in each replication.

Application of organic manures and fertilizers :

There were three treatments involving various sources of organic manures such as farm yard manure (FYM), *in situ* green manuring with sunhemp and green leaf manuring with eupatorium applied on equal N basis. These manures were analyzed for N, P and K contents and the quantity of organic manures were calculated and applied as per the treatments. For the management of weeds three hand weeding were done at 20, 40 and 80 days after rice emergence (DARE).

Leaf colour chart :

The LCC developed from a Japanese prototype with six green shades ranging from yellowish green to dark green was used in the trial. LCC readings were taken at 7 days interval starting from 21 DARE until the first flower appeared. Youngest fully expanded leaf of a plant was selected. From each plot, five leaves from five randomly selected plants were selected. LCC readings were taken by placing the middle part of the leaf on the chart and the leaf colour was observed by keeping the sun blocked by body as sun light affects leaf colour reading. Average of 20 LCC readings of four replications were calculated and when the average leaf colour reading fall below the set critical value the N fertilizer was top dressed immediately to correct the N deficiency. The amount of N fertilizer applied at different growth stages is given in Table A.

Nitrogen use efficiency (NUE) and lodging index was calculated as per the following formula :

Nitrogen use efficiency :

Using the data on grain yield and amount of N applied NUE was calculated using the formula:

$$\textbf{Nitrogen use efficiency (NUE)} = \frac{\textbf{Grain yield (kg)}}{\textbf{N applied (kg)}} \textbf{x100}$$

Lodging index :

Lodging index was worked out using the formula:

Lodging index = Score for no. of plants lodged (N) x Score for extent of lodging (E)

Score : 0-10

where, 0 = no lodging

10 = 100% of plants lodged/lodged plants completely touching the ground.

Statistical analysis :

The recorded data were subjected to statistical analysis as described by Gomez and Gomez (1984). The mean values were separately subjected to Duncan's multiple range test (DMRT) at 5 per cent probability under MSTAT –C programme. Correlation analysis was carried out to study the nature and degree of relationship of grain yield with growth and yield components and nitrogen uptake. The significance of correlation was tested at five and one per cent probability levels.

Table A : Amount of nitrogen applied in different treatments

Treatments	N (kg ha^{-1})
M_1F_1	110 (Four splits *viz.*, 5th,11th, 12th and 13th week)
M_1F_2	200 (Eight splits *viz.*, 3rd, 4th,6th,7th,8th,11th, 12th and 13th week)
M_1F_3	100 (Two splits *viz.*, 5th and 13th week)
M_2F_1	60 (Two splits *viz.*, 12th and 13th week)
M_2F_2	180 (Seven splits *viz.*, 4th,5th,8th,9th,10th,11th and 13th week)
M_2F_3	100 (Two splits *viz.*, 5th and 13th week)
M_3F_1	80 (Three splits *viz.*, 4th, 5th and 13th week)
M_3F_2	200 (Eight splits *viz.*, 4th,5th,8th,9th,10th, 11th, 12th and 13th week)
M_3F_3	100 (Two splits *viz.*, 5th and 13th week)
M_4F_1	100 (Three splits *viz.*, 4th, 5th and 11th week)
M_4F_2	250 (Ten splits *viz.*, 3rd,4th,5th,6th,8th ,9th,10th, 11th , 12th and 13th week)
M_4F_3	100 (Two splits *viz.*, 5th and 13th week)
Farmers' practice (Control)	100 (One split *viz.*,13th week)

RESEARCH ANALYSIS AND REASONING

The findings of the present study as well as relevant discussion have been presented under following heads :

Effect on growth and yield attributes :

Plant height :

Plant height did not vary significantly among the different organic sources, N management and also in the treatment combinations.

Number of tillers :

Tillering is an important trait for grain production and is thereby an important aspect in rice yield. Application of different organic manures significantly influenced the number of tillers per metre row length. *In situ* sunhemp incorporation recorded significantly higher number of tillers (72.4) than other treatments and check (Table 1). During the initial stage of crop with sunhemp green manuring it did not differ significantly due to simultaneous growth of green manuring crop, after the incorporation of sunhemp, the crop showed better growth as indicated by higher tillering, which was due to creation of more space and due to higher availability of N as reported by Satyanarayana *et al.* (2002) and Sharma (2013) and

Table 1 : Growth parameters of rainfed lowland rice at harvest as influenced by organic sources and LCC based N management at harvest

Treatments	Plant height (cm)		Number of tillers per metre row length		Leaf area per plant (cm^2)		Leaf area index		Dry matter production (g $plant^{-1}$)	
Factor I : Organics (M)										
M_1: Farm yard manure (FYM) @ 10 t ha^{-1}	113.2		68.8	b	186.1	a	0.93	a	33.53	
M_2: Sunnhemp @ 10 kg seeds ha^{-1}	117.6		72.4	a	191.7	a	0.96	a	34.38	
M_3: Eupatorium @ 5 t ha^{-1}	118.3		69.5	b	179.7	a	0.92	ab	33.43	
M_4: No organics	116.6		69.4	b	156.4	ab	0.78	b	33.20	
Farmers' practice (FP)	117.4		71.5	a	121.8	b	0.61	c	31.78	
F* - test	NS		S		NS		NS		NS	
Factor II : Nitrogen management (F)										
F_1: LCC 3	119.8		72.8	a	223.8	a	1.13	a	38.14	a
F_2: LCC 4	114.7		66.9	c	126.3	c	0.76	b	29.35	c
F_3: Recommended practice (RP)	114.9		70.4	b	160.4	b	0.80	b	32.64	b
Farmers' practice (FP)	117.4		71.5	ab	121.8	c	0.61	c	31.78	bc
F* - test	NS		S		S		S		S	
Treatment combinations (MXF) and C										
M_1F_1	119.5	ab	72.9	b	243.4	a	1.22	a	38.88	ab
M_1F_2	107.3	b	67.7	de	172.1	b	0.86	bc	30.44	de
M_1F_3	112.7	ab	65.9	de	142.7	b	0.71	b-d	31.36	c-e
M_2F_1	122.8	a	77.9	a	246.1	a	1.23	a	42.82	a
M_2F_2	116.0	ab	65.1	ef	176.4	ab	0.88	bc	27.61	e
M_2F_3	114.1	ab	74.2	b	152.5	b	0.76	b-d	32.59	b-e
M_3F_1	121.0	a	73.1	b	243.5	a	1.27	a	37.55	a-c
M_3F_2	116.0	ab	62.7	f	115.6	b	0.58	d	27.56	e
M_3F_3	118.1	ab	72.8	b	180.2	ab	0.90	b	35.20	b-d
M_4F_1	115.8	ab	67.6	de	162.1	b	0.81	b-d	33.41	b-e
M_4F_2	119.5	ab	72.1	b	141.0	b	0.70	b-d	31.79	c-e
M_4F_3	114.7	ab	68.7	cd	166.0	b	0.83	b-d	31.40	c-e
Farmers' practice (Control)	117.4	ab	71.5	c	121.8	b	0.61	cd	31.78	c-e
F**- test (MXF) and C	NS		S		S		S		S	

Note: F* - test at 5 per cent refers to Factor I and Factor II without check
NS= Non-significant
F** - test at 5 per cent refers to interaction effect of treatments with check
S= Significant

narrow C:N in sunhemp resulted in quicker decomposition and release of nutrients compared to other organic sources (Kumar *et al.*, 2011). Nitrogen management at LCC 3 recorded higher tiller number (72.8) than others. However, it was at par with farmers' practice (71.5). Among the treatment combinations, M_2F_1 *i.e.*, *in situ* green manuring with sunhemp at LCC threshold value of 3 nitrogen management recorded significantly higher tiller number (77.9) than all other treatment combinations and check. According to Miller (2007) more number of tillers per square meter might be due to the more availability of nitrogen, which plays a vital role in cell division. Organic sources offer more balanced nutrition to the plants, especially micro nutrients which positively affect number of tiller in plants.

Leaf area and leaf area index (LAI) :

Application of different organic sources recorded significantly higher leaf per plant and LAI than compared to the treatment with no organics. Nitrogen management at LCC-3 recorded significantly higher leaf area per plant and LAI (223.8 and 1.13, respectively) than other treatments (Table 1). Among the treatment combinations, significantly higher leaf area and LAI was recorded with

Table 2: Yield, nitrogen use efficiency (NUE), B:C, N uptake, NUE and lodging index of rainfed lowland rice as influenced by organic sources and LCC based N management

Treatments	No. of filled grains per panicle		Grain yield ($t\ ha^{-1}$)		B:C		NUE		Lodging index (No. X extent of plants lodged)
Factor I : Organics (M)									
M_1: Farm yard manure (FYM)@ 10 t ha^{-1}	111.4		3.30		0.61	c	27.1	c	
M_2: Sunnhemp @ 10 kg seeds ha^{-1}	120.0		3.22		1.04	a	36.1	a	
M_3: Eupatorium @ 5 t ha^{-1}	115.2		3.15		0.98	a	31.1	b	
M_4: No organics	104.1		3.05		1.02	a	25.5	c	
Farmers' practice (FP)	110.0		3.22		0.84	b	32.2	b	
F* - test	NS		NS		S		S		
Factor II : Nitrogen management (F)									
F_1: LCC 3	132.7	a	3.64	a	1.16	a	44.4	a	
F_2: LCC 4	101.8	b	2.68	c	0.62	d	13.3	c	
F_3: Recommended practice (RP)	103.5	b	3.21	b	0.96	b	32.2	b	
Farmers' practice (FP)	110.0	b	3.22	b	0.84	c	32.2	b	
F* - test	S		S		S		S		
Treatment combinations (MXF) and C									
M_1F_1	127.1	a-c	3.64	a-c	0.71	c-e	33.1	c	49.4
M_1F_2	107.8	cd	2.86	d-f	0.40	f	14.3	ef	38.0
M_1F_3	99.3	cd	3.38	a-d	0.73	c-e	33.9	c	54.3
M_2F_1	144.4	a	3.86	a	1.41	a	64.3	a	44.7
M_2F_2	111.8	cd	3.14	c-f	0.89	c	17.3	e	63.8
M_2F_3	103.7	cd	2.65	e-g	0.82	cd	26.5	d	49.7
M_3F_1	140.7	ab	3.81	ab	1.30	ab	47.6	b	44.4
M_3F_2	92.0	d	2.14	g	0.55	ef	10.7	f	77.7
M_3F_3	113.0	b-d	3.51	a-c	1.10	b	35.1	c	45.4
M_4F_1	118.6	a-d	3.26	a-d	1.22	b	32.6	c	62.0
M_4F_2	95.5	d	2.58	fg	0.64	de	10.9	f	82.5
M_4F_3	98.2	cd	3.30	a-d	1.20	b	33.0	c	55.3
Farmers' practice (Control)	110.0	cd	3.22	b-e	0.84	cd	32.2	c	37.5
F**- test (MXF) and C	S		S		S		S		

Note: F* - test at 5 per cent refers to Factor I and Factor II without check
NS= Non-significant
F** - test at 5 per cent refers to interaction effect of treatments with check
S= Significant

organics combined with N management at LCC threshold value of 3 (243.4, 246.1 and 243.5 and 1.22, 1.23 and 1.27). This is due to the fact that N fertilization amount had an important role in improving morpho-physiological characteristics of rice and N could increase rice leaves and roots growth to prepare an appropriate leaf area index (LAI) to obtain most plant height and grain yield (Barai *et al.*, 2009). Moreover, application of N in splits according to the plant needs in the LCC practice might be the reason for better rice growth parameters as indicated by Barai *et al.* (2009) and Sathiya and Ramesh (2009).

Dry matter production :

No significant differences were noticed in total dry matter production among different organic sources. However, the check *i.e.*, the farmers' practice recorded lower dry matter. Nitrogen management at LCC 3 recorded significantly higher total dry matter and its distribution (38.14 g plant^{-1}). Among the treatment combinations, M_2F_1 *i.e.*, *in situ* green manuring with sunhemp at LCC threshold value of 3 nitrogen management recorded significantly higher total dry matter and its distribution (42.82 g plant^{-1}) than all other treatment combinations and check but it was at par with M_1F_1 *i.e.*, application of FYM at LCC threshold value of 3 nitrogen management (Table 1). This could be due to higher photosynthetic area, better interception of solar radiation and presence of photosynthetically active leaves for longer time as evidenced by significantly higher LAI in these treatments. The available nutrients might have helped in enhancing leaf area, which thereby resulted in higher photo-assimilates and more dry matter accumulation. These results are supported by the findings of Swarup and Yaduvanshi (2000) and Yadana *et al.* (2009). The increase in fresh weight has also been reported by Sarwar *et al.* (2008).

Yield :

Data regarding effect of different nitrogen management practices on yield and economics are presented in Table 2. It is clear from recorded data that, organics did not differ significantly with respect to yield attributes and grain yield. In spite of favourable effect of organics on growth components, the advantage was not noticed on grain yield. This might be due to lack of response of organics alone on yield components like filled grains per panicle. This indicates that effect of organics can be noticed only by continuous use of organics in fixed site, which is likely to create fertility gradient compared to the plots without organics and is expected to give enhanced productivity. N- management at LCC-3 recorded (3.64 t ha^{-1}) significantly higher grain yields than in LCC-4 (2.68 t ha^{-1}), recommended practice (3.21 t ha^{-1}) and check (3.22 t ha^{-1}) (Table 2). Among the treatment combinations, M_2F_1 *i.e.*, *in situ* green manuring with sunhemp at LCC threshold value of 3 nitrogen management recorded significantly, filled grains per panicle than other treatment combinations and check. This resulted in significantly higher grain yield (3.86 t ha^{-1}), closely followed by M_3F_1 (3.81t ha^{-1}) which recorded 15.5 and 18.0 per cent increased grain yield over recommended practice and farmers' practice. N fertilizer is a major essential plant nutrient and key input for an increasing rice crop yield as supported by Salman *et al.* (2012). Nitrogen contributes to carbohydrates accumulation in culms and leaf sheaths during the pre-heading stage and in the grain during the ripening stage of rice. Our results are also in agreement with Krishnakumar and Haefele (2013) who found that the grain yield of rice was considerably affected by the N application and detected higher grain yield than the other treatments. The rate and timing of N application are critical for optimum rice grain yield.

Benefit cost ratio (B:C) :

Green manuring with sunhemp (1.04) and eupatorium (0.98) and no organic treatment (1.02) recorded higher B:C than FYM (0.61) application and check. This is due to low cost of green manures than compared to that of FYM. Among the N management treatments, N management at LCC 3 recorded significantly higher B:C (1.16) than others. Whereas, N management at LCC 4 recorded significantly lower B:C (0.62) than all other treatments. Data further revealed that progressive increase in N levels decreases the net return and thereby the B:C. Green manuring with sunhemp at LCC 3 *i.e.* M_2F_1 gave highest B:C (1.41) than almost all other treatment combinations and check. This might be due to lower cost of cultivation and number of splits of N application. The lowest B:C (0.40) was with M_1F_2. This gives a clear idea about the optimum level of input that could be recommended to obtain the maximum profit. Higher net returns with conjunctive use of green manures and inorganic N have also been reported by Channabasappa *et al.* (2005); Surekha *et al.* (2010) and

Baishya *et al.* (2015).

Nitrogen use efficiency (NUE) :

Nitrogen use efficiency (NUE) is dependent to a large extent on the synchronization between crop nitrogen demand and the available N supply (Bijay *et al.*, 2006). Nutrient removal is a function of climate, soil properties, amount and method of fertilizer application and the variety of rice where cultural practices and morphological variations account for differences in nutrient removal. In addition to dry matter production the yield also govern the nutrient removal. Higher the yield higher is the NUE. Thus, nitrogen use efficiency was significantly higher with sunhemp green manuring than other organics ad check (36.1%) (Table 2) due to difference in added nitrogen by different organics (Singh *et al.*, 2008). NUE was significantly higher with N management at LCC 3 than others (44.4) and N management at LCC 4 recorded significantly lower NUE (13.33%) than all other treatments. This indicated that, NUE decreased with increase in amount of N applied and it also depends on time of N application. Green manuring with sunhemp at LCC 3 *i.e.* M_2F_1 recorded significantly NUE (64.3%) compared to all other treatment combinations and check. Lower NUE was observed in M_4F_2 and M_3F_2 (10.9 and 10.7%, respectively). This clearly shows that the loss of N was maximum in these treatments.

Lodging index :

Lodging seemed to be a physiological phenomenon rather than a varietal character. It originated from structural weakness development in culm tissues and was caused primarily by high nitrogen concentration in soil. Excessive N causes “luxuriant” growth causing reduced stem strength resulting in lodging during flowering and grain filling. Lodging index was more in treatment with N management at LCC 4 which received 207.5 kg N per ha on an average compared to that at LCC 3- 87.5 kg N per ha and recommended practice -100 kg N per ha. In presence of organics, N management at LCC 3 recorded lower lodging than the recommended practice. M_4F_2 recorded highest lodging index of 82.5 (Table 3). This resulted in lower grain yield (2.58 t ha^{-1}). The results clearly show that N management at higher LCC values with higher quantity of N application resulted in excessive vegetative growth and lodging and inturn reduced yield. This could be due to increased N content which makes

Table 3: Correlation of grain yield with growth parameters, yield parameters, leaf N content (%) , N uptake, NUE and lodging index of rainfed lowland rice as influenced by organic sources and LCC based N management

Parameters	Correlation co-efficient (r)
Growth parameters	
Plant height (cm)	0.455
Tillers per m length	0.521
Leaf area per plant (cm^2)	0.588*
Leaf area index	0.593*
DMP (g/plant)	0.757**
Yield parameters	
Panicles per m length	0.740**
Spikelets per panicle	0.604*
Filled grains per panicle	0.801**
Per cent chaff	-0.890**
Panicle weight (g)	0.658**
1000 grain weight (g)	0.750**
Straw yield (t ha^{-1})	-0.689**
Harvest index	0.928**
N uptake	0.780**
NUE (kg grains/kg N applied)	0.853**
Lodging index	-0.745**

* and ** indicate significance of values at P=0.01 and 0.05, respectively

the plant succulent and thus, leads to lodging (Rajkumara, 2008).

Correlation studies :

Correlation studies provide a better understanding of the association of different characters with grain yield (Dixet and Dubey, 1984). The correlation analysis indicated that most of the phenological events, growth parameters, yield and yield related traits had either positive or negative relation with each other (Table 3). The analysis regarding the yield with growth parameters indicated that grain yield was positively correlated (P <0.01) with plant heights (r=0.455), tillers per meter length (r=0.521), leaf area per plant (r=0.588*), leaf area index (r=0.539*), dry matter production (r=0.757**). All the yield attributing characters had significant positive correlation with grain yield *viz.*, panicles per meter length (r=0.74**), spikelets per panicle (r=0.604*), filled grains per panicle (r=0.801**) panicle weight (r=0.658**) thousand grain weight (r =0.75**), harvest index (r=0.928**) and N uptake (r=0.78**) and NUE (0.853**) and was negatively correlated with per cent chaff (r = -0.890**) and lodging index (r = -0.745**). The positive and significant correlation co-efficient between LAI and other growth and grain yield components explains the true relationship between the parameters. Per cent chaff and lodging index were significantly and negatively correlated with grain yield due to higher leaf N content at LCC 4 than the others. Thus, makes the plant succulent and susceptible to lodging. The findings are in line with Andrew *et al.* (2014); Merkebu and Techale (2015) and Inamullah *et al.* (2011).

Conclusion :

Managing N application to rice is an essential activity to reduce N losses and to improve N use efficiency which in turn improves rice grain yields. An attempt was made to synchronize N supply with rice crop demands to achieve adequate grain yield forming components and consequently higher grain yields through use of LCC. From the above findings it is clear that for rice variety Intan the N management at LCC 3 is optimum.The LCC practice of nitrogen application along with sunnhemp *in situ* green manuring which was worked out to be 60 kg ha^{-1} is the most appropriate dose of N in rice crop which should be applied in splits. Thus, seems to be the promising combination with respect to grain yield and economics. The critical leaf colour depends on the varietal group and crop establishment method. The optimum use of N can be achieved by matching N supply with crop demand. This can be achieved by use of LCC. The leaf colour chart (LCC) is an easy-to use and inexpensive diagnostic tool for monitoring the relative greenness of a rice leaf as an indicator of the plant nitrogen status. The LCC can be used to guide the application of nitrogen fertilizer to maintain optimal leaf nitrogen content for achieving high rice yield with effective nitrogen management. Farmers generally use leaf colour as a visual and subjective indicator of the rice crops nitrogen status and need for N fertilizer application The LCC used at critical growth stages helps to decide whether the recommended standard nitrogen rate needs to be adjusted up or down based on the leaf colour. Consequently, improved nitrogen management can help produce greater yields and reduce the environmental pollution.

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