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Effect of nitrogen management through LCC and SPAD meter on growth and yield in direct seeded rice (*Oryza sativa* L.)

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Abstract
A field experiment was conducted on medium black soil during *kharif* 2016 & 2017 at Agricultural Research Station, Gangavathi to study the effect of nitrogen management through LCC and SPAD meter on growth and yield in direct seeded rice. The results revealed that application of N through farmers' method recorded higher plant height, number of tillers and plant dry weight but among real time methods, the LCC 5, LCC 4, recorded higher plant height, number of tillers and plant dry weight and were on par to recommended method during both the seasons. On the other hand, the treatment with No application of N but P and K applied and absolute control recorded lower plant height, number of tillers and dry weight. The pooled data on Grain yield (kg/ha) was significantly superior during both the years (4996 kg/ha) in application of N through farmers' method (T_7) which was superior over other treatments except LCC 5 (4699 kg/ha), LCC 4 (4649 kg/ha), SPAD 40 (4490 kg/ha) and SSNM method (4516 kg/ha) which were on par with each other by indicating saving of N to the tune of (31.8, 45.4, 36.3 and 22.7%, respectively) over N through farmers' method. Higher agronomic efficiency was noticed in real time methods than application of N through farmers' method. Among both the LCC 5 and LCC 4 being superior in growth and yield it is concluded that LCC 4 to be optimum for direct seeded rice.

Keywords: Farmers' method, LCC, Nitrogen management

Introduction
Rice (*Oryza sativa* L.) is the world's most important crop and is a staple food for more than half of the world's population. Centre of origin of cultivated rice is the part of South East Asia, which is considered as the heartland of rice cultivation. Asia accounts for 60% of the global population, about 92% of the world's rice production and 90% of global rice consumption (FAO, 2016) [8]. In India, rice is grown on 43.44 million hectares, with annual production of about 112.40 million tons and productivity of about 2700 kg ha^{-1} (Anon., 2016) [2]. India is the second largest country for rice production and rice continues to hold the key to sustain food production by contributing 20-25 per cent of agriculture and assures food security for more than half of the total population (Anon., 2012) [1].

In Tungabhadra Project area of Karnataka rice-rice is the most popular cropping sequence followed due to its easy management and high yielding potentiality. That too cultivar, Gangavathi sona (GGV- 05 - 01) is said to fetch very high price. However, in the recent past, the productivity of rice is declining. This may be attributed to indiscriminate use of water and fertilizers, particularly nitrogen, incorporating of higher plant protection chemicals and unscientific method of water management that had let to increase in the water table and soil salinity. Such soils demand high dose of nitrogen fertilizers. Farmers' are now in the habit of dumping very high dose of N (200 to 250 kg ha^{-1}) without proper management practices. This had further led to pollution in soil and water. Therefore, the sustainability has to be viewed very seriously and efforts towards application of the soil with N, based on the need of the crop. The current recommendations of split application of N fertilizer with fixed rates at specific growth stages for large rice growing area assume the requirement of rice for fertilizer is constant across large areas and years. The requirement of rice for N fertilizer can, however, vary greatly from location to location, season to season and year to year because of high variability among fields, seasons and years in N supplying capacity of soil (Cassman *et al*., 1993) [6]. One of the important problems among them is lack of suitable nutrient management technology to combat the various losses of nutrients such as runoff, leaching, volatilization, de-nitrification, fixation and removal by weeds etc.

and to provide steady supply of nutrients in available form throughout the cropping season for sustainable production. The present studies were directed with the concept to fulfill the sustainable and eco-friendly rice production by real-time N management, wherein N application in determined through periodic monitoring of crop N status. Two decision aids available for in situ monitoring of leaf N status in rice are the leaf colour chart (LCC) and chlorophyll meter (SPAD) (Balasubramanian *et al*., 1999 and Peng *et al*., 1996) [4, 9].

The present investigation was therefore taken up during *kharif* seasons of 2016 & 2017 at Agricultural Research Station, Gangavathi to study the effect of real-time N management in direct seeded rice. The study involved application of N based on LCC (3 to 5), SPAD meter 40, SSNM method compared with present recommended and farmers' method.

In real time N management in direct seeded rice crop, total amount of N applied varied with different treatments. In farmers' method, 220 kg N ha^{-1} was applied followed by SSNM method, 170 kg N ha^{-1}, recommended method (150 kg N ha^{-1}). Application of N through LCC and SPAD meter recorded lower quantity of N compared to farmers' and recommended method. The lowest N was applied in LCC 3 (90 kg ha^{-1}) while the highest in LCC 5 (150 kg ha^{-1}) and in SPAD 40 (140 kg ha^{-1}).

Materials & Methods

A field experiments on "Effect of nitrogen management through LCC and SPAD meter on growth and yield in direct seeded rice'' was conducted at Agricultural Research Station (ARS), Gangavathi during *kharif* 2016 & 2017. The soil of experimental site was medium black clay in texture. The soil was normal with an electrical conductivity of 0.52 dS/m, neutral in reaction (pH 8.22) and medium in organic carbon content (0.55%). The soil was low in available N (176.20 kg ha^{-1}) high in available P_2O_5 (154.31 kg ha^{-1}) and high in exchangeable K_2O (365.57 kg ha^{-1}). The experiment was laid out in RBD with three replications. The treatments consists of different LCC threshold levels, SPAD 40, SSNM compared with state recommendations (150 kg N/ha), farmers' method of N application and with control of treatment No application of N but P and K applied and absolute control with three replications. In farmers' method (220 kg N ha^{-1}) of N applications was applied in four splits and in recommended method (150 kg N ha^{-1}) of N applications was applied in three splits. Where as in LCC and SPAD based N application 30 kg N ha^{-1} was applied after sowing. The LCC and SPAD readings were taken once in every seven days starting at 21 days after sowing till flowering (Table 1). Rice variety selected for the study was Gangavathi Sona (GGV -05-01). The amount of N was applied when the critical level falls below threshold values as per guidelines of IRRI, Philippines. As per the guidelines N applied at early growth phase (30 kg N/ha), at rapid growth (30 kg N/ha) at late growth phase (30 kg N/ha). A uniform dose of 60 kg P/ha and 50 kg K/ha were applied to all the treatments. Other agronomic practices were carried out as per the state recommendations. LCC and SPAD measurements were recorded at seven days interval starting from Twenty one days after sowing till the first flower appears. The colour of the single leaf was measured by holding the leaf colour chart vertically and placing the middle part of leaf in front of colour strip for comparison, as prescribed by IRRI, Philippines in 1996. The chlorophyll meter readings were taken with SPAD-502 chlorophyll meter by selecting top most fully expanded leaf up to 50 % flowering stage (Babu *et al*., 2000) [3].

Results and Discussion

The pooled data on Grain yield (kg/ha) was significantly superior during both the years (4996 kg/ha) in application of N through farmers' method (T_7) which was significantly superior over other treatments except LCC 5 (4699 kg/ha) (Table 2 & Figure 2), LCC 4 (4649 kg/ha), SPAD 40 (4490 kg/ha) and SSNM method (4516 kg/ha) which were on par with each other by indicating saving of N to the tune of (31.8, 45.4, 36.3 and 22.7%, respectively) over N through farmers' method. Where as application of N through LCC 4 recorded on par grain yield with LCC 5 indicating a saving of 20% nitrogen. With respect to LCC levels, increase in LCC from 3 (90 kg/ha) to 4 (120 kg/ha) recorded significant increase in grain yield and further increase to LCC 5 (150 kg/ha) did not show significant difference confirming LCC 4 to be optimum in direct seeded rice. With regard to trend in increase of grain yield it was to a tune of 26.2% in LCC 3 to 4 and further increase to LCC 5 showed only 1.1%. Similar results were reported by Ravi *et al*. (2007) [10]. Among other real time N management methods the grain yield recorded was on par to LCC 4 and LCC 5. This was due to proper availability of nitrogen at right time and at right quantity.

Straw yield was significantly higher at farmers' method, LCC 5, LCC 4 and SPAD 40 over lower LCC 3, Absolute control and treatment with No application of N but P & K applied, which could be attributed to their favourable influence on vegetative growth and grain yield.

The increase in yield attributes was due to growth characters like dry matter accumulation, leaf area, leaf area index, number of leaves per plant and plant height.

The total dry matter production was the overall product of photosynthesis from source to sink. At harvest farmers' method recorded significantly higher total plant dry matter compared to other treatments where as in LCC levels from 4 to 5 there was not much difference in dry matter accumulation. On other hand, lower dry matter accumulation was seen in LCC 3, absolute control and treatment with No application of N but P & K applied this was due non availability of nitrogen at right time and right quantity (Figure 1).

The plant height had the predominant role in accumulation of dry matter. Higher height in these treatments helped in accumulating higher dry matter. Further, higher plant height accommodated more number of leaves on each stem. At optimum and at higher N levels the number of leaves was high thus, improving in the leaf area and in turn increased the leaf area index, which is the final index of efficient land utilization. The data clearly indicated that LCC 4, LCC 5 and SPAD 40 showed higher leaf area index which was almost same as that of farmers' method (Table 3 & 4). Where all the real time methods were much higher in all the parameters than recommended method of N application. This was due to timely supply of required quantity of nitrogen at all stages of the crop at right amount.

The growth and yield of rice is determined by the presence of sufficient quantity of nutrient in soil in the available form for plant uptake. The quantity of N uptake was directly related with the quantity of N applied to the soil.

In farmers' method, LCC 5, LCC 4 and SPAD 40 showed 78.6, 53.4, 45.4 and 44.1 per cent higher N uptake over LCC 3, respectively and only 5.5 and 22.8 per cent higher N uptake in LCC 5 and farmer method respectively.

The uptake of P and K was directly proportional with the N uptake. This proved the synchrony between N demand and supply from soil and fertilizer was probably the cause of

increased uptake of N, P and K and observed yield increase in these treatments. Dobermann *et al*. (2002) [7] reported that, the increase in yield components of rice at recommended dose of fertilizer might be due to availability of nutrients in active translocation of accumulated photosynthates from leaves to panicle and better development of grains. However, no additional response to higher dose of N in farmers' method (220 kg ha^{-1}) might be due to certain antagonistic interaction between and among the plant nutrients in the soil solution and to the root as reported by Saikia and Pathak (1997) [11].

With the practice of balanced fertilization, one nutrient increases the efficiency of other through synergistic effect. In the present study, application of N through LCC or SPAD or recommended method recorded higher agronomic efficiency over farmers' method. The LCC 4, LCC 5, SPAD 40 and recommended method have recorded a higher agronomic efficiency (21.88, 17.84, 17.62 & 15.05, respectively) over farmers' method (13.51) (Table 5). This might be due to increased recovery of applied N and this in turn manifested in the higher grain and straw yield of rice as reported by Bindra and Kalia (1996) [5].

Table 1: Quantity of N applied in different treatments

Treatments		Basal dose (kg N ha^{-1})	Top dressing weeks after sowing (kg N ha^{-1})										
			1	2	3	4	5	6	7	8	9	10	Total
T_1:	N application at LCC threshold 3.0	30	-	30	-	-	-	-	-	30	-	-	90
T_2:	N application at LCC threshold 4.0	30	-	30	-	30	-	-	30	-	-	-	120
T_3:	N application at LCC threshold 5.0	30	-	30	30	-	-	30	-	-	30	-	150
T_4:	N application at SPAD meter threshold 40.0	30	-	20	-	-	30	-	30	30	-	-	140
T_5:	SSNM based nitrogen fertilizer application	60		30			30		20		30		170
T_6:	No application of N but P and K applied	-	-	-	-	-	-	-	-	-	-	-	-
T_7:	Farmers' method of N application	70	-	40	-	-	55	-	-	-	55	-	220
T_8:	Recommended method of N application	75	-	-	-	-	37.5	-	-	-	37.5	-	150
T_9:	Absolute control	-	-	-	-	-	-	-	-	-	-	-	-

Table 2: Grain yield, straw yield and harvest index of direct seeded rice as influenced by real-time N management

Treatments		Grain yield (kg ha^{-1})			Straw yield (kg ha^{-1})			Harvest index		
		2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled
T_1:	N application at LCC threshold 3.0	2934	3926	3430	4617	5112	4864	0.40	0.43	0.42
T_2:	N application at LCC threshold 4.0	4495	4802	4649	5903	5833	5868	0.43	0.45	0.44
T_3:	N application at LCC threshold 5.0	4546	4852	4699	5967	5963	5965	0.45	0.45	0.45
T_4:	N application at SPAD meter threshold 40.0	4266	4714	4490	5667	5667	5667	0.43	0.45	0.44
T_5:	SSNM based nitrogen fertilizer application	4255	4776	4516	5680	5633	5657	0.42	0.46	0.44
T_6:	No application of N but P and K applied	2131	2003	2067	3733	3100	3417	0.37	0.39	0.38
T_7:	Farmers' method of N application	4924	5068	4996	6750	6067	6408	0.42	0.46	0.44
T_8:	Recommended method of N application	4224	4338	4281	5350	5300	5325	0.45	0.45	0.45
T_9:	Absolute control	2066	1980	2023	3133	3067	3100	0.39	0.39	0.39
	S.Em±	141.84	103.6	68.06	65.16	76.04	45.77	0.01	0.01	0.01
	CD at 0.05	425.24	310.6	204.03	195.34	227.98	137.23	0.02	0.02	0.02

Table 3: Dry matter production of direct seeded rice at various growth stages as influenced by real-time N management

Treatments		Plant dry weight (g $hill^{-1}$)											
		30 DAS			60 DAS			90 DAS			At harvest		
		2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled
T_1:	N application at LCC threshold 3.0	4.10	4.20	4.15	24.67	25.33	25.00	58.50	59.50	59.00	65.67	67.00	66.33
T_2:	N application at LCC threshold 4.0	6.90	6.77	6.83	38.00	38.67	38.33	66.68	67.68	67.18	80.33	81.67	81.00
T_3:	N application at LCC threshold 5.0	6.03	6.97	6.50	38.33	39.00	38.67	67.50	68.50	68.00	80.67	82.00	81.33
T_4:	N application at SPAD meter threshold 40.0	5.80	5.90	5.85	35.00	35.67	35.33	64.17	65.17	64.67	79.00	80.33	79.67
T_5:	SSNM based nitrogen fertilizer application	6.73	6.50	6.62	34.50	35.17	34.83	65.50	66.50	66.00	78.50	79.83	79.17
T_6:	No application of N but P and K applied	3.97	3.60	3.55	21.67	22.00	21.83	45.50	46.50	46.00	59.33	60.67	60.00
T_7:	Farmers' method of N application	7.07	7.20	7.13	39.67	40.33	40.00	69.17	70.17	69.67	88.67	90.00	89.33
T_8:	Recommended method of N application	4.83	5.20	5.02	31.00	31.67	31.33	62.50	63.50	63.00	73.00	74.33	73.67
T_9:	Absolute control	3.50	4.07	4.02	20.00	20.67	20.33	42.67	43.67	43.17	57.00	58.33	57.67
	S.Em±	0.11	0.1	0.09	0.97	0.87	0.87	1.05	1.34	1.09	1.47	1.5	1.33
	CD at 0.05	0.33	0.29	0.27	2.91	2.61	2.61	3.15	4.02	3.26	4.40	4.48	3.99

Table 4: Leaf area index of direct seeded rice at various growth stages as influenced by real-time N management

Treatments		Leaf area index											
		30 DAS			60 DAS			90 DAS			At harvest		
		2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled
T_1:	N application at LCC threshold 3.0	0.37	0.38	0.37	1.31	1.32	1.31	3.11	3.12	3.11	0.50	0.51	0.51
T_2:	N application at LCC threshold 4.0	0.50	0.51	0.51	1.69	1.70	1.70	3.53	3.54	3.53	0.75	0.76	0.76
T_3:	N application at LCC threshold 5.0	0.51	0.51	0.51	1.70	1.71	1.71	3.58	3.59	3.59	0.79	0.80	0.80
T_4:	N application at SPAD meter threshold 40.0	0.48	0.49	0.49	1.64	1.65	1.65	3.41	3.42	3.42	0.65	0.66	0.66
T_5:	SSNM based nitrogen fertilizer application	0.47	0.47	0.47	1.64	1.65	1.65	3.40	3.41	3.41	0.64	0.65	0.65
T_6:	No application of N but P and K applied	0.27	0.28	0.28	1.13	1.14	1.13	2.79	2.79	2.79	0.40	0.41	0.41

T_7:	Farmers' method of N application	0.58	0.59	0.58	1.76	1.77	1.76	3.67	3.68	3.68	0.90	0.91	0.91
T_8:	Recommended method of N application	0.39	0.40	0.40	1.61	1.62	1.61	3.16	3.17	3.16	0.57	0.58	0.58
T_9:	Absolute control	0.26	0.27	0.27	1.09	1.10	1.10	2.40	2.41	2.41	0.39	0.40	0.39
	S.Em±	0.01	0.01	0.01	0.02	0.02	0.02	0.03	0.03	0.03	0.02	0.01	0.01
	CD at 0.05	0.04	0.04	0.04	0.05	0.05	0.05	0.08	0.09	0.09	0.05	0.04	0.04

Table 5: Agronomic efficiency of direct seeded rice as influenced by real-time N management

Treatments		Agronomic Efficiency (kg grain kg^{-1} N applied)		
		2016	2017	Pooled
T_1:	N application at LCC threshold 3.0	9.64	21.63	15.64
T_2:	N application at LCC threshold 4.0	20.24	23.52	21.88
T_3:	N application at LCC threshold 5.0	16.53	19.15	17.84
T_4:	N application at SPAD meter threshold 40.0	15.71	19.53	17.62
T_5:	SSNM based nitrogen fertilizer application	12.88	16.45	14.66
T_6:	No application of N but P and K applied	0.00	0.00	0.00
T_7:	Farmers' method of N application	12.99	14.04	13.51
T_8:	Recommended method of N application	14.38	15.72	15.05
T_9:	Absolute control	0.00	0.00	0.00
	S.Em±	0.64	0.49	0.95
	CD at 0.05	1.93	1.46	2.86

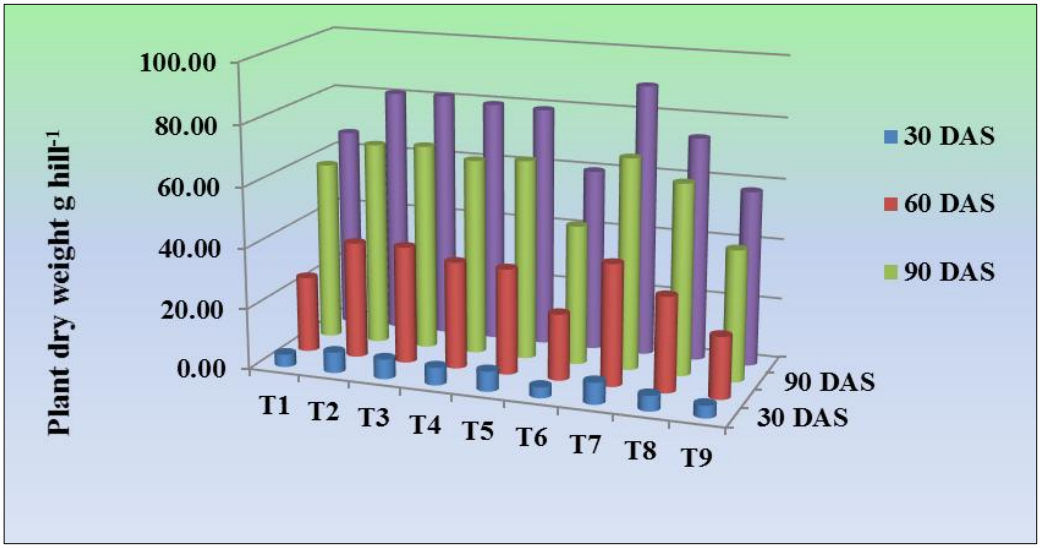

Fig 1: Dry matter production of direct seeded rice at various growth stages as influenced by real-time N management

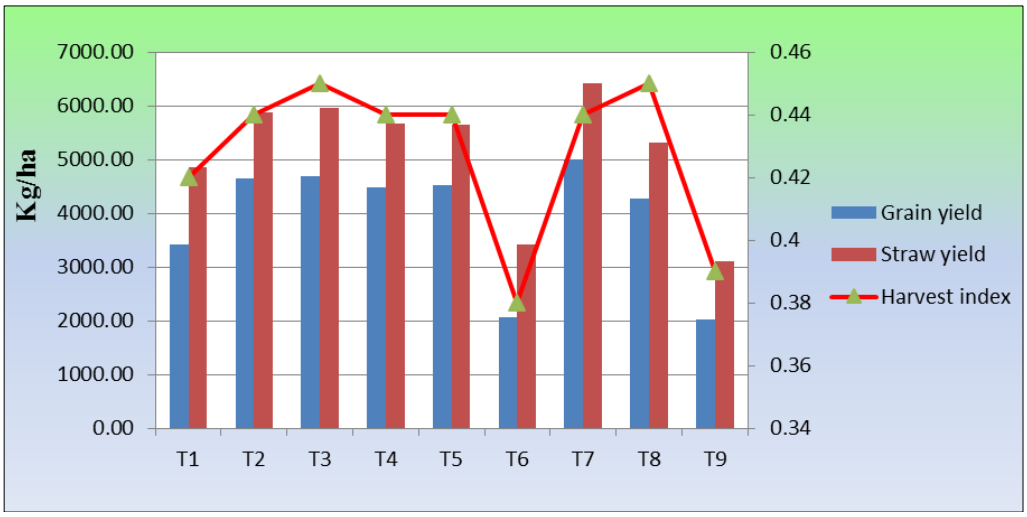

Fig 2: Grain yield, Straw yield and Harvest index of direct seeded rice as influenced by real-time N management

Conclusion

Among the different LCC threshold values LCC 4 recorded on par growth, yield and yield parameters.LCC 4 recorded significantly higher BC ratio over farmers and recommended method but among these LCC 4 was on par to LCC 5 and found to be optimum.

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