

Calibrating the Leaf Colour Chart and SPAD Based Nitrogen Management on Leaf N Content and Yield in Rice

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ABSTRACT

A field experiment was conducted on a sandy loam soil during kharif season of 2012 with a view to study the relation between leaf N content, LCC and SPAD values, yield of rice. The leaf colour chart (LCC) and SPAD based N management can be used to optimize N application with crop demand or to improve existing fixed split N recommendations. We conducted a field experiment to determine the LCC and SPAD critical value for N application in irrigated rice. Treatments included 3 LCC based and 3 SPAD based N management contained the combination of three critical levels of LCC shade values (4, 4.5, 5) and three critical levels of SPAD (37, 39 and 41) values with different levels of N application were compared with recommended fertilizer dose (RFD) and soil test crop response (STCR) equation based fertilizer application. Nitrogen was applied in the form of urea as per treatment schedule and the SPAD and LCC assessed at 10 days intervals starting from 15 DAT. Result showed a considerable opportunity to increase yield, N concentration in leaf through improved N management with LCC and SPAD values. There exists a positive correlation between index leaf N, LCC and SPAD values. Since SPAD and LCC values from 45 DAT to 65 DAT had shown a significant and positive correlation with leaf N content and finally grain yield

Key words: Leaf colour chart, Nutrients uptake, SPAD, N concentration

INTRODUCTION

Rice is the staple food for half of the world population. Nitrogen is one of the most limiting nutrients in rice in tropics. Adequate N supply is needed throughout the active growing period of rice. Thus proper N management is very crucial for successful rice production. Rice crop requires large amounts of N (15-25 kg N t⁻¹ of rice yield) and crop response is fast and high. Excessive N application leads to an inefficient N

acquisition by the rice crop and contributes to contamination of surface and ground water, volatilization of ammonia and emission of green house gases viz., nitrous and nitric oxides to the atmosphere, and increases the “far end depression” in rice crop¹¹. Conversely, inadequate N supply results in reduced yield and profit. Soil and to a certain extent irrigation water provide N, P and K and it is termed as the indigenous nutrient supply to rice.

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There is enormous variability in soil nutrient status or supply from field and / or farm to farm. This makes blanket recommendation highly ineffective for most submerged rice situations. The blanket recommendations of N are developed for large tracts having similar climate and land forms and these vary from 60 to 240 kg ha⁻¹ for different parts of Telangana. Therefore, field specific approach is warranted⁸. Keeping in view the significance of N on productivity of rice, crop need based fertilizer application, reduce the N losses and also cost of fertilizer and application cost, an attempt has been made to examine the effect of site specific nitrogen management on rice.

In India, rice is cultivated round the year in one or other part of the country. It occupies 42.8 M ha with a production of 95.9 Mt and productivity of 2.23 t ha⁻¹. In Telangana and Andhra Pradesh, rice is grown in an area of 4.7 M ha with a production of 14.4 M t and productivity of 3.06 t ha⁻¹.

MATERIAL AND METHODS

A field experiment was conducted on a sandy loam soil (Alfisol) at College Farm, College of Agriculture, Rajendranagar, Hyderabad during *kharif* season of 2012 with a view to study the effect of site specific nitrogen management in rice in terms of yield and nutrient uptake by the crop during crop growth period. Experiment was laid out in Randomized Block Design with 3 replications and 8 treatments viz., T₁ (Recommended Fertilizer Dose of NPK i.e. RFD), T₂ (Soil test based N P K application using fertilizer adjustment equations), T₃ (N₃₀ basal+ N₃₀ if SPAD value is < 37), T₄ (N₃₀ basal+ N₃₀ if SPAD values is < 39), T₅ (N₃₀ basal+ N₃₀ if SPAD values is < 41), T₆ (N₃₀ basal+ N₃₀ if LCC value is < shade 4.0), T₇ (N₃₀ basal+ N₃₀ if LCC value is < shade 4.5), T₈ (N₃₀ basal+ N₃₀ if LCC value is < shade 5.0). The recommended doses of P₂O₅ (60 kg ha⁻¹) and K₂O (60 kg ha⁻¹) were applied uniformly to all the treatments except in T₂.

The initial soil was sandy loam in texture. The physico chemical properties revealed that the soil was slightly alkaline (7.49 pH) in reaction, non saline (0.24 dS m⁻¹) in nature and medium in organic carbon (5.4 g

kg⁻¹). The soil under study was low in available nitrogen (206 kg N ha⁻¹), medium in available phosphorus (17.5 kg P₂O₅ ha⁻¹) and potassium (223 kg K₂O ha⁻¹). The LCC readings were recorded in all the treatments (T₁ through T₈) at 10 days interval simultaneously along with SPAD readings starting from 15 DAT till 65 DAT (and presented in table 2). The plant samples were also analysed for nutrient contents to compute nutrient uptake by plants. Grain yield was also recorded to know the impact of different treatment combinations under integrated management approaches (Table 1).

RESULTS AND DISCUSSION

The N received through real time approaches based on SPAD and LCC values were 90 kg ha⁻¹ (T₃), 120 kg ha⁻¹ (T₄), 180 kg ha⁻¹ (T₅), 150 kg ha⁻¹ (T₆), 180 kg ha⁻¹ (T₇), 210 kg ha⁻¹ (T₈). The number of applications in these treatments (T₃ through T₈) ranged from 3 to 7 as per SPAD/LCC values recorded from time to time. Maximum number of split applications (7 splits) occurred in T₈ i.e., N₃₀ if LCC value is < shade 5.0. The least number of split applications (3 splits) happened in T₃ i.e., apply N₃₀ if SPAD value is < 37. Number of split applications in T₁ and T₂ are predetermined as per recommended practice. Number of split applications of N and total N received were same (6 splits and 180 kg ha⁻¹) in T₅ (SPAD 41) and T₇ (LCC 4.5). Treatment T₄ and T₆ (SPAD 39 and LCC 4.0) received 120 kg ha⁻¹ and 150 kg ha⁻¹ in 4 and 5 splits respectively. The table.1 clearly brings out how the N application was managed through real time and dynamic approaches.

Highest SPAD values of 41.6 and 41.0 were recorded in T₈ and T₅, which received highest N of 210 kg & 180 kg in 7 and 6 split doses respectively. The SPAD values in T₃ (SPAD 37) ranged between 33.1 to 37.2 as it received only 90 kg N ha⁻¹ in 3 splits. The SPAD readings indicate chlorophyll content and higher chlorophyll content is the indication of higher photosynthetic efficiency of plants. Application of higher levels of nitrogen increases the chlorophyll content resulting in higher photosynthetic capacity

which may lead to higher yields. These results are in conformity with the findings of Mahajan⁵ and Miah⁶.

The LCC values recorded at different days after transplanting (DAT) in different treatments. Significant differences in LCC values were not observed among the treatments up to 25 DAT. All the treatments except T₃ received N at 25 DAT, hence there was an increase in LCC values recorded at 35 DAT. Highest LCC value of 3.77 at 35 DAT was recorded in T₂ as it received 53 kg N ha⁻¹ (2nd split) as compared to 30 kg N ha⁻¹ in other treatments (Table 3). The lowest LCC value of 3.01 was recorded in T₃ as it did not receive N at 25 DAT. However significant difference was not observed in LCC value at 45 DAT though T₂ is deprived of N application as the SPAD values recorded were > 37 up to 55 DAT. But LCC values remained low in T₃ as compared to other treatments. The results were in conformity with the findings of ².

At 55 DAT, the LCC values recorded were significantly higher in T₅ to T₈ treatments than in T₁ to T₄. This may be attributed to application N *i.e.*, at 45 DAT for T₁, T₂, T₃ and T₄ treatments than T₅, T₆, T₇ and T₈ treatments as these treatments received N at 55 DAT.

Grain yield was significantly influenced by dynamic N management practices where in, rate of N application and number of split applications varied (90 to 210 kg ha⁻¹ in 3 to 7 splits respectively) as per treatmental demand from time to time. The grain yield ranged from 4901 kg ha⁻¹ in T₃ (SPAD 37) which received 90 kg N ha⁻¹ in 3 splits to 5879 kg ha⁻¹ in T₇ (LCC 4.5) which received 180 kg N ha⁻¹ in 6 splits (Table 2). The grain yield recorded in other treatments which received N @ 159 kg ha⁻¹ (T₂: STCR) to 210 kg ha⁻¹ (T₈: LCC 5.0) were found on par with each other. The treatments which received 90 kg N ha⁻¹ (T₃) and 120 kg N ha⁻¹ (T₁ and T₄) recorded significantly low yields and were found on par with each other though the number of split applications varied from 3 to 4. Treatment T₈ (LCC 5.0) which received highest N (210 kg ha⁻¹) in 7 splits stood on par with other treatments that received 159 to 180 kg N ha⁻¹ in 3 to 6 split applications. There

was no significant difference in grain yield recorded in T₂ (Soil test based fertilizer adjustment equations that received 159 kg N ha⁻¹ in 3 splits) and T₆ (LCC 4.0 and received 150 kg N ha⁻¹) though the number of split applications were more (5 no's) in the later treatment as compared to 3 splits in the former treatment. Significant increase in grain has also been reported by ^{8,5,9}.

It indicates that N fertilizer application ranging from 159 to 180 kg ha⁻¹ based on dynamic N management strategies viz., soil test based fertilizer equation (T₂) or SPAD based approach (T₅- SPAD 41) or LCC based approach (T₇- LCC 4.5) can be considered for achieving higher yield. Other important observation that targeted grain yield of 6.5 tonnes could not be achieved in T₂ where N, P & K were applied based on fertilizer adjustment equations as the soils are sandy loam in texture (about 80% sand), the N applied must have lost through leaching.

Leaf N content, SPAD and LCC values recorded at 10 days interval and grain yield at harvest showed a significant correlation between them. The relationship of correlation values are presented in Tables 4, 5 & 6. There was a strong relationship between leaf N content, and SPAD values at 45, 55 and 65 DAT. Similarly good correlation was observed between leaf N content and LCC values at 35, 45, 55 and 65 DAT (Table 4). In turn, there was a strong correlation between SPAD and LCC values (Table 5) at 35, 45, 55 and 65 (R= 0.385*, 0.385*, 0.651* and 0.508* respectively). The relationship indicates that when the rice crop show higher SPAD or LCC value, it has certainly higher nitrogen content. Similar relationship was observed by ³ and ⁴ in rice.

SPAD value at 65 DAT (R= 0.423*) and LCC values at 55 and 65 DAT (R= 0.431* and 0.650* respectively) were significantly and positively correlated with grain yield. (Table 6) LCC value showed higher correlation with grain yield when compared to SPAD values. N application must to maintain leaf N concentration and thereby increased levels of chlorophyll, photosynthesis, carbohydrates accumulation and in turn yield of rice.

Table 1: Leaf nitrogen content (%) of rice as influenced by different nitrogen management options (values in the parentheses indicate the quantity of N applied in kg ha⁻¹)

Tr. No	Basal dose	Days after transplanting (DAT)					
		15	25	35	45	55	65
T ₁ -RFD	40	1.88 (30)	1.94 (40)	2.3	2.45	2.57	2.43
T ₂ -STCR	53	2.00 (30)	2.68 (53)	2.56	2.54	2.61	2.48
T ₃ -SPAD 37	30	1.85 (30)	2.26	2.12	2.26	2.49	2.30 (30)
T ₄ -SPAD 39	30	1.86 (30)	2.26 (30)	2.75 (30)	2.86	2.57	2.18
T ₅ -SPAD 41	30	1.82 (30)	2.34 (30)	2.84 (30)	2.91 (30)	3.47 (30)	3.14
T ₆ -LCC 4	30	1.87 (30)	2.14 (30)	2.83 (30)	2.91 (30)	3.40	2.91
T ₇ -LCC 4.5	30	1.79 (30)	2.26 (30)	2.84 (30)	2.94 (30)	3.56 (30)	3.35
T ₈ -LCC 5	30	1.88 (30)	2.25 (30)	2.82 (30)	2.96 (30)	3.70 (30)	3.57 (30)
SE(m) ±	-	0.07	0.090	0.13	0.01	0.17	0.19
CD (0.05)	-	NS	0.27	0.39	0.30	0.50	0.57

Nitrogen contents are first: numbers in parenthesis (xx) are quantity of N applied in kg ha⁻¹ are in bold characters

Table 2: Treatments details of the experiment, N applied (kg ha⁻¹) and Grain yield (kg ha⁻¹)

Tr. No	Notation	Treatments details	N applied (kg ha ⁻¹) and no. of split applications (in parenthesis)	Grain yield (kg ha ⁻¹)
T ₁	RFD	Recommended fertilizer dose (RFD) (120-60-40 kg N-P-K ha ⁻¹ N in 3 splits, entire P as basal and K in 2 splits)	120 (3)	5133 b
T ₂	STCR	N P K application as per fertilizer adjustment equations (159- 67- 88 N-P-K kg ha ⁻¹ N in 3 splits)	159 (3)	5412 b
T ₃	SPAD 37	N ₃₀ basal+ N ₃₀ if SPAD value is < 37	90 (3)	4901 bc
T ₄	SPAD 39	N ₃₀ basal+ N ₃₀ if SPAD values is < 39	120 (4)	5159 b
T ₅	SPAD 41	N ₃₀ basal+ N ₃₀ if SPAD values is < 41	180 (6)	5869 a
T ₆	LCC 4	N ₃₀ basal+ N ₃₀ if LCC value is < shade 4.0	150 (5)	5370 bc
T ₇	LCC 4.5	N ₃₀ basal+ N ₃₀ if LCC value is < shade 4.5	180 (6)	5879 a
T ₈	LCC 5	N ₃₀ basal+ N ₃₀ if LCC value is < shade 5.0	210 (7)	5622 a
		SE(d) ±	-	163.2
		CD (0.05)	-	480

Table 3: Chlorophyll (SPAD) meter and LCC readings as influenced by Site specific and dynamic nitrogen management options

Treatments	Days after transplanting (DAT)					
	15	25	35	45	55	65
RFD	33.1 (2.90)	34.8 (3.00)	37.0 (3.07)	34.7 (3.37)	34.9 (3.46)	37.2 (4.16)
STCR	35.0 (3.21)	36.1 (3.23)	40.8 (3.77)	35.7 (3.77)	35.5 (3.80)	37.6 (4.20)
SPAD 37	33.1 (2.70)	37.0 (3.03)	37.2 (3.06)	37.1 (3.41)	36.8 (3.86)	35.4 (4.03)
SPAD 39	33.5 (2.73)	37.4 (3.06)	38.8 (3.56)	39.8 (3.57)	39.6 (3.86)	39.8 (4.06)
SPAD 41	33.0 (2.86)	37.4 (3.03)	38.6 (3.60)	39.6 (3.86)	39.6 (4.06)	41.0 (4.63)
LCC 4	33.8 (2.73)	37.4 (3.03)	38.7 (3.30)	39.4 (3.70)	39.6 (4.10)	40.1 (4.40)
LCC 4.5	33.3 (2.80)	37.4 (3.06)	38.6 (3.60)	39.8 (3.83)	39.8 (4.16)	39.8 (4.56)
LCC 5	33.6 (2.76)	37.4 (3.07)	38.9 (3.46)	39.0 (3.83)	39.9 (4.20)	41.6 (4.67)
SE(d) ±	1.43 (0.17)	1.07 (0.176)	1.12 (0.153)	1.15 (0.18)	1.18 (0.141)	1.22 (0.14)
CD (0.05)	NS	NS	NS (0.46)	3.5 (NS)	3.6 (0.24)	3.7 (0.414)

SPAD readings are first: values in the parentheses indicate the corresponding mean LCC shade values

Table 4: Correlation coefficient worked out between SPAD, LCC and leaf N content

	Leaf N 35 DAT	Leaf N 45 DAT	Leaf N 55 DAT	Leaf N 65 DAT
SPAD 35 DAT	NS	NS	NS	0.394*
SPAD 45 DAT	0.527**	0.538**	0.523**	NS
SPAD 55 DAT	0.417*	0.417*	0.541**	NS
SPAD 65 DAT	0.512**	0.512**	0.517**	NS
LCC 35 DAT	0.483**	0.415*	NS	0.368*
LCC 45 DAT	0.462**	0.453*	0.366*	NS
LCC 55 DAT	0.364*	0.524**	0.585**	0.362*
LCC 65 DAT	0.548**	0.541**	0.737**	0.495*

Table 5: Correlation coefficient worked out between SPAD and LCC values at different DAT

	SPAD 35 DAT	SPAD 45 DAT	SPAD 55 DAT	SPAD 65 DAT
LCC 35 DAT	0.385*	-	-	-
LCC 45 DAT	-	0.385*	-	-
LCC 55 DAT	-	0.670**	0.651**	0.370*
LCC 65 DAT	-	0.369*	0.367*	0.508**

Table 6: Correlation coefficient between SPAD, LCC value and grain yield and N uptake

	SPAD 15	SPAD 25	SPAD 35	SPAD 45	SPAD 55	SPAD 65	Grain yield
Grain yield	NS	NS	NS	NS	NS	0.423*	1
	LCC 15 DAT	LCC 25 DAT	LCC 35 DAT	LCC 45 DAT	LCC 55 DAT	LCC 65 DAT	Grain yield
Grain yield	NS	NS	NS	NS	0.431*	0.649**	1
	Leaf N 15 DAT	Leaf N 25 DAT	Leaf N 35 DAT	Leaf N 45 DAT	Leaf N 55 DAT	Leaf N 65 DAT	Grain yield
Grain yield	NS	NS	0.522**	0.599**	0.689**	0.518**	1

CONCLUSION

The grain yield ranged from 4910 kg ha⁻¹ in T₃ which received 90 kg ha⁻¹ in 3 splits to 5879 kg ha⁻¹ in T₇ which received 180 kg ha⁻¹ in 6 splits. Treatments T₂, T₅, T₇ & T₈ are on par with each other which received N ranging from 159-210 kg ha⁻¹. The relationship between SPAD and LCC on leaf N content, Nutrients uptake and grain yield indicates that N fertilization in rice can be effectively managed to with the help of simple tools *i.e.*, SPAD (chlorophyll meter) and LCC to match with that of N requirement of crop for achieving higher yields.

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