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Original Research Article

Relation between Leaf N Content, LCC and SPAD Values on Yield in Rice (*Oryza sativa* L.)

M. Suresh[1*], D. Balaguravaiah[2], G. Jayasree[1] and Y. Balachennaiah[1]

[1]Department of Soil Science & Agricultural Chemistry, College of Agriculture, Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad-500030, Telangana, India
[2]Dept. of Soil Science & Agricultural Chemistry, Agricultural College, ANGRAU, Mahanandi, 518501, A.P., India
**Corresponding author*

A B S T R A C T

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

Keywords

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 greenhouse gases *viz.*, nitrous and nitric oxides to the atmosphere, and increases the “far end depression” in rice crop (Wilcox, 1930). 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.

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 warranted (Nagarajan et.al., 1997). 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} (CMIE, 2011).

Materials 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., T_1 (Recommended Fertilizer Dose of NPK i.e. RFD), T_2 (Soil test based N P K application using fertilizer adjustment equations), T_3 (N_{30} basal+ N_{30} if SPAD value is < 37), T_4 (N_{30} basal+ N_{30} if SPAD values is < 39), T_5 (N_{30} basal+ N_{30} if SPAD values is < 41), T_6 (N_{30} basal+ N_{30} if LCC value is < shade 4.0), T_7 (N_{30} basal+ N_{30} if LCC value is < shade 4.5), T_8 (N_{30} basal+ N_{30} if LCC value is < shade 5.0). The recommended doses of P_2O_5 (60 kg ha^{-1}) and K_2O (60 kg ha^{-1}) were applied uniformly to all the treatments except in T_2.

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 P_2O_5 ha^{-1}) and potassium (223 kg K_2O ha^{-1}). The LCC readings were recorded in all the treatments (T_1 through T_8) 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} (T_3), 120 kg ha^{-1} (T_4), 180 kg ha^{-1} (T_5), 150 kg ha^{-1} (T_6), 180 kg ha^{-1} (T_7), 210 kg ha^{-1} (T_8). The number of applications in these treatments (T_3 through T_8) ranged from 3 to 7 as per SPAD/LCC values recorded from time to time. Maximum number of split applications (7 splits) occurred in T_8 *i.e.*, N_{30} if LCC value is < shade 5.0. The least number of split applications (3 splits) happened in T_3 *i.e.*, apply N_{30} if SPAD value is < 37. Number of split applications in T_1 and T_2 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 T_5 (SPAD 41) and T_7 (LCC 4.5). Treatment T_4 and T_6 (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 T_8 and T_5, which received highest N of 210 kg & 180 kg in 7 and 6 split doses respectively. The SPAD values in T_3 (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 Mahajan *et al.*, (2011a) and Miah *et al.*, (1997).

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 T_3 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 T_2 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 T_3 as it did not receive N at 25 DAT. However significant difference was not observed in LCC value at 45 DAT though T_2 is deprived of N application as the SPAD values recorded were > 37 up to 55 DAT. But LCC values remained low in T_3 as compared to other treatments. The results were in conformity with the findings of Houshmandfar and Kimaro (2011).

At 55 DAT, the LCC values recorded were significantly higher in T_5 to T_8 treatments than in T_1 to T_4. This may be attributed to application N *i.e.*, at 45 DAT for T_1, T_2, T_3 and T_4 treatments than T_5, T_6, T_7 and T_8 treatments as these treatments received N at 55 DAT.

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

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 T_3 (SPAD 37) which received 90 kg N ha^{-1} in 3 splits to 5879 kg ha^{-1} in T_7 (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} (T_2: STCR) to 210 kg ha^{-1} (T_8: LCC 5.0) were found on par with each other. The treatments which received 90 kg N ha^{-1} (T_3) and 120 kg N ha^{-1} (T_1 and T_4) recorded significantly low yields and were found on par with each other though the number of split applications varied from 3 to 4. Treatment T_8 (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 T_2 (Soil test based fertilizer adjustment equations that received 159 kg N ha^{-1} in 3 splits) and T_6 (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 Reddy *et al.,* (2012), Mahajan *et al.,* (2011b) and Shekara *et al.,* (2010). 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 (T_2) or SPAD based approach (T_5- SPAD 41) or LCC based approach (T_7- 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 T_2 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 Islam *et al.,* (2009) and John *et al.,* (2000) 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.

The grain yield ranged from 4910 kg ha^{-1} in T_3 which received 90 kg ha^{-1} in 3 splits to 5879 kg ha^{-1} in T_7 which received 180 kg ha^{-1} in 6 splits. Treatments T_2, T_5, T_7 & T_8 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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