Applied Biological Research 17 (1): 24-30; (2015)
DOI: 10.5958/0974-4517.2015.00004.X

MANAGEMENT OF NITROGEN THROUGH LEAF COLOUR CHART (LCC) IN RICE UNDER IRRIGATED CONDITIONS OF KASHMIR

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(Received 13 July, 2014; accepted 23 December, 2014)

ABSTRACT

A field experiment was conducted at Research Farm, SKUAST-Kashmir, Shalimar, Srinagar (India) to study the management of N through leaf colour chart (LCC) in two rice genotypes cv. 'Jhelum' and 'SR-2' during *kharif* 2012 and 2013. The soil of experimental field was silty clay loam with organic C 0.92%, pH 6.6, EC 0.22 dS m^{-1}, available N 308.96 kg ha^{-1}, P 33.38 kg ha^{-1} and K 169.26 kg ha^{-1}. Genotype 'SR-2' gave significantly more yield than 'Jhelum' whereas LCC ≤ 5 @ 30 kg N ha^{-1} i.e. 150 kg N ha^{-1} applied in 5 splits gave significantly higher grain yield but was at par with 120 kg N ha^{-1} applied in 6 splits [LCC ≤ 5 @ 20 kg N ha^{-1}] as compared to the recommended dose of 120 kg N ha^{-1}. Chlorophyll content increased significantly with increase in N through LCC. The mean chlorophyll content varied from 0.22 to 0.39 and 0.22 to 0.40 g m^{-2} during 2012 and 2013, respectively. The correlation coefficient between SPAD and LCC, and SPAD and N were positively correlated at all growth stages of rice. Use of LCC also saved 10 to 40 kg N ha^{-1} over fixed-time N applications. The application of N through LCC ≤ 5 @ 30 kg N ha^{-1} gave higher gross returns, net returns and benefit cost ratio in both the rice genotypes.

Key words: Correlation, LCC, N content, rice, SPAD, yield

INTRODUCTION

To achieve higher yields in rice (*Oryza sativa* L.), farmers in many parts of the world tend to apply nitrogen in excess of the requirements which leads to further lowering recovery efficiency of N fertilizer, which is already not more than 50% (Singh *et al*., 2001). When N application is not synchronized with crop demand, N losses from soil-plant system are large, resulting in lower N fertilizer use efficiency. Hence, plant need-based application of N is crucial to achieve higher yield and N-use efficiency. Real time corrective N management is based on periodic assessment of plant nitrogen status and the appearance of nitrogen deficiency symptoms especially on leaves. Thus, the key ingredient for real time N management is a method of rapid assessment of leaf nitrogen content that is closely related to the photosynthetic rate and biomass production and is a sensitive indicator of changes in crop nitrogen demand within a growing season. The chlorophyll meter, also known as SPAD (soil plant analysis development), can quickly and reliably assess the N status of a crop based on leaf area. It has successfully been used in rice (Follett *et al*., 1992). The high cost of chlorophyll meter keeps it out of reach of many Asian farmers. The leaf colour chart (LCC) is an inexpensive alternative to chlorophyll meter. The critical colour shade on LCC needs to be determined to guide N applications. Fertilizer N-use efficiency of irrigated rice is relatively low due to rapid loses of applied N through volatilization and denitrification in soil. The leaf N content is closely related to photosynthetic rate (Peng *et al*., 1996) and the N concentration on a dry weight basis of the top most fully expanded leaf has been used as an index to determine N top-dressing. Use of this approach in developing countries is very limited. The chlorophyll meter or SPAD and LCC provide a simple, quick and non-destructive method for estimating N of rice leaves. Very less research works are available so far to establish LCC and SPAD for rice in Jammu and Kashmir state. Therefore, the present study was aimed to evaluate need-based N management strategies for rice genotypes using LCC.

MATERIALS AND METHODS

Field experiments were conducted during *kharif* seasons of 2012 and 2013 using 2 rice genotypes at Research Farm, SKUAST-Kashmir, Shalimar, Srinagar (34^{o}08′ N latitude and 74^{o}83′ E longitude and 1587 m altitude). The soil of experimental field was silty clay loam having 0.92% organic C (Walkley and Black, 1934), pH 6.6 (Jackson, 1973), EC 0.22 dS m^{-1} (Piper, 1966), available N 308.96 kg ha^{-1} (Subbiah and Asija, 1954), P 33.38 kg ha^{-1} (Olsen *et al*., 1954) and ammonium acetate extractable K 169.26 kg ha^{-1} (Jackson, 1973). Under average climatic conditions, the area receives 690 mm mean annual rainfall, most of which occurs from December to April. Rainfall received during rice-growing season (June to September) was 222 and 375 mm in 2012 and 2013, respectively. Mean monthly maximum and minimum temperatures during rice growth period varied from 9.94 to 19.36 and 9.51 to 19.11 and 22.14 to 32.36 and 22.96 to 32.50^{o}C during 2012 and 2013, respectively.

The experiment was laid out in a factorial randomized block design with three replications. The treatments included 2 rice genotypes (Jhelum and SR-2) and 8 rates of N application (control, recommended practice and LCC $\leq$ 3, 4 and 5 levels @ 20 and 30 kg N ha^{-1}). In recommended practice, 120 kg N ha^{-1} N was applied in 3 equal splits at transplanting (basal), mid-tillering and panicle initiation stages. Field preparation for rice included two disc ploughings in dry soil followed by two puddlings. Thirty five days old seedlings were transplanted manually at 15 × 15 cm spacing in 2nd week of June. All the treatment plots received uniform dose of 60 kg P ha^{-1}, 30 kg K ha^{-1} and 15 kg zinc sulphate ha^{-1}. Whole P, K and Zn were applied as basal dose before transplantation. The crop was irrigated daily during 1st two weeks and thereafter as per need to prevent soil surface from being dry. Standard cultural practices were carried out until the crop was mature. Rice was harvested in the 3rd week of September. For leaf colour chart-based N management, LCC readings were taken at 4 days interval starting from 12 DAT till 50% flowering. Ten disease free hills were selected at random from the sampling area in each plot. From each hill, top most fully expanded leaf was selected and LCC readings taken by placing the middle part of leaf on chart and leaf colour observed by keeping the sun blocked by body as sun light affects leaf colour reading. 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 (LCC 3, 4 and 5), N was applied as per the treatments in both the varieties. The total amount of N applied (kg N ha^{-1}) in both genotypes was 0 (control), 120 (recommended doze), 80 (LCC$\leq$3, 4 splits @ 20 kg N ha^{-1}) , 90 (LCC$\leq$3, 3 splits @ 30 kg N ha^{-1}), 100 (LCC$\leq$4, 5 splits @ 20 kg N ha^{-1}), 120 (LCC$\leq$4, 4 splits @ 30 kg N ha^{-1}), 120 (LCC$\leq$5, 6 splits @ 20 kg N ha^{-1}) and 150 (LCC$\leq$5, 5 splits @ 30 kg N ha^{-1}). SPAD-502 was used for taking readings on 5 topmost fully expanded leaves at 10 day intervals at a specified time and average of 6 readings taken in each plot and then converted into chlorophyll content according to Gandia *et al*. (2007). The data was statistically analyzed for critical difference and correlations worked out as per the standard methods (Cohran and Cox, 1955).

RESULTS AND DISCUSSION

Grains per panicle and yield

The genotype 'SR-2' gave significantly higher grains panicle^{-1} and grain yield than 'Jhelum' (Table 1). Genotype 'SR-2' had 93.76 and 96.19 grains panicle^{-1} during 2012 and 2013, respectively, as compared to 91.77 and 94.10 in 'Jhelum'. This may be ascribed to their genetic makeup. Laza *et al.* (2004) also reported variation in yield contributing characters of different rice cultivars. LCC ≤ 5 @ 30 and 20 kg N ha^{-1} gave significantly higher grains panicle^{-1} (101.7 and 102.9) than LCC ≤ 4 @ 30 and 20 kg N ha^{-1}, LCC ≤ 3 @ 30 and 20 kg N ha^{-1} and recommended N in both the years. More number of early formed tillers under favourable N nutrition tend to bear more panicles and grains panicle^{-1}. It may be attributed to higher availability and uptake of N which is a substrate for the organic compounds involved in protoplasm and chlorophyll synthesis (Avijit *et al*., 2011). The grain yield in 'SR-2' was 72.18 and 74.31 q ha^{-1} as compared to 63.95 and 67.67 q ha^{-1} in 'Jhelum' during 2012 and 2013, respectively. Rice yield is dependent on the number of panicles m^{-2} and grains panicle^{-1} which were significantly higher in 'SR-2' and hence higher grain yield. 'SR-2' also gave significantly higher dry matter than 'Jhelum'. Ganajaxi *et al.* (2001) and Avijit *et al.* (2011) also reported variation in grain yield in rice cultivars. Grain yield exhibited remarkable variation at different scores of LCC. Real time nitrogen application with LCC ≤ 5 @ 30 kg N ha^{-1} registered maximum grain yield (80.21 and 82.84 q ha^{-1}) which was at par with treatment LCC ≤ 5 @ 20 kg N ha^{-1} (77.80 and 79.77 q ha^{-1}). Higher grain yield in LCC ≤ 5 @ 30 and 20 kg N ha^{-1} based N management might be due to the higher quantum of N and more number of splits as compared to other levels (Narasimhan *et al*., 1999). Application of N through LCC ≤ 3 @ 30 and 20 kg N ha^{-1} were at par with the recommended N level but superior to control during both the years with a saving of 30 and 40 kg N ha^{-1}. The application of N at LCC ≤ 5 matched the crop demand at different

Table 1: Effect of real time nitrogen management on chlorophyll content, grains panicle^{-1} and grain yield in rice genotypes

Treatments	Chlorophyll content (g m^{-2})												Grains panicle^{-1}		Grain yield (q ha^{-1})	
	Days after transplanting															
	20		30		40		50		60		70					
Varieties	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013
Jhelum	0.30	0.31	0.31	0.32	0.32	0.33	0.34	0.35	0.35	0.36	0.27	0.27	91.8	94.1	63.95	67.67
SR-2	0.31	0.32	0.33	0.33	0.34	0.35	0.35	0.36	0.36	0.37	0.27	0.28	93.8	96.3	72.18	74.31
S.Em±	0.01	0.01	0.01	0.01	0.02	0.03	0.02	0.01	0.01	0.02	0.03	0.01	0.64	0.68	0.84	0.75
CD$_{0.05}$	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	1.94	2.04	2.54	2.25
Nitrogen management (kg ha^{-1})																
Control	0.24	0.25	0.26	0.26	0.27	0.28	0.30	0.30	0.30	0.31	0.22	0.22	74.4	75.2	39.16	42.13
Recommended N	0.30	0.31	0.33	0.33	0.33	0.34	0.34	0.35	0.35	0.36	0.26	0.27	90.6	92.2	70.07	72.87
LCC ≤ 3 @ 20 N	0.29	0.29	0.29	0.31	0.32	0.32	0.32	0.32	0.33	0.34	0.23	0.24	87.6	89.7	66.10	69.24
LCC ≤ 3 @ 30 N	0.29	0.30	0.31	0.31	0.32	0.33	0.33	0.34	0.34	0.35	0.24	0.25	90.6	91.6	68.57	71.54
LCC ≤ 4 @ 20 N	0.32	0.32	0.35	0.35	0.35	0.37	0.37	0.37	0.37	0.37	0.28	0.29	93.7	95.1	72.84	75.63
LCC ≤ 4 @ 30 N	0.32	0.33	0.36	0.36	0.36	0.37	0.37	0.37	0.38	0.39	0.30	0.31	94.3	96.7	73.77	76.92
LCC ≤ 5 @ 20 N	0.34	0.35	0.36	0.38	0.37	0.39	0.38	0.38	0.39	0.39	0.31	0.32	96.0	98.3	77.80	79.77
LCC ≤ 5 @ 30 N	0.35	0.36	0.38	0.38	0.38	0.39	0.39	0.40	0.39	0.40	0.33	0.33	101.7	102.9	80.21	82.84
S.Em±	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	1.77	1.73	1.70	1.74
CD$_{0.05}$	0.02	0.02	0.02	0.02	0.01	0.01	0.02	0.03	0.01	0.01	0.02	0.01	5.38	5.10	5.10	5.22

physiological stages, reduced the losses through denitrification and volatilization and resulted in highest grain yield (Porpavai *et al.,* 2002). The increased availability of nutrient at distinct physiological phases would have supported better assimilation of photosynthates towards grain and also due to the favourable effect of accelerating the yield characters (Ravi *et al.*, 2007).

LCC and chlorophyll content

The chlorophyll content increased significantly with increase in N levels through LCC (Table 1). The chlorophyll content increased upto 60 DAT of rice. The chlorophyll content ranged between 0.22 and 0.39, and 0.22 and 0.40 g m^{-2} during 2012 and 2013, respectively, in various treatments, irrespective of progress of crop growth, whereas the two cultivars did not differ significantly with respect to SPAD during both the years and at different stages. This may be due to higher amount of nitrogen which eventually caused increased chlorophyll content of the leaf (Islam *et al*., 2004).

Correlation between LCC and SPAD

The correlation coefficient (r) values between SPAD and LCC at different growth stages were significant and positive in both the genotypes (Table 2). The significant positive correlations of these parameters (r = 0.931 to 0.991) indicated that top dressing of N can be practiced on the basis of LCC and SPAD. This indicated that LCC value-based N management may replace the SPAD meters because both were significantly correlated. Further, LCC is cheaper than SPAD and can be handled easily. These results corroborate with those of Yang *et al*. (2003) who reported that leaf colour chart scores were closely related to SPAD values. Shukla *et al*. (2004) observed that LCC and SPAD readings had strong positive correlation in rice and wheat. Chlorophyll content depicts the N status of plants (Shukla *et al*., 2004) and it showed that plants under recommended split of N suffered from nitrogen deficiency at all growth stages (Debtanu and Das, 2013). The relationship between SPAD values and LCC scores was linear for ‘Jhelum’ and ‘SR-2’ during both the years (Fig. 1-4). Overall SPAD value in ‘SR-2’ was non-significantly higher than ‘Jehlum’ which was most probably due to more leaf thickness. Yang *et al.* (2003) also reported from Philippines that leaf thickness directly affected the chlorophyll content and corresponding LCC score in rice. Moreover, direct relationship of LCC score with SPAD readings across the genotypes and crop growth stages provides confidence that single LCC threshold can be used as critical LCC colour for making need-based fertilizer N topdressing decisions in different rice genotypes (Avijit *et al*., 2011).

SPAD and N content

Significantly positive correlation was observed between SPAD values and N content in both rice genotypes at different crop growth stages during both the years (Table 3). LCC scores and leaf N content showed significant correlation at different growth stages. Since leaf colour chart score is closely related to leaf N concentration and SPAD meter readings across the rice genotypes and crop growth stages it can be used as reliable indicator of indigenous N supply status of soil (Dobermann *et al*., 2003). The LCC measures leaf colour as an indicator of leaf N concentration and therefore can be used as atoll for N application based on threshold LCC value (Debtanu and Das, 2013).

Economics

The application of N through LCC ≤ 5 @ 30 kg N ha^{-1} gave gross returns of ₹145075.60, net returns of ₹ 103425.80 and benefit cost ratio of 2.24 in genotype Jhelum, whereas gross returns of ₹ 151361.70, net returns of ₹ 106588.70 and benefit cost ratio of 2.38 was obtained in SR-2, respectively,

Table 2: Correlation coefficients between SPAD and LCC scores

	30 DAT		60 DAT		80 DAT	
	2012	2013	2012	2013	2012	2013
Jhelum	0.931**	0.932**	0.968**	0.969**	0.990**	0.991**
SR-2	0.941**	0.943**	0.952**	0.955**	0.984**	0.985**

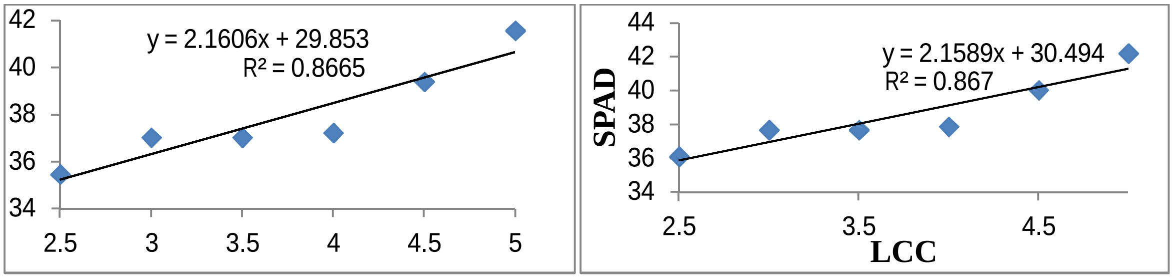

Fig 1: Linear regression line for LCC vs SPAD at 30 DAT in 'Jhelum' a) year 2012; b) year 2013

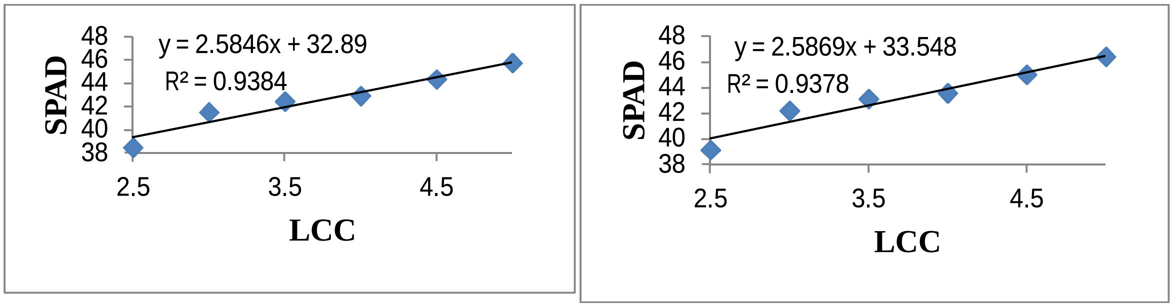

Fig 2: Linear regression line for LCC vs SPAD at 60 DAT in 'Jhelum' a) year 2012; b) year 2013

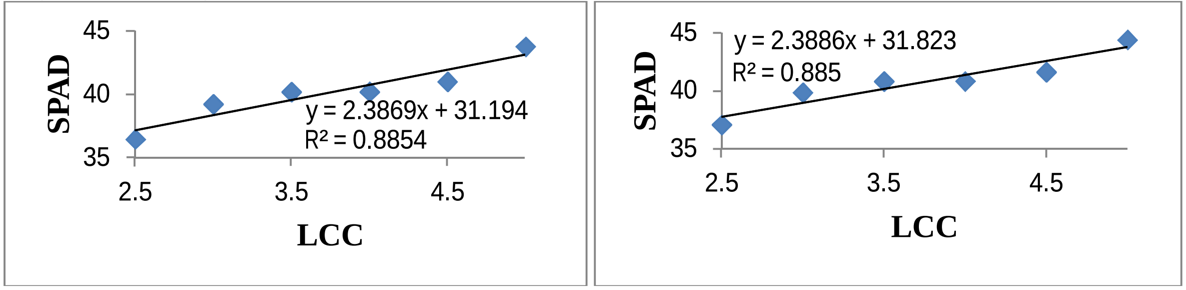

Fig 3: Linear regression line for LCC vs SPAD at 30 DAT in 'SR-2' a) year 2012; b) year 2013

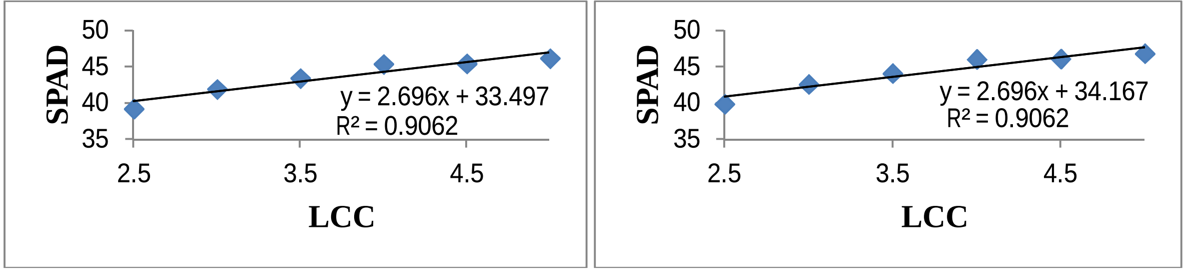

Fig 4: Linear regression line for LCC vs SPAD at 60 DAT in 'SR-2' a) year 2012; b) year 2013

Table 3: Correlation matrix between SPAD and N content in Jhelum and SR-2

Treatments	N content at 20 DAT		N content at 40 DAT		N content at 60 DAT	
	2012	2013	2012	2013	2012	2013
Jhelum						
SPAD at 20 DAT	0.889**	0.912**	0.872**	0.889**	0.910**	0.933**
SPAD at 40 DAT	0.869**	0.867**	0.867**	0.869**	0.896**	0.898**
SPAD at 60 DAT	0.928**	0.930**	0.928**	0.926**	0.951**	0.953**
SR-2						
SPAD at 20 DAT	0.905**	0.903**	0.909**	0.879**	0.926**	0.919**
SPAD at 40 DAT	0.892**	0.894**	0.878**	0.875**	0.914**	0.917**
SPAD at 60 DAT	0.915**	0.918**	0.921**	0.924**	0.944**	0.946**

**Significant at 0.01%

Table 4: Relative economics of different treatment combinations (mean of 2012 and 2013)

Treatments ($N\ ha^{-1}$)	Cost of cultivation (₹)	Gross returns (₹)		Total returns (₹)	Net returns (₹)	B:C ratio
		Grain	Straw			
Jehlum						
Control	35980	47092	28738.35	75830.35	39870.85	0.77
Recommended N	37415	82186	41305.00	123491.00	80519.34	1.78
LCC≤3 @ 20 kg	36937	77456	39596.67	117052.70	75949.84	1.66
LCC≤3 @ 30 kg	37056	80140	40993.35	121133.40	80764.34	1.75
LCC≤4 @ 20 kg	37175	85428	44368.74	129796.80	88754.08	1.94
LCC≤4 @ 30 kg	37415	87260	46940.74	134200.80	91885.92	2.02
LCC≤5 @ 30 kg	37415	90952	49208.57	140160.60	99175.77	2.16
LCC≤5 @ 30 kg	37773	93460	51615.57	145075.60	103425.80	2.24
SR-2						
Control	35980	50448	30410.00	94848.00	51868.00	1.21
Recommended	37415	89344	44400.00	131235.70	86820.67	1.96
LCC≤3 @ 20 kg	36937	84950	41891.69	128041.70	84104.67	1.92
LCC≤3 @ 30 kg	37056	87988	43091.69	133738.00	89682.00	2.04
LCC≤4 @ 20 kg	37175	92724	45750.00	139117.30	94942.33	2.15
LCC≤4 @ 30 kg	37415	93568	46393.32	141229.70	96814.67	2.18
LCC≤5 @ 20 kg	37415	98128	47661.67	147289.70	102874.70	2.32
LCC≤5 @ 30 kg	37773	102200	49161.69	151361.70	106588.70	2.38

(Table 4). The higher net returns in treatment LCC ≤ 5 @ 30 kg N ha^{-1} was due to steady supply of nitrogen which synchronized with the peak period of nitrogen requirement that had produced higher yield (Gupta *et al.*, 2011). Similarly, Reddy and Pattar (2006) also reported that higher net returns were recorded with leaf colour chart-based nitrogen management (LCC ≤ 5 @ 30 kg N ha^{-1}) as compared to recommended practices.

Conclusions: Significant and positive correlation between LCC with SPAD and SPAD with N content indicated that current recommendation of fixed time split N applications at specified growth time is not adequate to synchronize N supply with actual crop N demand due to poorly designed N splitting and variations in crop N demand. Through the use of LCC, 10–40 kg N ha^{-1} can be saved over fixed-timing N applications. Use of LCC and SPAD is economically viable and cost effective.

Acknowledgments: The authors are grateful to the INSPIRE-DST, New Delhi, India for funding this research programme.

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