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RELATIONSHIP AMONG LEAF NITROGEN CONTENT, SPAD AND LCC VALUES IN RICE

The leaf nitrogen concentration, photosynthetic rate and the crop yield in rice are closely related since nitrogen is an essential constituent of chlorophyll. Poor nitrogen management strategies lead not only to low recovery of the applied nitrogen but also results in pollution of the environment. To decide the nitrogen requirement based on crop demand and nitrogen supply power of the soil it is necessary to estimate accurately the crop nitrogen status. Measurement of leaf nitrogen by the kjeldhal procedure is destructive, laborious, costly, time-consuming and need the expertise of scientists or extension workers. The use of chlorophyll meter, otherwise called the SPAD meter (Soil and Plant Analysis Department, Japan) for taking instant and quick estimate of crop nitrogen status in rice has already been established (Peng and Cassman, 1995; Johnkutty and Palaniappan, 1996). However, the high cost of the equipment prohibits its wide adoption by farmers in developing countries.

A leaf colour chart (LCC) developed from a Japanese prototype (Furuya, 1987) by IRRI, Philippines is a simple, easy-to-use, and inexpensive tool to determine the time of nitrogen top-dressing in rice (IRRI, 1998). The relationship between the leaf colour intensity and nitrogen concentration in rice leaves may differ markedly depending on genotype and environment (Takabe and Yoneyama, 1989). Therefore, accurate prediction of plant nitrogen status using the LCC requires separate calibration of the relationship of leaf nitrogen concentration with SPAD meter and LCC for specific growth conditions and different growth stages of different cultivars.

The objective of the study was to determine the relationships between leaf nitrogen concentration, SPAD meter readings and LCC values in rice.

The study was conducted with the observations in three field experiments, one in wet season (May to September) and two in dry season (October to February) during 1998-'99 at the Regional Agricultural Research Station (RARS), Pattambi, Kerala.

The treatments of the Experiment I, laid out in split-plot design during the kharif season (May to September, 1998) constituted different combinations of N and P (N at 0, 90. 120 and 150 kg ha^{-1}; P at 0, 40, 60 and 80 kg ha^{-1}) at a common level of K of 50 kg ha^{-1} as main plots and three hybrids (HRI-119, HRI-129 and VRH-704 and one inbred line (Jyothy) as sub-plots. Experiment II was laid out during the rabi season (October-February, 1998) in RBD with timings of nitrogen application, sources of nitrogen (prilled urea - PU, green manure + PU, control release urea -CRU) and SPAD based nitrogen application as the treatments. Nitrogen was applied at 70, 105 or 42 kg ha^{-1} and timings were at basal. at active tillering (AT), at panicle initiation (PI) and at heading stage (HD). The test variety was Jyothy. In Experiment III, which was conducted during the rabi period (October, 1998 to February, 1999), nitrogen levels and varieties formed the main plots and subplots, respectively. The nitrogen levels varied as 60, 90, 120 and 150 kg ha^{-1} and the varieties were Jyothy, Kairaly, Kanchana and Aiswarya, the inbred lines predominant in Kerala with the duration ranging from 110 to 116 days.

The observations on nitrogen concentration, SPAD readings and LCC values were done on the uppermost fully expanded leaf up to heading stage and on flag leaf from heading onwards as described by Peng *et al.* (1993). The SPAD 502 meter and LCC supplied by IRRI, Philippines were used for the observations of SPAD readings and LCC values, respectively. The colour of the leaves was compared with the LCC and the shade number formed the LCC values. Average of 10 readings formed the LCC for each plot. After the SPAD and LCC measurements, the individual leaves were detached for determination of total nitrogen (Bremmer and Mulvaney, 1982). Correlation coefficients between different parameters were worked out for different growth stages and also on pooling the data over the stages and over all experiments.

The relationships between leaf nitrogen concentration (Nc), SPAD, and LCC were studied

Table 1. Correlation coefficent(r) between different parameters at various growth stages of rice

Growth stage	SPAD vs LCC	SPAD vs Nc	LCC vs Nc	Nc vs yield	SPAD vs yield	LCC vs yield
			ExperimentI			
46 DAT (PI)	0.28*	0.33**	0.11	0.06	0.1	0.13
64 DAT (HD)	0.69**	0.34**	0.32**	0.13	0.36**	0.17
Pooled	0.65**	0.32**	0.10	0.15	0.28*	0.16
			ExperimentII			
17 DAT	0.41**	0.27	0.44**	0.09	0.10	0.09
24 DAT (AT)	0.51**	0.25	0.40*	0.09	0.08	0.15
31 DAT (PI)	0.75**	0.65**	0.70**	0.30	0.41**	0.51**
37 DAT	0.70**	0.30	0.22	0.49**	0.64**	0.41**
44 DAT	0.67**	0.80**	0.71**	0.49**	0.32*	0.44**
51 DAT (HD)	0.84**	0.62**	0.55**	0.53**	0.58**	0.46*
58 DAT	0.83**	0.23	0.42*	0.18	0.66**	0.62**
65 DAT	0.79**	0.75**	0.63**	0.53**	0.68**	0.60**
Pooled	0.71**	0.33**	0.33**	0.23**	0.36**	0.30**
			Experiment III			
25 DAT (AT)	0.52**				0.11	0.08
37 DAT (PI)	0.37**				0.31*	0.42*
53 DAT (HD)	0.68**				0.37*	0.48**
64 DAT	0.56**				0.27*	0.54**
Pooled	0.80**				0.32*	0.38**
All expts pooled	0.81**	0.49**	0.51**	0.35**	0.48**	0.41**

AT = Active tillering; PI = Panicle initiation; HD = Heading

by working out the correlation coefficients. The correlation coefficients between SPAD and Nc were significant at almost all sampling stages. The relationship became stronger at late growth stages. The r-values were 0.33** at 46 DAT (PI) and 0.34** at 64 DAT (HD) in Experiment I. The values in Experiment II ranged from 0.23 to 0.80** during the various growth stages. When the data were pooled over the growth stages within the experiments, the correlations were found highly significant (0.32** in Experiment I and 0.33** in Experiment II). The strength of relationship between NC and SPAD value got further improved when the data were pooled over all experiments (r = 0.49**) with regression as SPAD = 27.35 + 0.295 Nc g kg^{-1}

The relationship between Nc and LCC was significant at HD stage in Experiment I (r=0.32**), but the relationship was not so at PI stage. The r-values in Experiment II gave clear and definite positive relationship between LCC and Nc. The r-values were significantly positive at all sampling stages except at 37 DAT. The r-values ranged from 0.40 to 0.71**. The pooled value also exhibited a better relationship (r = 0.33**). On pooling the data over all experiments, the LCC-NC relationship proved to be strong with an r-value of 0.51** and the resultant regression equation could be expressed as LCC = 1.56 + 0.057 Nc.

In all the experiments, the coefficients of correlation between SPAD and LCC values were significant at all sampling dates and also on pooling data over the growth stages within each experiment. In Experiment I, the relationship was better at HD stage (r = 0.69**) than that at PI stage (r=0.28*). The relationship was found to be strong at all sampling dates in Experiment II and III (r-values ranging from 0.41** to 0.84** in Experiment II; and from 0.37** to 0.68** in Experiment III). On pooling the data over the stages, the r-values were 0.65**, 0.71** and 0.80** in Experiment I, II and III respectively. The relationship got further improved on pooling the data over all experiments with an r-value of 0.81**. The SPAD–LCC relationship could be expressed as SPAD = 21.86 + 4.373 LCC. The results of the experiments revealed significant relationship between leaf nitrogen concentration and SPAD values, which corroborates with earlier findings (Peng and Cassman, 1995; Johnkutty and Palaniappan, 1996). Though the SPAD meter is found useful in estimating the crop nitrogen status to decide on in-season nitrogen side-dressing, the cost of the meter prohibits its large-scale use. The leaf colour intensity measured by LCC also gave equally significant relationship with leaf nitrogen concentration. The SPAD meter would be a useful tool to scientists for nutrient management studies and to extension workers for advisory services. The LCC prototype developed by 1RRI would be a useful tool to determine the nitrogen status of rice plant and to decide on in-season nitrogen management strategies. Since it is a very simple, easy-to-use and inexpensive tool, it would be well accepted by the farmers in developing countries like India. Under high rainfall situations as prevalent in Kerala, LCC can help in promoting need based nitrogen application to rice and thereby maximizing nitrogen uptake and yield and reducing nitrogen losses.

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