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Nitrogen management through soil and plant analysis development and leaf colour charts in different groups of rice (*Oryza sativa*) varieties grown on Vertisols of Deccan plateau

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ABSTRACT

A field experiment was conducted during the rainy *(kharif)* and winter *(rabi)* seasons of 1997–98 at Rajendranagar, Hyderabad, to compare the N-use efficiency of SPAD-502 (soil and plant analysis development) chlorophyll meter-based N fertilizer management with recommended fixed schedule of N fertilizer splits applied at critical growth stages and to assess the relation of SPAD and leaf colour chart (LCC) readings recorded at critical crop-growth stages with grain of rice (*Oryza sativa* L.). In SPAD-based N management, the N was applied when SPAD value decreased below 35 of fixed value and the amount applied as per the stage of the crop. Hybrids recorded higher grain yield of 4.85 and 5.16 tonnes/ha during rainy and winter season respectively than scented and high-yielding varieties respectively. The SPAD–N application gave significantly higher grain yield than 135 kg N/ha during rainy season, while on par with that in winter. The agronomic efficiency (Δ kg grain/Δ kg N) and partial factor productivity (kg grain/unit N) was higher for SPAD-based N application than 135 and 90 kg N/ha. The SPAD and leaf colour chart values recorded at critical stages were significantly higher with application of N. These values showed positive correlation (0.78 to 0.85 in rainy season and 0.78 to 0.90 in winter season) in both seasons at all crop-growth stages, indicating use of LCC as a tool for N top-dressing. Thus increased N fertilizer efficiency at high yield levels is possible in hybrids and high-yielding varieties using a chlorophyll meter and LCC to monitor leaf N status and guide fertilize N timing in irrigated rice. These methods not only reduced N requirement but also improved congruence of N supply and crop demand than fixed timing of N application treatment.

Key words : Nitrogen management, SPAD meter, LCC, Cultivars, Hydrids, Rice

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Rice yields are decelerating or stagnating with indiscriminate use of chemical fertilizers, especially nitrogenous one due to its easy availability and cheaper cost causing environmental pollution and more incidences of pests and diseases. The tendency of increased application of N fertilizer is very common with our farmers, as they attribute the crop greenness and growth due to N application to yields of the rice crop. Blanket or package fertilizer recommendations over large areas are not efficient because of indegenous nutrient supply varies among rice fields. Hence there is a need to synchronize N fertilizer application to plant needs to optimize nutrient use and minimize environmental pollution. Appro- priate diagnosis of N status in leaves is necessary to decide about the top-dressing of fertilizer N. Improving the congruence between crop N demand and the available N supply from soil and applied fertilizer N is one strategy to increase N-use efficiency in these system (Shiga *et al.*, 1977). There are 2 methods of non-destructive diagnosis of nitrogen status in leaves (leaf greenness) by chlorophyll meter (SPAD-502) and leaf colour chart (LCC) (Balasubramanian *et al.*, 1999). However, they require testing under different environmental conditions and adjustment to different rice varieties such as those grown in southern India.

MATERIALS AND METHODS

The field experiment was carried out during the rainy and winter seasons of 1997–98 at Directorate of Rice Research, Rajendranagar, Hyderabad, Andhra Pradesh, to evaluate the performance of 3 high-yielding rice varieties ('Rasi', 'Krishna Hamsa' and 'Vikas', 3 hybrids ('VRH 4', 'DRRH 1' and 'Pro Agro 6201') and 3 scented varieties ('Kasturi', 'Pusa Basmati' and 'IET 13549') with the objectives to compare different approaches of N management, assess the varietal differences in SPAD and LCC readings and correlate SPAD readings with LCC readings with grain yield for future work. The trials were conducted in split- plot design with 5 main-plot treatments consisting of 4 nitrogen levels (0,45, 90 and 135 kg N/ha, applied in 2 splits–half at basal + half at maximum tillering) along with SPAD-based N management. Rice cultivars (9) of 3 different groups were taken as subplot treatments. The critical or threshold SPAD value of 35 was used uniformly for all varieties whenever it fell below 35, N was applied. A single threshold SPAD value of 35 which represents nitrogen availability (N_a) of about 1.4 g N/m^2 leaf area, was used to determine the need for top-dressing. This threshold appears to be sufficient to achieve potential yield levels with 'IR 72' in both the seasons under IRRI experimentation. Mean N applied with SPAD N treatment was 75 and 80 kg/ha in rainy and winter seasons respectively. Correlation was worked between chlorophyll meter values and grain yields, leaf-colour chart readings vs grain yield as well as SPAD-502 vs LCC at different growth stages to assess the relationship. The experiment was conducted in typical Vertisol having soil pH (1:2) 8:2; CEC 43.5 centimole (P^+/kg), organic carbon content 0.58% and $KMnO_4$-N 165 kg/ha; Olsens' P 25.52 kg/ha and exchangeable K (ammonium acetate-K) 217.46 kg/ha in

Table 1. Effect of varieties and nitrogen levels on grain yield (tonnes/ha) during rainy and winter seasons of 1997–98

Treatment	Nitrogen (kg/ha)											
	0		45		90		135		SPAD-N*		Mean	
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
High-yielding variety												
'Rasi'	2.24	3.39	2.79	4.37	4.82	4.54	4.34	5.51	5.04	4.95	3.85	4.55
'Vikas'	2.25	3.16	3.48	4.15	4.00	4.79	4.20	5.47	4.58	5.52	3.70	4.62
'Krishna Hamsa'	2.14	3.49	4.20	4.18	4.17	6.00	4.40	5.65	4.80	5.81	3.94	5.03
Mean	2.21	3.35	3.49	4.23	4.33	5.11	4.31	5.54	4.81	5.43	3.83	4.73
Hybrid												
'ProAgro'	2.92	3.28	4.36	4.69	5.93	6.41	5.76	5.98	6.25	5.64	5.04	5.20
'DRH 1'	2.59	3.57	4.26	4.73	5.66	5.53	5.66	5.64	5.93	5.40	4.82	4.97
'VRH 4'	2.41	3.41	3.80	4.64	5.72	6.41	5.58	5.65	5.98	6.45	4.70	5.31
Mean	2.64	3.42	4.14	4.69	5.77	6.12	5.67	5.76	6.05	5.83	4.85	5.16
Scented variety												
'Kasturi'	1.57	2.30	2.96	2.85	3.17	3.06	2.58	3.26	3.09	3.10	2.67	2.91
'Pusa Basmati'	2.23	2.22	3.03	2.50	3.41	2.83	2.99	2.41	3.14	3.06	2.96	2.60
'IET 13549'	2.05	2.59	2.81	3.85	3.92	4.38	3.61	4.68	4.35	4.70	3.35	4.04
Mean	1.95	2.37	2.93	3.07	3.50	3.42	3.06	3.45	3.53	3.62	2.99	3.19
Mean of N	2.27	3.05	3.52	4.00	4.54	4.88	4.35	4.92	4.80	4.96	3.89	4.36
CD (P=0.05)			*Wet*	*Dry*								
Nitrogen			0.26	0.37								
Variety			0.46	0.43								
Interaction			Sig	Sig								
M×S			1.0	0.92								
S×M			0.98	0.92								
AEN			27.77	21.11	25.11	20.33	15.40	13.85	33.73	23.87		
AFP			78.22	88.88	50.33	54.22	32.22	36.44	64.00	62.00		

AEN-Grain yield in fertilized plot–grain yield in control/fertilizer N; PFP-grain yield/fertilizer N; N in SPAD–N-rainy season 75 and winter 80 kg/ha

Table 2. Mean SPAD-502 and LCC values as influenced by varieties

Treatment	Rainy season								Winter season							
	30 DAT		60 DAT		90 DAT		Mean		30 DAT		60 DAT		90 DAT		Mean	
	SPAD	LCC	SPAD	LCC	SPAD	LCC	SPAD	LCC	SPAD	LCC	SPAD	LCC	SPAD	LCC	SPAD	LCC
High-yielding variety																
'Rasi'	33.95	4.36	34.39	4.45	34.12	4.52	34.15	4.44	34.94	5.00	34.62	4.70	34.61	4.55	35.21	4.70
'Vikas'	34.53	4.51	34.39	4.76	33.63	4.69	34.18	4.65	35.85	4.98	35.08	4.95	35.81	5.00	35.83	4.99
'Krishna Hamsa'	34.40	4.46	34.17	4.78	34.02	4.80	34.20	4.68	35.80	5.08	35.02	5.13	34.56	5.13	35.64	5.11
Mean	34.29	4.44	34.32	4.66	33.92	4.67	34.18	4.59	35.53	5.02	34.91	4.93	34.99	4.89	35.56	4.94
Hybrid																
'ProAgro'	34.69	4.85	34.56	5.31	33.78	4.86	35.75	5.07	35.49	5.11	36.16	5.56	35.44	5.64	37.48	5.65
'DRH 1'	35.87	5.12	35.34	5.23	35.04	4.91	35.42	5.09	36.52	5.28	37.04	5.81	35.68	5.60	36.70	5.49
'CRH 4'	37.05	5.23	35.74	5.16	34.43	5.01	34.34	5.01	36.64	5.35	37.38	5.85	37.52	5.80	35.98	5.46
Mean	35.87	5.07	35.21	5.23	34.42	4.93	35.17	5.05	36.22	5.25	36.86	5.74	36.21	5.68	36.72	5.54
Scented variety																
'Kasturi'	35.67	5.19	34.82	5.53	34.60	5.00	35.03	5.24	35.77	5.45	38.10	5.98	38.87	5.82	36.44	5.70
'Pusa Basmati'	35.80	5.17	35.66	5.47	34.37	4.88	35.28	5.17	36.50	5.11	38.44	5.85	36.61	5.76	36.88	5.54
'IET 13549'	34.68	5.21	35.38	5.53	34.09	4.89	34.72	5.21	36.80	5.28	36.43	5.79	36.12	5.64	36.53	5.45
Mean	35.38	5.19	35.29	5.51	34.23	4.92	35.01	5.21	36.36	5.28	37.66	5.87	37.20	5.74	36.62	5.56
Overall mean	35.18	4.90	34.94	5.14	34.19	4.84	34.79	4.95	36.03	5.18	36.47	5.51	36.14	5.44	36.30	5.35
CD (P=0.05)	0.81	0.17	0.79	0.21	1.17	0.26			0.83	0.22	1.15	0.20	0.77	0.27		

DAT, Days after transplanting; SPAD, soil and plant analysis development; LCC, leaf colour chart the surface soil of 20 cm depth.

The SPAD-502 meter measurement was taken at critical crop-growth stage for the top-most fully expanded leaf. A minimum of 10 readings at randomly selected hills were taken from each treatment plot and average values recorded. Similarly, the colour chart readings were also taken at the same time. The other fertilizers, P and K and pest management were done as per the recommended practice/rate (60 and 40 kg/ha) and time of application uniformly.

RESULTS AND DISCUSSION

The effect of nitrogen application had significant influence on grain yield in both seasons. Averaged over the varieties, the SPAD-based N application resulted in significantly maximum grain yield over N (135 kg N/ha) during rainy season, while they were comparable during winter 1997. Similarly, SPAD-N resulted in higher yields than fixed-timing of N in wet season than dry season (Peng *et al.*, 1996). The grain yield increase was 45 and 43% (mean of seasons) over the control with SPAD-N and N-135 respectively (Table 1). Mean over varieties the amount of N applied with SPAD-based application was 75 and 80 kg N/ha during the rainy and winter season respectively.

Among the cultivars, averaged over N levels, hybrids recorded higher grain yields than high-yielding and scented varieties. The hybrid 'ProAgro 6201' recorded the maximum grain yield than others in the rainy season and comparable yield with 'VRH 4' during winter season. Mean over the seasons and N levels, hybrids recorded 38.3 and 24.57% higher grain yield over

Table 3. Mean SPAD-502 and LCC values as influenced by nitrogen

Treatment	Rainy season								Winter season							
	30 DAT		60 DAT		90 DAT		Mean		30 DAT		60 DAT		90 DAT		Mean	
	SPAD	LCC	SPAD	LCC	SPAD	LCC	SPAD	LCC	SPAD	LCC	SPAD	LCC	SPAD	LCC	SPAD	LCC
N_0	28.01	3.29	26.87	3.42	29.55	3.06	28.14	3.26	26.35	3.84	28.77	3.86	29.67	3.70	29.87	3.80
N_{45}	34.76	4.46	35.94	4.45	33.82	3.87	34.84	4.26	36.39	4.37	35.78	5.05	35.38	5.13	35.85	4.85
N_{90}	37.42	5.14	36.76	5.58	35.98	5.46	36.72	5.39	38.08	5.51	37.53	5.88	37.86	5.83	37.82	5.74
N_{135}	37.75	5.82	37.66	6.10	35.99	5.59	37.13	5.84	39.23	6.05	41.50	6.38	40.19	6.13	39.12	6.19
N-SPAD	37.98	5.78	37.46	6.13	35.83	6.21	37.09	6.04	40.12	6.13	38.80	6.38	37.57	6.39	38.84	6.30
Mean	35.18	4.90	34.94	5.14	34.23	4.84	34.79	4.96	36.03	5.18	36.47	5.51	36.14	5.44	36.30	5.37
CD (P=0.05)	0.52	0.17	0.88	0.21	0.69	0.16			0.59	0.17	1.31	0.10	0.98	0.32		

SPAD, Soil and plant analysis development; LCC, leaf colour chart

DAT, Days after transplanting

scented and high-yielding varieties respectively.

The agronomic efficiency (kg grain/kg N) was higher for SPAD-based N application than N application at different levels (2 splits application). Partial factor productivity (kg grain/unit N) was higher for SPAD-based N application than maximum dose of N application (N 135 kg/ha).

At the same growth-stage varieties exhibited different SPAD and LCC values. Among the cultivars, higher SPAD and LCC values were recorded with scented varieties at all the growth stages than high-yielding ones but on par with hybrids (Table 2). Although this higher values did not reflect on the grain yield, which signifies the inherent trait of some genotypes to show a consistent greenness right from the planting to maturity. In such cases fixing of constant SPAD value of 35 for all the cultivars doES not work. This attribute might also mislead us by giving a false idea of having high leaf nitrogen; lead to the insufficient application of nitrogen fertilizer, finally resulting in low grain yields. Peng *et al.* (1993) also suggested adjustment of SPAD values for specific leaf

Table 4. Correlation coefficient values ('r) between SPAD vs LCC and SPAD and LCC vs grain yield during rainy and winter seasons

Parameter	LCC 30	LCC 60	LCC 90	SPAD 30	SPAD 60	SPAD 90	Grain yield
			Rainy season 1997				
LCC 30	1.00	0.93**	0.88**	0.85**	0.83**	0.80**	0.58**
LCC 60		1.00	0.91**	0.84**	0.81**	0.78**	0.58**
LCC 90			1.00	0.84**	0.81**	0.84**	0.70**
SPAD 30				1.00	0.88**	0.87**	0.63**
SPAD 60					1.00	0.90**	0.67**
SPAD 90						1.00	0.68**
Grain yield							1.00
			Winter 1997–98				
LCC 30	1.00	0.86**	0.86**	0.81**	0.78**	0.72**	0.51**
LCC 60		1.00	0.95**	0.84**	0.86**	0.74**	0.40**
LCC 90			1.00	0.89**	0.88**	0.75**	0.44**
SPAD 30				1.00	0.85**	0.67**	0.53**
SPAD 60					1.00	0.92**	0.36*
SPAD 90						1.00	0.36*
Grain yield							1.00

** P=0.05 and 0.01; * P=0.05

SPAD, Soil and plant analysis development; LCC, leaf colour chart

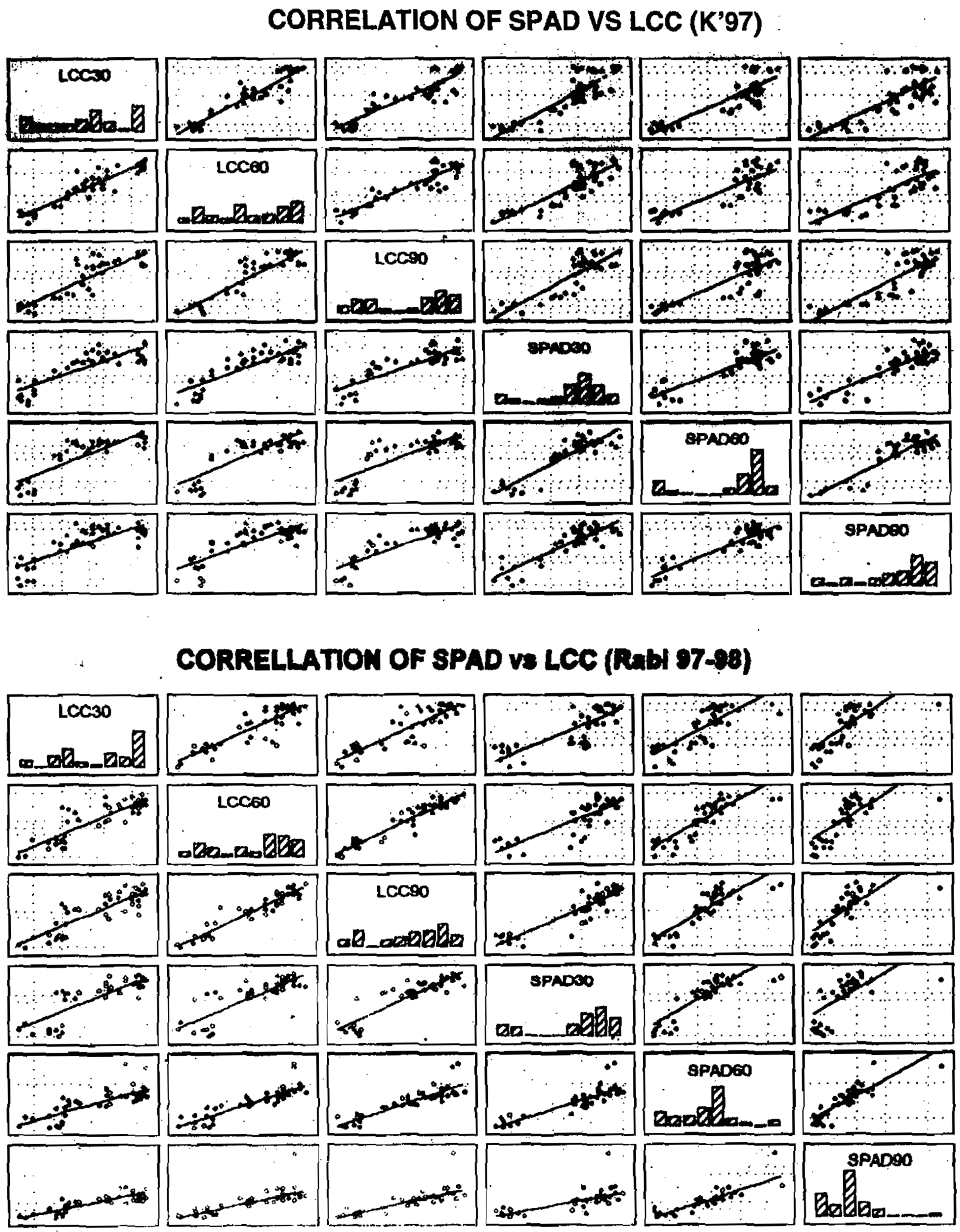

Fig 1. Correlation of SPAD-502 vs LCC at different growth stages of rice

weight (SLW) for getting stronger relationship between SPAD vs LCC.

The SPAD and LCC values increased significantly with the increase of N (Table 3). In general, higher SPAD and LCC values were observed during winter season, indicating better growth and higher N content. The SPAD and LCC values higher N application (N 135 kg/ha) and SPAD-N application was comparable and superior to other treatments. However, the lower amount of N applied in SPAD-based N indicates that we can save about 50–55 kg N/ha.

The mean SPAD values and leaf colour chart readings were positively correlated at all growth stages with mean grain yield of the cultivars (0.58–0.70 and 0.36–0.53 in rainy and winter season respectively). The correlation ('r') values between SPAD vs LCC at different growth stages were also significant and positively correlated at all the growth stages in both seasons. The 'r' values ranged from 0.78 to 0.93 in rainy and 0.67 to 0.95 in winter reason (Fig. 1). The positive significant correlation of these parameters indicates that the top-dressing of nitrogen can be practised based on the colour chart values also. These colour charts can be prepared at low cost and are freely available and easy to handle in the field as compared to chlorophyll meter, which is expensive and requires technical skill for operation. The colour charts are well accepted by farmers in developing countries which will benefit significantly by adjusting N inputs to actual crop condition and nutrient requirement. The use of colour charts for top-dressing of N not only reduces the N requirement but also enhances NUE as N is applied based on the requirement of the crop. The lower amount of N applied in SPAD-based N management indicates that 50–55 kg N/ha can be saved with out any yield loss.

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