

**EVALUATION OF SPAD AND LCC BASED NITROGEN
MANAGEMENT IN RICE (*Oryza sativa* L.)**

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Abstract

A study was conducted during Boro and T. Aman seasons of 2002 at Bangladesh Rice Research Institute (BRRI), Gazipur to see the relationship of SPAD (Soil plant analysis development) reading with chlorophyll and N contents of leaves and to determine the critical LCC value for rice crops. Hybrid varieties Sonarbangla-1 and BRRI hybrid dhan01 were used for both rice crops and BRRI dhan29 and BRRI dhan31 were used as checks for Boro and T. Aman crops, respectively. Sonarbangla-1, BRRI hybrid dhan01 and BRRI dhan29 had similar leaf chlorophyll contents in Boro season. The maximum chlorophyll content (1.6-1.8 mg/g leaf) was observed at 39-42 soil plant analysis development (SPAD) value. In T. Aman season, the inbred BRRI dhan31 showed lower amount of chlorophyll (1.2-1.4 mg/g leaf) at 39-42 SPAD value compared to the hybrids Sonarbangla-1 and BRRI hybrid dhan 01. Seasonal variation in chlorophyll content between Sonarbangla-1 and BRRI hybrid dhan01 was not large. Relationship between SPAD value and chlorophyll content was very close ($R^2 \Rightarrow 0.8$) at panicle initiation and flower initiation stages for all the varieties. Similar relationship was also observed in case of SPAD value and nitrogen content in leaves. The results indicated that the rice leaves showing higher SPAD readings (>35) had higher chlorophyll and nitrogen contents. The adjusted critical LCC values were 3.0 for Boro and 3.5 for T. Aman seasons for all rice varieties.

Key Words: Chlorophyll, nitrogen.

Introduction

Nitrogen is the most deficient nutrient element in Bangladesh soils. An adequate supply of nitrogen can increase as much as 60% rice yield (Mikkelsen *et al.*, 1995). Top dressing of N is needed when the crop has a great need for N and when the rate of N uptake is large (Dobermann and Fairhurst, 2000). Crop-demand based N application is one of the important options to reduce N loss and to increase N use efficiency of a crop. Chlorophyll meter (SPAD) or leaf colour chart (LCC) can be used for adjustment of fertilizer N application based on actual plant N status (Balasubramanian *et al.*, 1999). Need based N application would result in greater agronomic efficiency of N fertilizer than the commonly practiced

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method (Hussain *et al.*, 2000). Au (2005) reported that the requirement of N fertilizer based on SPAD reading was found 15 and 40 kg N/ha lower compared to conventional N management during wet and dry seasons, respectively. The SPAD value-based N application can increase grain yield and N use efficiency of both hybrid and inbred varieties and hybrid can give an advantage of 6.5 % due to heterosis over the inbred varieties (Peng *et al.*, 1998). The SPAD meter- based N management appeared to be more efficient and would save 20-30 kg N/ha than the conventional N management practices to produce similar grain yield (Miah and Abmed, 2002). Tropical hybrid rice generally has thinner leaves and a slightly lower leaf N concentration than inbreds. So, the SPAD threshold for tropical hybrids will be slightly less than that of inbred cultivars. A SPAD threshold value of 35 is equivalent to 1.4-1.5 g N/m² leaf area in semi-dwarf indica varieties (Peng *et al.*, 1996).

However, in Bangladesh, most research works have so far been focused mostly on the rate and timing of N application without considering the initial soil nitrogen and crop demand. So, a study is needed on crop-demand based N management through assessing the soil plant analysis development (SPAD) value and to correlate SPAD values with leaf colour chart (LCC) reading for specific variety and season. The present study was, therefore, undertaken to determine relationship between SPAD reading and N and chlorophyll content in rice leaves, iv) determine critical threshold LCC value of hybrid and inbred rice varieties.

Materials and Method

Site and soil

Field experiments were conducted at the experimental farm of the Bangladesh Rice Research Institute (BRRI), Gazipur during Boro and T. Aman seasons 2002. The soil was silty clay loam and slightly acidic (pH 6.2) with total N 0.11% and organic matter (OM) 2.05%.

Treatments

The experiment was conducted in a randomized complete block design (RCBD) with 3 replications. It was a 2 factor experiments, one factor was N management and the other factor was rice variety. There were 10 N management treatments:

N₀= Control (No)

N₁= 40 kg N/ha in 2 equal splits at early tillering (ET) and panicle initiation (P1) stage

N₂= 80 kg N/ha in 2 equal splits at ET and P1 stage

N₃= 120 kg N/ha in 3 equal splits at basal, mid-tillering (MT) and P1 stage

N₄= 120 kg N/ha in 3 equal splits at ET, MT and P1 stage

N₅= 160 kg N/ha in 4 equal splits at basal, MT, P1 and heading stage

N₆= 160 kg N/ha in 4 equal splits at ET, MT, P1 and heading stage

N₇= 30 kg N/ha at ≤ 35 Soil Plant Analysis Development (SPAD) value with basal 30 kg N/ha

N₈= 30 kg N/ha at ≤ 35 SPAD value (from 20 DAT to heading) without basal N

N₉= 80 kg N/ha as USG deep placement [3 granules (0.9 g size) in-between alternate 4 hills]

Concerning varieties, hybrid Sonarbangla-1 and BRRI hybrid dhan01 were common and inbred varieties BRRI dhan29 and BRRI dhan31 were used in Boro and T. Aman seasons, respectively.

Cultural operations

The experiment was laid out in a randomized complete block design (RCBD) with three replications, the unit plot size being 4 m x 4 m. Transplanting was done with 40-day and 25-day old seedlings in Boro and T. Aman season, respectively. One healthy seedling (for both hybrid and inbred varieties) was transplanted in a spacing of 20 x 20 cm. Gap filling for dead seedling was done within 10 days after transplanting (DAT). Fertilizers were applied @ 26-41-10-5 kg/ha P, K, S and Zn (blanket dose) as basal before transplanting. Cultural practices for weed and pest management were done as and when necessary.

SPAD reading

The SPAD meter is a simple portable diagnostic tool used for monitoring crop N status *in situ* in the field. To achieve the maximum yield target, the N concentration of the upper most fully expanded leaf must be maintained at or above 1.4 g N/m² (leaf area basis). Leaf N status at this critical level gives a SPAD value of 35 regardless of genotypes (Dobermann and Fairhurst, 2000). The SPAD reading was taken by a chlorophyll meter (SPAD-502, Minolta Camera Co., Japan). The LCC is a plastic scale with a green colour gradient from 1 to 6 (very light green to dark green) by which greenness of rice leaves can be measured. Data for SPAD and LCC values were collected from the same leaves from 20 DAT at 7-day intervals up to 50% flower initiation. The SPAD and LCC readings were taken from the middle portion of the fully expanded youngest leaves from 5 randomly selected hills. When the SPAD reading came down to critical value 35, corresponding LCC value was considered as critical LCC value of that variety.

Determination of N and chlorophyll content in rice leaves

To establish the relationship between SPAD value and N content and chlorophyll content in the leaves, the leaves were harvested just after taking the SPAD

readings. This sampling was done at panicle initiation, flowering and hard dough stages. For chlorophyll estimation, harvested leaf samples were taken in a bowl with water with marked SPAD values and numbering. Leaf samples were then immediately taken to the laboratory for subsequent analysis. Leaf samples were segmented, 20 mg sample was weighed and poured into small pots containing 20 ml 80% acetone solution and placed in dark for 48 hours. Chlorophyll was measured from the leaf extract by a spectrophotometer following Yoshida *et al.* (1976) as:

$$\text{Total chlorophyll (mg/g)} = \frac{\text{D652 nm} \times 1000 - \text{mg/liter}}{34.5}$$

where, D652 (nm) = Wave length adjusted during spectrophotometer readings when chlorophyll a and b intersect; 34.5 is the specific absorption coefficient for both pigments at this wave length.

The rest of the leaves were kept in marked envelopes (with SPAD value) and dried in oven at 70°C for 72 hours for subsequent estimation of leaf nitrogen content. Nitrogen concentration in leaves was determined from leaf samples at different growth stages following Kjeldahl wet oxidation method (Page *et al.*, 1982).

Table 1. Critical LCC values of different varieties of rice.

Variety	Critical SPAD value	Critical LCC value
T.aman rice		
Sonarbangla-1	35	3.4 ≈ 3.5
BRRi hybrid dhan01	35	3.4 ≈ 3.5
BRRIdhan31	35	3.4 ≈ 3.5
Boro_rice		
Sonarbangla-1	35	3.0
BRRi hybrid dhan01	35	3.1 ≈ 3.0
BRRIdhan31	35	3.1 ≈ 3.0

Results and Discussion

Relationship between SPAD value and chlorophyll content

Figure 1a and 1b show strong linear relationship between SPAD value and chlorophyll content ($R^2 = 0.9$) at different growth stages. For Boro rice, all varieties had similar leaf chlorophyll content (Figure 1a). In T. Aman, BRRi dhan31 showed lower amount of chlorophyll (1.2-1.4 mg/g) at 39-42 SPAD value compared to the others (Fig. 1b). BRRi dhan29 had about 1.6-1.8 mg chlorophyll/g leaf within the same range of SPAD values in Boro season. Chlorophyll content in rice leaves mostly varied with varieties and seasons. Sonarbangla-1 and BRRi hybrid dhan01 showed similar amount of chlorophyll

content in leaves for both seasons. Boro variety BRRi dhan29 contained higher amount of chlorophyll compared to T. aman variety BRRi dhan31.

Table 2.1. SPAD reading and N content in leaves of BRRi hybrid dhan01 under different nitrogen management, Boro 2002.

N management	PI stage		FI stage		Dough stage	
	SPAD	N content (%)	SPAD	N content (%)	SPAD	N content (%)
Control	33.5	2.82	34.9	1.64	34.0	1.64
40kg N/ha	35.2	3.05	37.8	1.75	36.4	1.75
80kg N/ha	35.7	3.33	39.5	1.88	37.4	1.88
120kg N/ha + Basal	36.8	3.47	39.4	2.00	39.3	2.00
120kg N/ha -Basal	37.0	3.51	41.1	2.12	41.1	2.12
160kg N/ha + Basal	39.5	3.83	42.6	2.20	42.0	2.20
160kg N/ha-Basal	39.2	3.82	40.9	1.99	42.9	1.99
SPAD35+ Basal	36.6	3.60	41.7	2.07	38.4	2.07
SPAD35-Basal	36.0	3.49	38.8	1.89	39.1	1.89
USG(80kg N/ha)	40.0	3.97	37.7	1.79	37.0	1.79

On the other hand, all the hybrid and inbred varieties showed higher amount of chlorophyll at panicle initiation and flowering stages compared to dough stage in both seasons. Considering the R^2 value, the relationship was stronger at panicle initiation and flower initiation stage compared to soft dough stages for all varieties (Fig. 1a and 1b). Mamin (2003) reported a strong, linear and positive relationship between SPAD values and chlorophyll a and b contents.

Relationship between SPAD value and leaf N content

Table 2.1, 2.2 and 2.3 show the relationship between SPAD values and leaf N content (%) of different varieties under different N management at different growth stages in Boro 2002. At critical value SPAD35, Sonarbangla-1 showed about 3.0 %N in leaves at P1 stage, 1.6% at FI stage and 1.3% at dough stage (Table 2.1). BRRi hybrid dhan01 showed 3.2, 1.5 and 1.4% N, respectively, at similar growth stages (Table 2.2). BRRi dhan29 showed 3.4, 1.6, and 1.3% N, respectively, at similar growth stages (Table 2.3). The results indicated that all the varieties showed optimum level (>3.0% N) at P1 stage but deficiency level (<2.0% N) at FI and dough stages (Dobermann and Fairhurst, 2000). On the other hand, the same variety Sonarbangla-1 showed 2.2, 1.5 and 1.2% N, respectively, at P1, FI and dough stage during T. Aman 2002 (Table 3.1). BRRi hybrid dhan01 showed 2.6, 1.35 and 1.15% N, respectively, at similar growth stages (Table 3.2). BRRi dhan31 showed 2.1, 1.5, and 1.3% N, respectively, at similar growth

Table 2.2. SPAD reading and N content in leaves of Sonarbangla-1 under different nitrogen management, Boro 2002.

N management	PI stage		FI stage		Dough stage	
	SPAD	N content (%)	SPAD	N content (%)	SPAD	N content (%)
Control	34.6	3.12	34.4	1.43	33.2	1.30
40kg N/ha	35.9	3.24	36.3	1.63	35.1	1.43
80kg N/ha	36.0	3.34	37.2	1.70	36.0	1.52
120kg N/ha + Basal	36.7	3.46	38.4	1.88	37.7	1.52
120kg N/ha -Basal	38.0	3.54	38.7	1.83	39.4	1.62
160kg N/ha + Basal	39.6	4.05	40.9	1.95	41.1	1.65
160kg N/ha-Basal	39.4	4.01	41.4	1.99	41.0	1.63
SPAD35+ Basal	36.8	3.54	37.2	1.68	35.9	1.43
SPAD35-Basal	36.3	3.41	37.7	1.72	39.0	1.59
USG(80kg N/ha)	40.4	4.08	39.0	1.81	36.3	1.44

Table 2.3. SPAD reading and N content in leaves of BRRI dhan29 under different nitrogen management, Boro 2002.

N management	PI stage		FI stage		Dough stage	
	SPAD	N content (%)	SPAD	N content (%)	SPAD	N content (%)
Control	35.0	3.41	34.5	1.48	34.4	1.30
40kg N/ha	35.7	3.49	34.9	1.57	35.5	1.40
80kg N/ha	36.9	3.56	37.3	1.81	37.2	1.46
120kg N/ha + Basal	37.1	3.60	38.6	1.88	38.0	1.51
120kg N/ha -Basal	37.9	3.61	39.4	1.91	37.6	1.48
160kg N/ha + Basal	41.0	3.88	40.3	2.01	40.9	1.72
160kg N/ha-Basal	40.2	3.79	40.8	1.99	42.7	1.78
SPAD35+ Basal	37.6	3.60	37.9	1.82	36.0	1.41
SPAD35-Basal	38.3	3.63	39.6	1.85	38.6	1.55
USG(80kg N/ha)	40.9	3.88	37.6	1.68	34.7	1.31

stages (Table 3.3). It was clear from the results that the N content in leaves varied in different varieties at different growth stages. Sonarbangla-1 and BRRI hybrid dhan01 showed higher N content in leaves at all growth stages in Boro compared to T. Aman season. There is a strong relationship between SPAD values and leaf N concentration, but this relationship varies with crop growth stage and or variety (Turner and Jund, 1994), mostly because of leaf thickness or specific leaf

weight (Peng *et al.*, 1993). The relationship between leaf N content and SPAD value indicated that when a variety will show higher SPAD value, it has certainly higher amount of nitrogen.

Table 3.1. SPAD reading and N content in leaves of Sonarbangla-1 under different nitrogen management, T. Aman 2002.

N management	PI stage		FI stage		Dough stage	
	SPAD	N content (%)	SPAD	N content (%)	SPAD	N content (%)
Control	35.1	2.22	34.9	1.49	33.5	1.17
40kg N/ha	36.2	2.61	37.8	1.70	35.4	1.22
80kg N/ha	36.9	2.68	39.5	1.85	36.4	1.32
120kg N/ha + Basal	37.3	2.97	39.4	1.92	37.8	1.41
120kg N/ha -Basal	38.6	3.06	41.1	2.12	39.1	1.50
160kg N/ha + Basal	39.5	3.33	42.6	2.20	40.5	1.60
160kg N/ha-Basal	39.7	3.42	40.9	1.99	40.6	1.63
SPAD35+ Basal	38.0	3.25	41.7	2.07	37.0	1.44
SPAD35-Basal	38.0	3.04	38.8	1.74	36.0	1.37
USG(80kg N/ha)	41.0	3.62	37.7	1.79	36.5	1.38

Table 3.2. SPAD reading and N content in leaves of BRRI hybrid dhan01 under different nitrogen management, T. Aman 2002.

N management	PI stage		FI stage		Dough stage	
	SPAD	N content (%)	SPAD	N content (%)	SPAD	N content (%)
Control	35.4	2.83	34.9	1.33	34.2	1.10
40kg N/ha	36.4	2.90	36.3	1.53	35.1	1.19
80kg N/ha	37.0	3.04	37.2	1.65	36.2	1.27
120kg N/ha + Basal	37.5	3.08	38.4	1.78	37.2	1.37
120kg N/ha -Basal	38.0	3.24	39.0	1.73	38.2	1.57
160kg N/ha + Basal	40.1	3.56	40.9	1.90	41.6	1.65
160kg N/ha-Basal	39.4	3.50	41.4	1.79	42.0	1.63
SPAD35+ Basal	37.4	3.12	37.5	1.58	36.4	1.33
SPAD35-Basal	36.3	2.78	36.7	1.47	36.6	1.29
USG(80kg N/ha)	40.9	3.84	40.0	1.81	36.8	1.44

Table 3.3. SPAD reading and N content in leaves of BRRI dhan31 under different nitrogen management, T. Aman 2002.

N management	PI stage		FI stage		Dough stage	
	SPAD	N content %	SPAD	N content %	SPAD	N content %
Control	34.9	2.09	34.2	1.56	34.1	1.19
40kg N/ha	36.3	2.27	36.1	1.61	34.8	1.31
80kg N/ha	37.3	2.35	36.0	1.66	35.4	1.31
120kg N/ha + Basal	39.8	2.62	37.8	1.84	37.1	1.44
120kg N/ha -Basal	41.1	2.90	37.8	1.78	37.5	1.52
160kg N/ha + Basal	42.7	3.00	39.8	2.05	40.8	1.68
160kg N/ha-Basal	42.0	2.99	40.1	2.08	40.6	1.73
SPAD35+ Basal	36.2	2.38	37.9	1.91	36.8	1.48
SPAD35-Basal	35.9	2.38	37.9	1.83	37.0	1.46
USG(80kg N/ha)	39.1	2.62	39.0	1.98	36.2	1.41

Changing pattern of SPAD and LCC readings

Figure 3a shows that Sonarbangla-1 reached critical SPAD value (35) at 27 DAT and at 55 DAT in T₈. At that time, the LCC reading was 3.0. On the other hand, Sonarbangla-1 reached a much lower SPAD value of 30 at 20 DAT and at critical SPAD value in between 55 and 62 DAT in N₈. The critical level of LCC reading was found to be 3.0 for Sonarbangla-1 in Boro season. Similarly, BRRI hybrid dhan01 reached critical SPAD value at 27 DAT, in between 55 and 62 DAT and in between 76 and 83 DAT in N₇. At that time, the LCC reading was about 3.0. On the other hand, BRRI hybrid dhan1 reached a much lower SPAD value at 20 DAT and at critical SPAD (35) in between 55 and 62 DAT and 76 and 83 DAT in N₈. The critical value of LCC reading was in between 3.0 and 3.2 for BRRI hybrid dhan01 in Boro season (Fig. 3b).

BRRI dhan29 reached at critical SPAD (35) value at 27 DAT in between 55 and 62 DAT and 76 and 83 DAT in N₇. At the time of interception with critical SPAD value, the LCC reading was 3.0 for N₇. On the other hand, BRRI dhan29 reached a much lower SPAD value (32) at 20 DAT and at critical SPAD level (35) in between 55 and 62 DAT and 76 and 83 DAT for N₈. Therefore, the critical level of LCC reading might be in between 3.0 and 3.2 for BRRI dhan29 (Fig. 3c).

Figure 4a indicates that Sonarbangla-1 reached critical SPAD value (35) only at 55 DAT in N₇ where basal N was applied. At that time, the LCC reading was 3.4. On the other hand, Sonarbangla-1 reached critical SPAD value at 48 DAT in N₈ when basal N was not applied. At that time the LCC reading was 3.4. So, the critical level of LCC reading might be 3.4 for Sonarbangla-1 in T. Aman season.

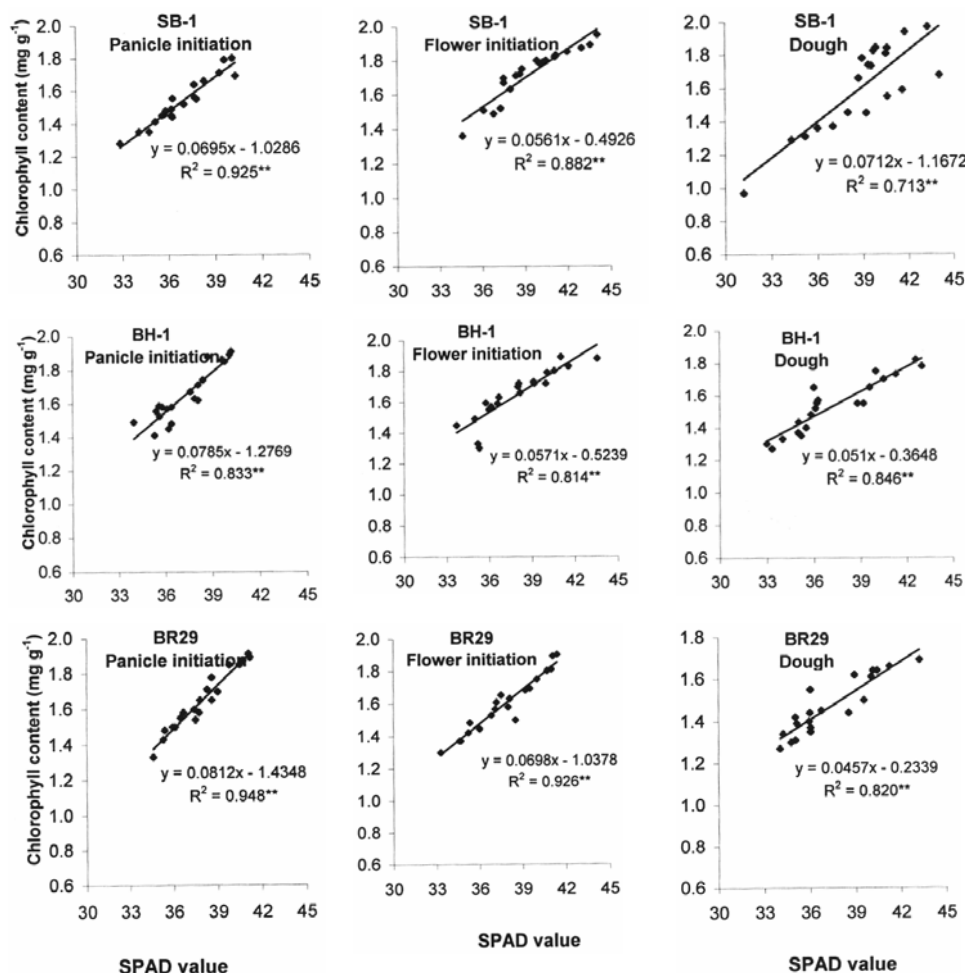


Fig. 1a. Relationship between chlorophyll content in leaves and SPAD values of different varieties at different growth stages in Boro rice. (SB-1= Sonarbangla-1, BH-1=BIRRI hybrid dhan01 and BR29= BIRRI dhan29).

Fig. 4b shows that BIRRI hybrid dhan01 reached critical SPAD value (35) only at 55 DAT in N₇ when basal N was applied. At that time, the LCC reading was 3.4. On the other hand, BIRRI hybrid dhan01 reached at critical SPAD level at 48 DAT in N₈ when basal N was not applied. At that time, the LCC reading was 3.4. So, the critical level of LCC reading might be 3.4 for BIRRI hybrid dhan01 in T. Aman. BIRRI dhan31 reached critical SPAD value (35) only at 55 DAT in N₇ when basal N was applied. At that time, the LCC reading was 3.4. On the other hand, BIRRI dhan31 reached at critical level in between 41 and 48 DAT in N₈ when basal N was not applied. At that time the LCC reading was 3.4 (Fig. 4c). So, the critical level of LCC reading might be 3.4 for BIRRI dhan31 in T. Aman.

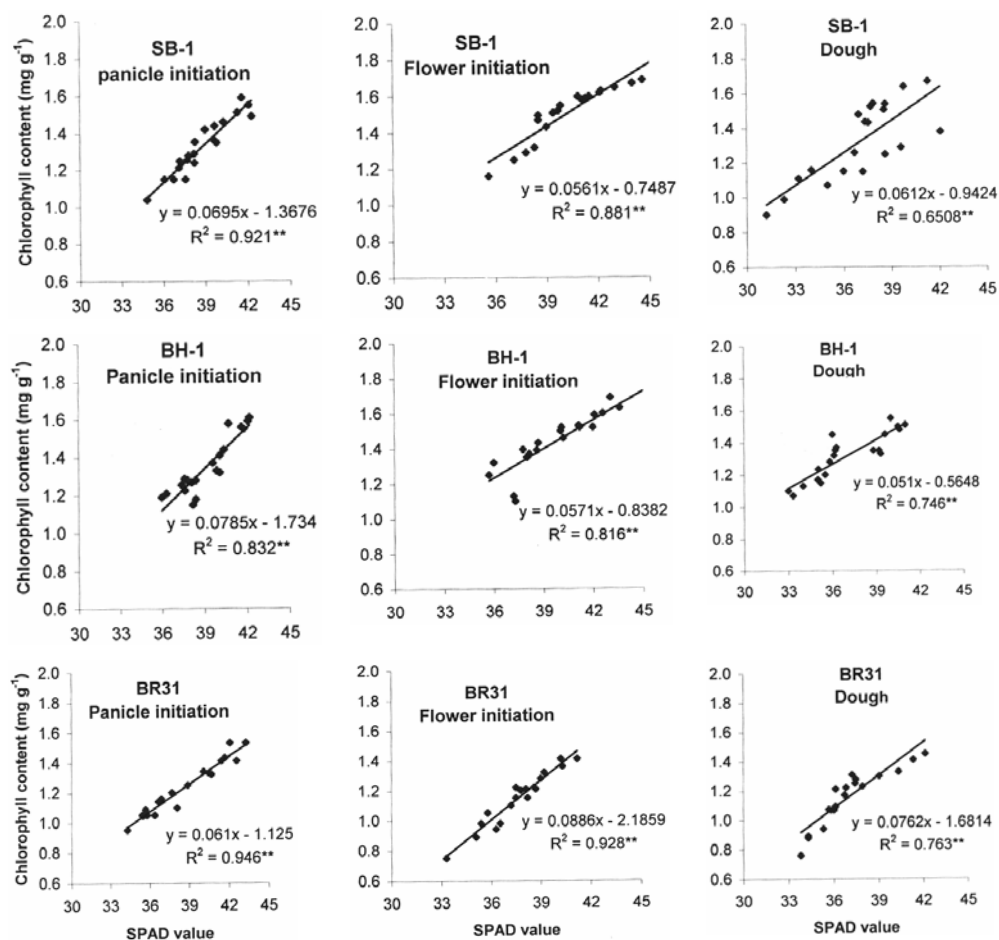


Fig. 1b. Relationship between chlorophyll content in leaves and SPAD values of different varieties at different growth stages in T.Aman rice. (SB-1= Sonarbangla-1, BH-1=BRI hybrid dhan01 and BR29= BRI dhan31).

From the above results, it is clear that the critical LCC value for BRI dhan29 was 3.0 in Boro season and for BRI dhan31 was 3.4 in T. Aman. This finding is in agreement with that reported by Islam *et al.* (1998). The hybrid varieties Sonarbangla-1 and BRI hybrid dhan01 expressed critical LCC reading of 3.0 in Boro season and 3.4 in T. Aman season. Thus, leaf colour is a reliable indicator of N-status in plants, which might vary from season to season and variety to variety. Although leaf colour is a genetic character, little difference in leaf colour was observed with the varieties under study. The critical LCC values of different varieties based on SPAD 35 threshold value have been summarized in Table 1. Critical LCC values need to be adjusted with nearest whole number or 0.5 unit for practical readability.

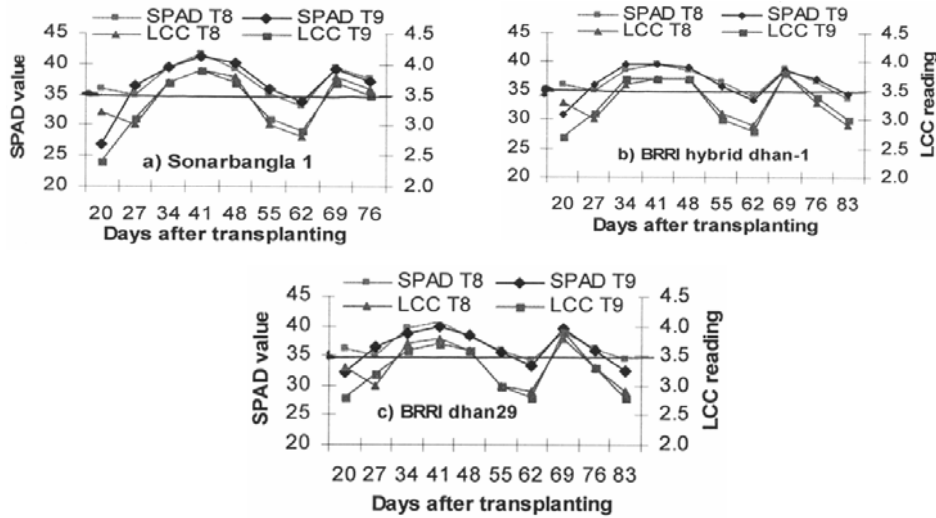


Fig. 2a, b and c, Changing pattern of SPAD and LCC value of 3 variety at different DAT in Boro rice.

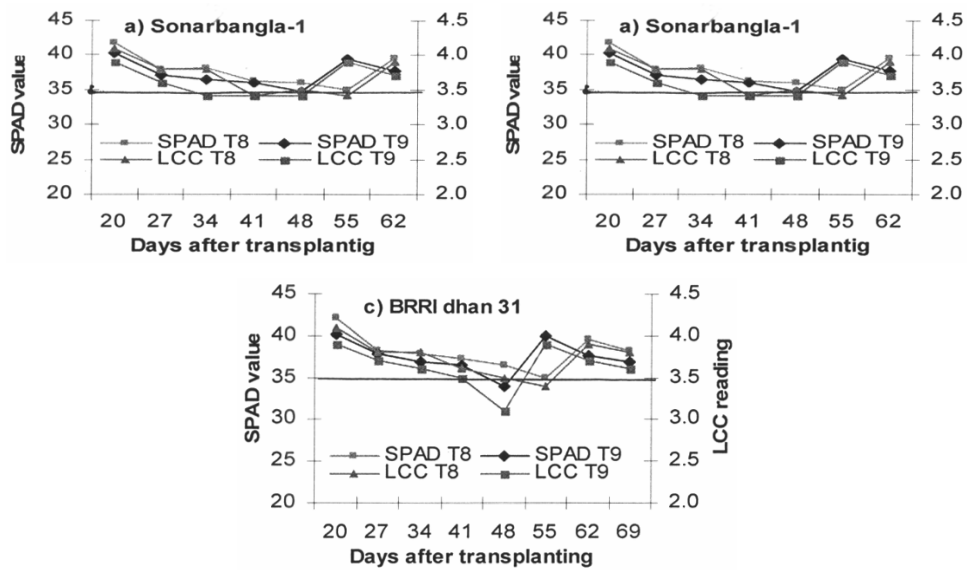


Fig. 3a, b and c. Changing pattern of SPAD and LCC value of 3 varieties at different DAT in T.Aman rice.

Conclusion

It may be concluded that when rice leaves will show >35 SPAD value, it has higher amount of chlorophyll as well as nitrogen. The adjusted critical LCC value is 3.0 for Boro and 3.5 for T. Aman seasons.

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