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USE OF LEAF COLOUR CHARTS TO DETERMINE NITROGEN REQUIREMENT AND YIELD RESPONSE OF RICE VARIETIES

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ABSTRACT

An experiment was conducted at the Rice Research and Development Institute, Batalagoda to find out the variation in leaf colour of rice varieties with the application of nitrogen and its relation to nitrogen response. Four rice varieties, Bg 300, Bg 305, Bg 250 and Bg R1, as sub plots and four nitrogen levels, 0, 50, 100 and 150 Kg N/ha, as main plots were used with split plot arrangement. Leaf Colour Chart (LCC) readings were taken on uppermost fully expanded leaves at 2 week intervals. Nitrogen response of rice varieties was determined on the basis of grain yield at different N levels. It was observed that LCC readings of nitrogen treated rice plants were always higher than the untreated plants and all the varieties showed significant increase in leaf colour up to 100kg N/ha and thereafter increment was not significant or colour reduction was observed. As seen in the LCC readings, yield response of all rice varieties were only up to 100 kg N/ha and thereafter there was no yield increase due to application of nitrogen. Variety Bg 350 recorded the highest yield followed by Bg 300, Bg 250 and Bg R1. There was a reduction in leaf colour of some rice varieties (Bg 300, Bg 305, Bg 250) at high level of N (150 kg N/ha) and as a result there was a reduction in grain yield of the same rice varieties. Relationships between LCC readings across the growth duration and grain yields of all varieties were positive but the highest relationship ($r^2 > 0.70$) between grain yield and LCC readings was recorded at 4th and 8th weeks after sowing. Change of LCC readings at 4 weeks after sowing with increasing N levels and change of grain yield of varieties at each N level showed a similar trend. According to the above results, it can be suggested that under local conditions leaf colour changes of rice with the N application is a better indicator of N requirement and readings taken at 4 weeks after sowing are highly related to yield response to added N. Therefore, measurement of leaf colour at 4 weeks after sowing using LCC as a tool can be used as a better indicator to screen rice varieties which respond to N fertilizer.

KEYWORDS: Leaf colour charts, Nitrogen response, Rice.

INTRODUCTION

Application of high rate of nitrogen fertilizer has become a common practice in Sri Lankan paddy cultivation because urea is available at subsidised prices. Under present cultivation system of rice, nitrogen recovery is about 30% and as such large amounts of applied nitrogen are lost from the system as ammonia gas and pollute the environment (Sirisena *et al.*, 2001). In addition, uptake of high nitrogen by rice plants increases the bio-mass, decreases the crop yield due to lodging and susceptibility to diseases (Yoshida, 1981). Therefore, management of nitrogen is one of the most important criteria in rice cultivation in Sri Lanka to meet the rice requirement of the country with minimum environmental pollution. Introduction of rice varieties responding to N-fertilizer and application of nitrogen on demand driven basis are the important two criteria to suit the above conditions. At present N response of rice is determined through yield measurements at increased N-level and there is no method developed so far to find out the optimum N levels under local conditions.

Because leaf-N content is closely related to photosynthetic rate (Peng *et al.*, 1995) and biomass production (Kropff *et al.*, 1993), it is a sensitive indicator of the dynamic changes in crop-N demand within a growing season. Therefore, measurement of leaf N content at different N levels is a good indicator to determine the N response of rice. The direct measurement of leaf-N concentration by laboratory procedures is laborious, time consuming, and costly. Such procedures have limited use as a diagnostic tool to determine N response because of the extensive time delay between sampling and obtaining results.

Sirisena *et al.* (2002) did some experiments under local conditions with Minolta SPAD 502 meter and reported that leaf colour measurement with SPAD meter can effectively be used to determine the N responsiveness of rice. Sirisena *et al.* (2003) further reported that SPAD meter results can also be used to cut down N application by ¼ when N is applied on the basis of leaf colour.

The high price of SPAD meter limits its use by individual income-poor farmers. Another simple, quick, and nondestructive method for estimating leaf N status is a LCC. There are several types of LCC developed for determining leaf greenness in rice around the world (Yang *et al.*, 2003). The most common ones are those developed by the International Rice Research Institute (IRRI, 1996). Unlike the SPAD, which measures light absorption, LCC measures leaf greenness and the associated leaf N by visually comparing light reflection from the surface of leaves.

Even though LCC has been tested for real-time N management in the farmers' fields in several other countries (Balasubramanian *et al.*, 1999), limited information is available on the accuracy of LCC in estimating leaf colour changes and N response of rice varieties under Sri Lankan conditions. Therefore, this paper reports the observations made in the change of leaf colour with the N application under local conditions and how LCC can be used as a tool to determine nitrogen response of rice varieties.

MATERIALS AND METHODS

An experiment was conducted at the Rice Research and Development Institute, Batalagoda in *maha* 2005/2006 with the objective of identifying variation in leaf colour of rice varieties with the application of nitrogen and its relation to nitrogen response. Experimental site was Plinthudults in Kurunegala soil series. Soil pH is 6.5 and Olsen's P and exchangeable K contents are at 9 ppm and 70 ppm, respectively. Experimental design was split plot with four replicates. Nitrogen (0, 50, 100, and 150 kg/ha) was designated as main plot and cultivar (Bg 300, Bg 305, Bg 250 and BgR1) was designated as subplots. Bg 300, Bg 305 and Bg 250 were recommended varieties and Bg R1 was an elite breeding line. Pre-germinated seeds were sown as 100 kg seed paddy per hectare. Fertilizer N in the form of urea was split-applied, with 6% at basal, 26% at two weeks after sowing, 44% at 4 weeks after sowing and 24% at 6 weeks after sowing. All plots received 45 kg P_2O_5/ha and 20 kg K_2O/ha and 1 kg Zn/ha at the time of sowing. All basal fertilizers were uniformly broadcasted manually before sowing and incorporated to the soil. At 6 weeks after sowing additional 20 kg K_2O/ha was added to all plots. Pests and diseases were intensively controlled using chemicals to avoid yield losses. Fields were flooded 7 days after sowing and a floodwater depth of 5-10 cm was maintained until 14 d before harvest when fields were drained. The LCC, which has been developed by International Rice Research Institute consisting of six green strips showing increasing greenness with increasing number, was used to take the leaf colour readings. Twenty disease-free rice plants were randomly selected in the plot, and the colour of the youngest fully expanded leaf of the selected plant was compared by placing its middle part on top of the color strip in the LCC. LCC readings were taken before fertilizer application and continued up to 50% flowering stage at two weeks intervals. Each plot was harvested at maturity, grains were air dried for a period of 2-3 weeks to bring down the moisture content to14% and then weighed.

Data were analyzed following analysis of variance (SAS Inst., 1982), and means were compared by DMRT. Relationships of LCC scores to grain yield were determined by regression analysis using data from LCC scores across the growth duration and grain yield.

RESULTS AND DISCUSSION

As shown in Figure 1, LCC readings increased with the application of nitrogen fertilizer. Changing pattern of green colour across the growth duration was similar in all varieties. Analysis of leaf colour readings of rice varieties at different N levels showed significant increase in LCC score with the application N fertilizer. It was observed that irrespective of the varieties, difference of LCC scores between zero and 50 kg N/ha was vary much higher and comparatively lower between 50 and 100 kg N/ha. Difference of LCC scores between 100 kg N/ha and 150 kg N/ha was not as high as earlier.

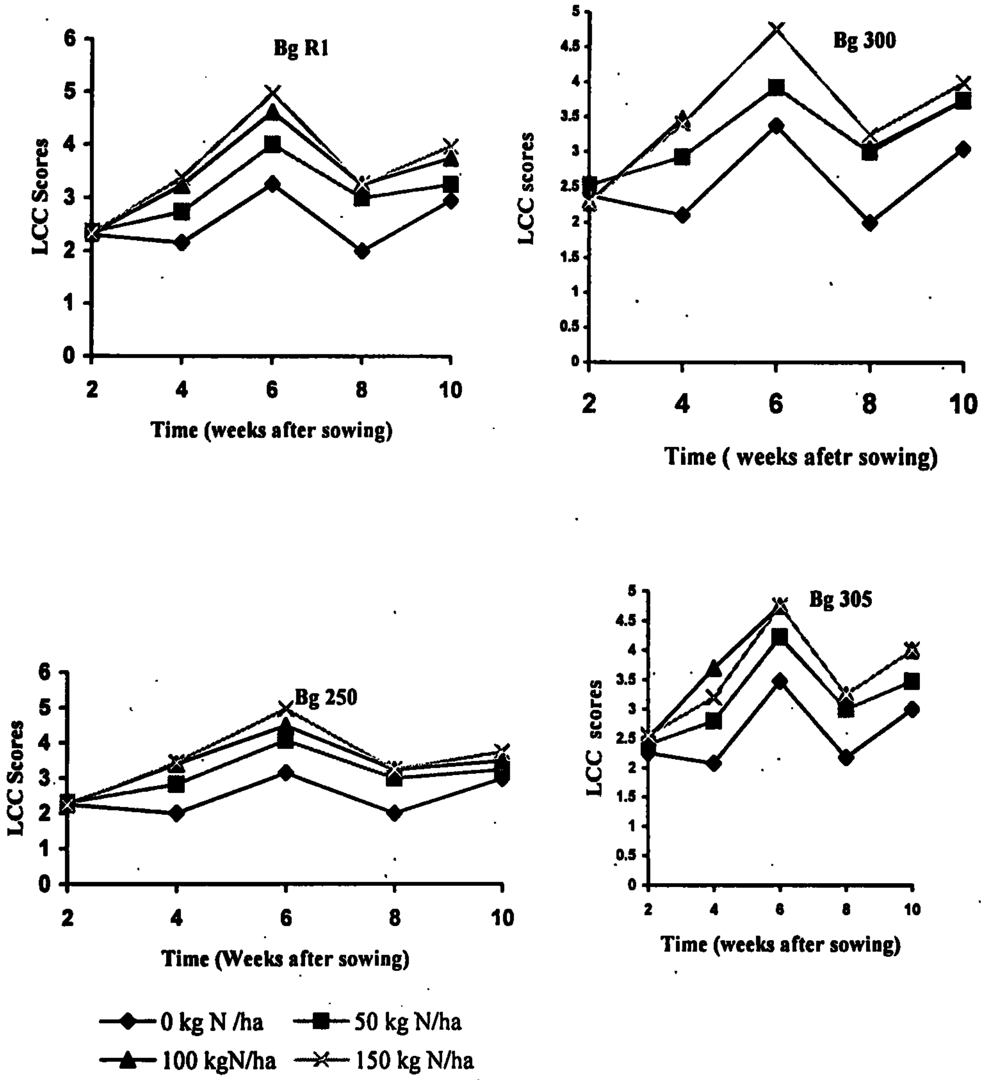


Figure 1. Difference of LCC scores of rice varieties after application of different rates of nitrogen fertilizer.

All the varieties showed positive and linear relationship between nitrogen levels and LCC scores throughout the growth period. Regression coefficient of Bg 305 ranged from 0.64 to 0.95 while that for Bg 300, Bg 250 and Bg R1 varied from 0.36 to 0.87, 0.26 to 1.00 and 0.10 to 0.98, respectively (Table 1).

Table 1. Regression coefficient (r2) between nitrogen levels and LCC scores at different N levels.

Variety	*Regression coefficient (r2) between N levels Vs LCC scores*				
	2 WAS	*4 WAS*	*6 WAS*	*8 WAS*	*10 WAS*
Bg 300	0.36	0.82	0.87	0.62	0.80
Bg 305	0.64	0.95	0.86	0.86	0.89
Bg 250	0.26	0.88	0.96	0.75	1.00
Bg R1	0.10	0.94	0.97	0.75	0.98

As suggested by Singh *et al.* (2002) and results appearing in Figure 1, the critical LCC score for the timing of N topdressing, however, can be determined on the basis of LCC scores across the growth duration. Under local conditions at 4 weeks after sowing, leaf colour of the N zero plots and plots receiving 50 Kg N/ha is around 3 and as such N has to be applied at this time even if the leaf colour score is around 3. At 6 weeks after sowing, leaf colour of all the N levels had gone close to 4.5 even in the N zero plots. At 8 weeks after sowing, average leaf colour was above 3.5. As such critical LCC readings at 2 and 4 weeks should be around 3.0 and at 8th week should be around 3.5. Leaf colour readings at 6 weeks after sowing should be around 4.5 to have a better rice production. Singh *et al.* (2002) reported that N management based on the critical LCC reading of 4.0 with LCC-IRRI helped avoid over-application of N to rice crop. It is seen in this experiment that under local conditions LCC reading to determine N requirement is between 3.5 and 4.5. Results of this experiment agreed with the findings of Balasubramanian *et al.* (1999) that readings of leaf color chart can be tested for real-time N management. It has also been suggested that different threshold LCC values may have to be used for different varietal groups (Balasubramanian *et al.*, 2000) but it is not observed here because all the varieties performed similarly. Therefore, to attain maximum yield with minimum N losses, experiments have to be undertaken to find out the minimum N requirement to achieve the above critical leaf colour readings.

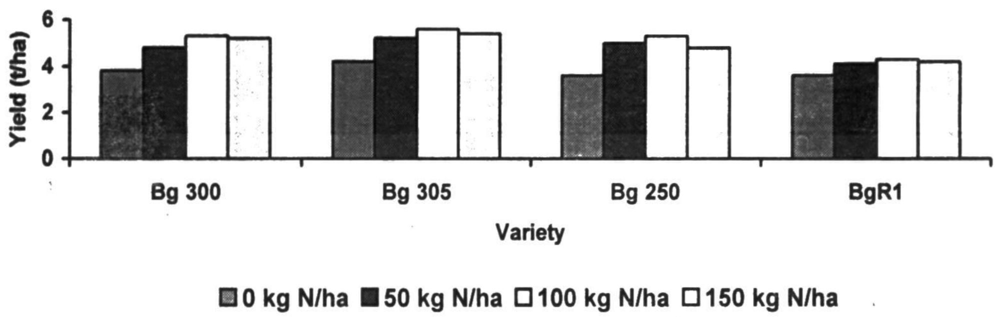


Figure 2. Grain yield of rice obtained with the application of different rates of N fertilizer.

Figure 2 shows that grain yield of rice in all varieties increased with the application of nitrogen. All rice varieties had higher N response to first 50 kg N/ha but comparatively lower response to the second 50 kg N/ha and least to 3rd 50 kg N/ha. All the varieties had a little reduction in yield at 150 kg N/ha.

Relationship between grain yield and pooled values of LCC readings across growth stages is shown in Figures 3, 4, 5 and 6. It is clear from these results that better linear relationships between LCC scores and grain yield were obtained at 4 and 8 weeks after sowing and $r^2 > 0.75$.

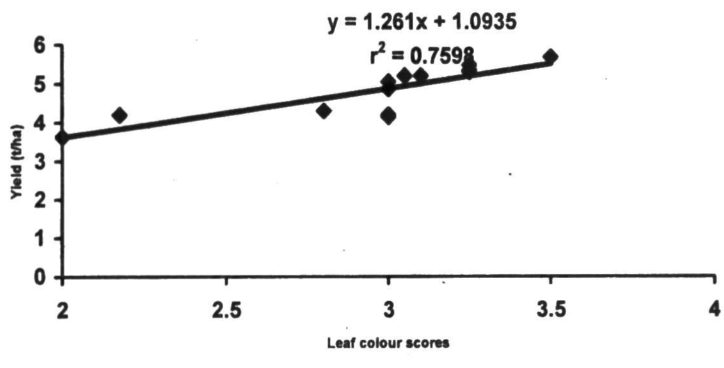


Figure 3. Relationship between LCC scores pooled data and grain yield of rice grown under different N levels at 4 weeks after sowing.

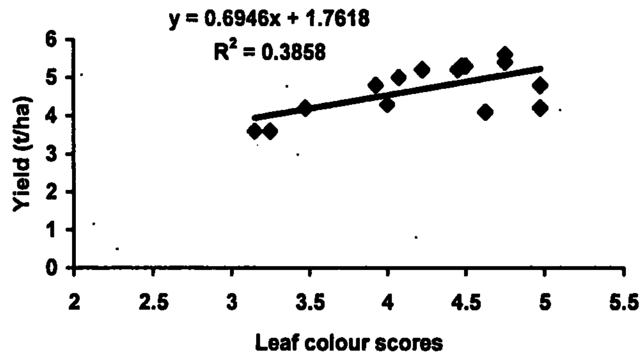


Figure 4. Relationship between LCC scores pooled data and grain yield of rice grown under different N levels at 6 weeks after sowing.

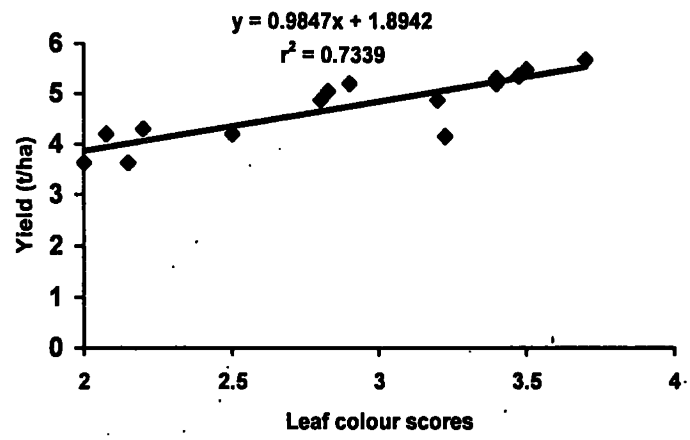


Figure 5. Relationship between LCC scores pooled data and grain yield of rice grown under different N levels at 8 weeks after sowing.

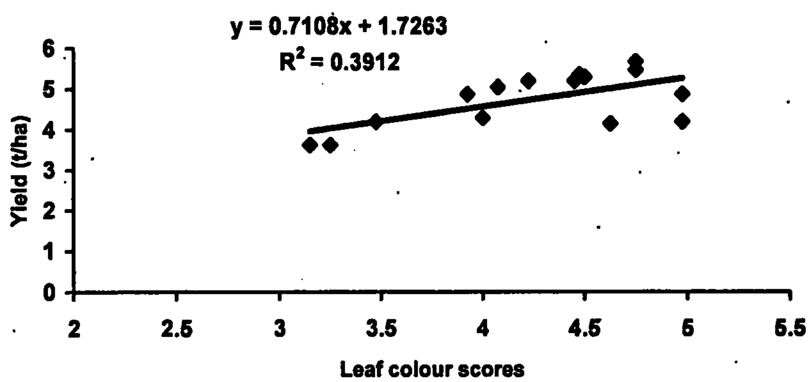
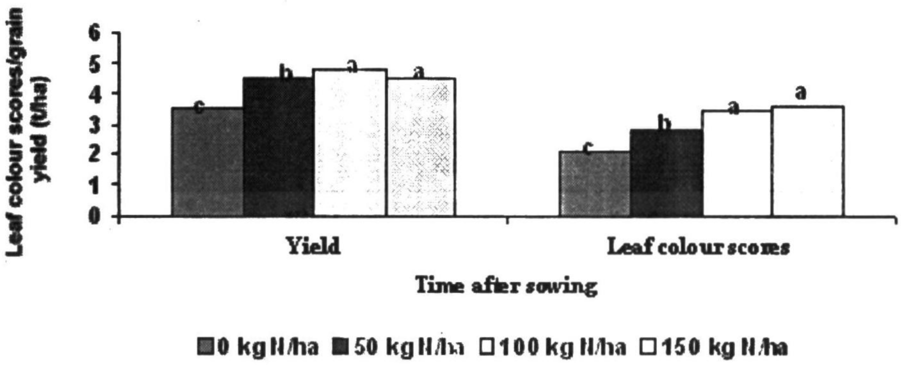


Figure 6. Relationship between LCC scores and grain yield of rice grown under different N levels at 10 weeks after sowing.

Figure 7 shows the changes of LCC scores at four weeks after sowing and changes of grain yield irrespective of the varieties. It is clear from the results that there is no increase in yield beyond 100 kg N/ha and improvement of green colour with N application showed the similar trend.



* Same letters on the column are not significantly different by DMRT (P=0.05)

Figure 7. Average leaf colour scores of rice varieties at 4 weeks after sowing and average grain yield of rice varieties at different N levels.

Table 2. Yield response and leaf colour changes at 4 weeks after sowing of four rice varieties at different N levels.

Varieties	*Grain yield (t/ha)**				*LCC scores at 4 weeks after sowing**			
	0kg N/ha	*50 Kg N/ha*	*100 kg N/ha*	*150 kg N/ha*	*0kg N/ha*	*50 Kg N/ha*	*100 kg N/ha*	*150 kg N/ha*
Bg 300	**3.54a**	**4.57a**	5.02a	4.64ab	2.07b	**2.87a**	**3.57a**	**3.37a**
Bg 305	**3.97a**	**4.88a**	5.34a	5.12a	2.07b	**2.90a**	**3.97a**	**3.60a**
Bg 250	**3.37a**	**4.74a**	4.98a	4.57ab	2.87a	**2.95a**	**3.80a**	**3.30a**
Bg R1	**3.37a**	3.78b	3.87b	3.92b	2.27b	2.55b	**2.67b**	**3.15a**

***Means within a column** followed by same letter are not significantly different by the DMRT (p=0.05)

Results appearing in Table 2 show that there is a change of grain yield of varieties with the application of nitrogen at 50 kg N/ha and 100 kg N/ha and change of leaf colour with the same levels of N at 4 weeks after sowing showed the similar trend. It is clear from the results that leaf colour changes and yield changes of Bg 300, Bg 305, Bg 250 and Bg R1 were similar at all the N levels. At 150 kg N/ha there was a reduction in yield in Bg 300, Bg 305 and Bg 250. Similarly there was a reduction in leaf colour of the same varieties as well. Application of nitrogen enhances the leaf colour in rice varieties but application of high level of N enhances the production of new tillers (Yoshida, 1981) and this may reduce the leaf colour as well as the grain yield of rice. It is clear from these results that if there is a variation in leaf colour among varieties there is a variation in yield as well. Therefore, leaf colour is a good indicator to identify the yielding ability of rice varieties at different rates of N fertilizer. Therefore, determination of leaf colour with the application of N fertilizer can be used to determine the optimum level of nitrogen of rice crops.

CONCLUSIONS

Irrespective of the varieties, LCC readings are linearly increased with the application of nitrogen fertilizer but at high level of nitrogen there is a reduction in both leaf colour as well as the grain yield of rice. As such LCC reading is a good indicator to determine N requirement of rice varieties under local conditions. The critical levels of LCC readings change according to the growth stage of the crop. At the early and latter stages, it should be around 3.5 but at middle it should be 4.5. Similarity was observed in changing grain yield with the application of nitrogen and changing LCC readings at 4th week after sowing. Therefore, LCC scores at 4 weeks after sowing can be used to screen the rice varieties which respond to added N.

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