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Leaf Colour Chart based N Management and Red Edge Reflectance of Rice

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ABSTRACT

Field experiments were carried out in the farmer's field of Biswanathpur in the Kharif season of 2008-09 and 2009-10 to study the effect of different N treatments and water depths (<15cm) on the yield of rice cv. Samrat and Puja. The treatments were farmer's applied dose (one time: 15 kg / ha for Samrat and two times: 45 kg N /ha for Puja), recommended dose (60 kg N / ha), leaf colour chart based (75 kg N / ha), and N spray (32 kg /ha). The red edge mid point were calculated for leaf samples from extracted chlorophyll solutions by using a spectrophotometer through linear interpolation technique (Guyot and Barret , 1988). Results showed that with the increase in 'red edge' there was a significant increase in total biomass content, grain and straw yield of rice (cv. Puja). The B: C ratio for leaf colour chart based application, recommended dose and N spray were higher than farmer's applied doses (two).

Key words: Leaf colour chart, N management, red edge parameter

Introduction

Phasing of N application at critical developmental stages is very important for the efficient utilization of the applied N by rice (Velu and Thiyagarajan, 2005). In some water logged areas such as in Biswanathpur of Khurda district, Orissa status of soil N is very low (<0.01%). Farmers usually do not apply N to rice crop where depth of water logging is more. In some low lying areas where there is no water logging or where depth of water logging is < 15 cm during early growth stage of rice (and no water logging during later stages) they apply small amount of N. But sometimes farmers' application of N does not coincide with the critical growth stages and proper amount may not be always maintained. Therefore, to provide an optimum N schedule to the farmers proper monitoring of N is required. N requirements vary among crop varieties. Rice leaf colour chart (L.C.C.) acts as a visual and subjective indicator of crop need for N fertilizer (Wells and Turner, 1984). A chart developed in Japan is used to measure the green colour intensity of rice leaves (Furuya, 1987) and is being standardized with chlorophyll meter for rice varieties under Indian conditions (Porpavai *et al*., 2002).

One of the advantages of remote sensing is that the technique can provide timely information with fair accuracy and precision on the current status of interested targets (Barret and Curtis, 1982). In the past years, varied spectral indices have been developed from spectral transformations of several wavebands to improve the radiometric measurements of crop vegetation and to monitor and evaluate vegetation development(Anderson and Hanson, 1992; Elvidge and Chen, 1995; Gilabert *et al*., 1996; Huete, 1988; Wiegand *et al*., 1991). It is well known that reflectance in red light is negatively correlated with chlorophyll concentration while reflectance in the near infra-red is positively correlated correlated with the leaf area (Knipling, 1970; Tucker, 1979). Thus, spectral indices have been widely used in many agricultural applications and combined with various growth models for vegetation growth and activity comparisons in field, regional and global scales (Clevers, 1988; Elvidge and Chen, 1995). However, the spectral nature of crop vegetation and its relationship with

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growth parameters should be well defined before practical agricultural applications are undertaken (Gates *et al*., 1965; Gausman *et al*., 1971; Rouse *et al*., 1974; Wiegand *et al*., 1991). Hence the first objective of the present study was to establish relationships between growth parameters of rice and the examined spectral index calculated from atomic absorption spectrophotometer data at the end of vegetative growth stage (just before flowering). The 2^{nd} objective was to evaluate farmers' applied N management to provide optimum N schedule to them in relation to L.C.C based application.

Materials and Methods

Rice seedlings of the variety Samrat and Puja were raised in nursery (2008 & 2009 kharif seasons respectively) and were transplanted at about 12 cm x 10 cm spacing in puddled, leveled and drained plots. The treatments were farmers applied N in the form of urea @ 15 kg N / ha (45 kg/ha for rice cv. Puja) at transplanting (N_F i.e., control), recommended dose i.e., @ 30+15+15 = 60 kg / ha applied during transplanting, maximum tillering and panicle initiation stage (treatment N_3), 2% urea spray according to L.C.C. timing (treatment N_{LS}) and L.C.C. based management practice (need based) starting from 21 days after transplanting (treatment N_L). L.C.C. critical value 4 was taken as the critical value for N application for the treatments N_L and N was applied to the crop as and when the L.C.C. threshold value fell below the set critical value based on the guidelines given by Balasubramanian (1998), where in the quantum of fertilizer N applied for each time was 10 kg N / ha during early growth stage (14-21 DAT), 15 kg N / ha during the rapid growth stage (21-49 DAT) and 10 kg N / ha during the late growth stage (49 DAT –flowering) of the crop (half of the IRRI recommended doses were taken to save fertilizer N). The taken treatments were based on the results obtained from the experiment conducted in the WTCER research farm. In those experiments it was found that yields of Surendra and Swarna varieties of rice were significantly higher in leaf colour chart based N-applied plots and recommended dose applied plots as compare to one or two times applied doses (Raut *et al*., 2008). The soil of the experimental field was sandy clay loam with a pH of 5.5, E.C. 0.1 dS / m, N content 0.004%, Bray and Kurtz P_2O_5 15 mg / kg, NH_4OAc extractable K_2O 200 mg / kg.

The L.C.C values were recorded at weekly intervals from 21 DAT and then application of N to N_L was taken up as and when needed. Farmers applied P_2O_5 and K_2O @ 30 kg / ha through Diammonium Phosphate (DAP) and Muriate of Potash (MOP) all basal to all treatments. The experiment was carried out in Randomized Block Design (R.B.D.) design with five replications (for Samrat) and in split plot design with three replications where in water depths (10-15cm, 8-10cm, 5-8cm and 0-5cm) were put in the main plots and fertilizer doses in the subplots (Puja). N applications were stopped just before flowering in N_L plots and green leaves were collected from all plots for including the effect of N application in N_L plots (for cv Puja). The leaves were crushed with mortar and pestle and chlorophyll was extracted with 80% acetone (Mohanty, 1998). The absorbance of the chlorophyll solution was measured in different bands (640 -740 nm) in atomic absorption spectrophotometer. Spectral reflectance % in all bands were calculated considering that the transmittance was negligible. Red edge slope was calculated by linear interpolation technique (Guyot and Baret, 1988) as given below:

Calculation of the reflectance at the inflection point (Rre):

$$R_{re} = (R\ 670 + R\ 780)/2$$

Calculation of the red edge wavelength :

$$REP = 700 + 40\ (R_{re} – R\ 700)/\ (R\ 740 – R\ 700)$$

The data on growth parameters like total biomass, grain and straw yield and biometrical parameters like no. of panicles/m^2 & no. of filled grains /panicle, panicle length, plant height of rice were recorded. The B:C ratio was computed taking into account the grain cost at Rs. 7/- and the straw at Rs. 0.75/- per kg with a basic cultivation cost of Rs. 12,000/- per ha, fertilizer N at Rs. 20/- per kg and the application cost at Rs. 100/- per ha.

Results and Discussion

Rice Grain and Straw Yield

The fertilizer N consumption under different N management strategies varied from 15 to 85 g / ha for Samrat variety. To maintain L.C.C. critical value 4 a total of 85 kg / ha N was needed for the variety. L.C.C. critical value 4 (85 kg / ha), nitrogen spray (32 kg / ha) and three times of application (60 kg /ha) treatments recorded markedly higher grain yield over farmers' one time applied dose (15 kg /ha) (Table 1). This result is in agreement with the findings of Thiyagarajan *et al*. (2001) and Shukla *et al*. (2006).

Table 1. Mean grain and straw yield (t/ha) and B:C ratio of rice (cv. Samrat)

Treatments	Mean yield (t/ha)		B:C ratio
	Grain	Straw	
N_F	2.5	4.0	1.34
N_3	4.1	4.8	2.0
N_{LS}	4.1	4.8	2.0
N_L	4.8	5.5	2.23
SE_m	0.40		
C.D. (p=.01)	1.2	NS	

N_F is control (N_{15kg}), N_3 three times application (N_{60kg}), N_{LS} is N spray, N_L is N application based on L.C.C.

B:C Ratio

The B:C ratio in the rice variety under different management practices ranged from 1.34 to 2.23 during the crop seasons. The B:C ratio of treatments L.C.C. critical value 4 were found relatively higher (2.23) along with nitrogen spray (2.0), and three times of application (2.0) than the farmers' one time application (Table 1). The B: C ratio of rice cultivation in the study season 2009 was calculated under different N applied doses. The B: C ratio of farmer's applied N dose was lower (1.96) than other doses (N_L : 2.50, N_{LS}: 2.53 and N_3: 2.54) (Table 2).

Table 2. B: C ratio and N uptake under different treatments for rice (cv. Puja)

N treatments	B:C ratio
N_F	1.96
N_3	2.54
N_{LS}	2.53
N_L	2.50

N_F : Farmers' applied N dose (45 kg /ha); N_3: Recommended dose (60 kg / ha); N_{LS} : Nitrogen spray through leaf (32 kg /ha) and N_L: Leaf colour chart based (75 kg / ha) application

The growth parameters of rice like total biomass, grain yield, straw yield, panicle no. / m^2 and filled grains /panicle were linearly correlated with red edge slope (Guyot and Baret, 1988). The linear regressions showed that there were highly significant correlations (r^2 is 0.40 and 0.38 ; p< 0.01) of total biomass, and filled grain per panicle with red edge slope and significant correlation (r^2 is 0.24, 0.30 and 0.31 respectively; p< 0.01) between the grain, straw yield and panicle no./m^2 with red edge slope (Table 3, Fig. 1). Gilabert *et al*. (1996) pointed out that Normalized Difference Vegetation Index (NDVI) and Soil Adjusted Vegetation Index (SAVI) of a corn canopy as a function of plant growth could be approximated by quadratic equations. Values of indices increased as plants developed until a maximum was reached and then decreased during senescence. Thus life span of rice is divided into two growth phases (Gilabert *et al*., 1996, Yang and Su, 1998, Yoshida and Ahn, 1968). The growth parameters showed significant relationships with red edge slope but the r^2 values were less because the plants were about to enter the reproductive growth phase (Yang and Chen, 2004). To examine the relationships of growth parameters to spectral reflectance at various narrow bands, simple linear correlation analysis was conducted across the measured spectral spans (640-740nm). The correlation intensity

Table 3. Relationship between growth parameters (Y) and red edge slope (before flowering, x) of rice

Growth parameter (Y)	Relation	r^2
Total biomass (t / ha)	Y= 86.6 x + 7.12	0.40**
Grain yield (t / ha)	Y =23.0 x + 2.8	0.24*
Straw (t / ha)	Y = 41.07 x + 4.66	0.30*
Panicle no. /m^2	Y = 1234.6 x + 159.4	0.31*
Filled grains /panicle	Y = 545.3 x + 71.95	0.38**

** highly significant (p<0.01), * significant (p<0.05)

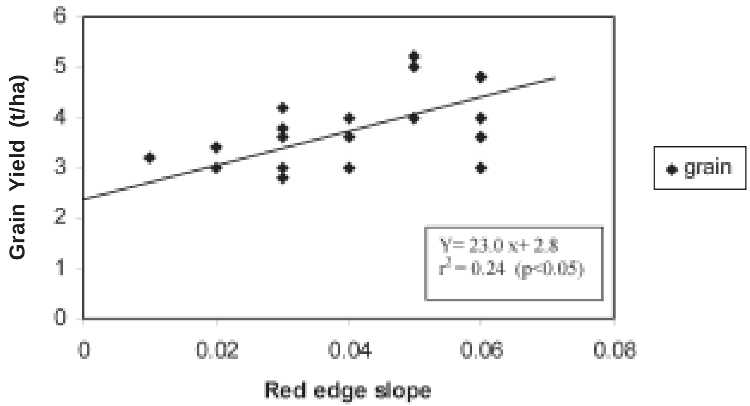

Fig. 1. Relation between grain yield (Y) and red edge slope (x) of rice

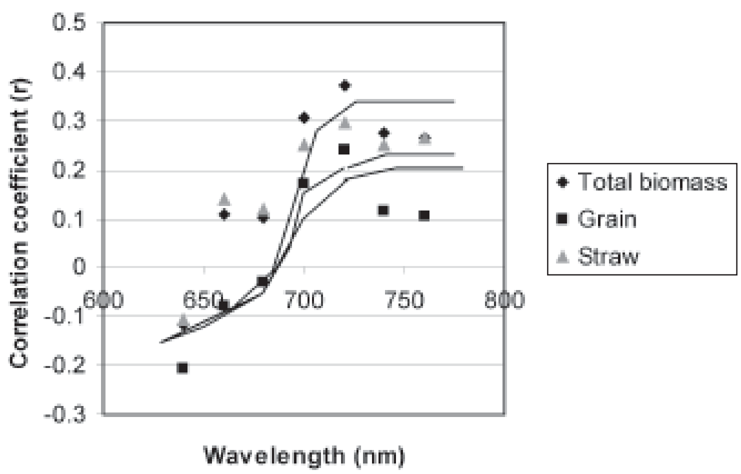

Fig. 2. The correlation intensity curves of growth parameters to spectral reflectance (640-760nm)

curves (Fig. 2) shows a picture of the correlation profile in the wave band axis and a comparison among different growth parameters in the growth phase. The correlation intensity curves indicated that growth parameters were negatively correlated with reflectance in the visible region but were positively correlated to reflectance in the near infrared bands, in agreement with reports by Knipling (1970), and Tucker (1979).

The grain yields of rice cv. Puja for different treatments differed significantly (Table 4). Grain yield under treatment farmer's applied doses was significantly lower than other applied doses (C.D. 0.73). The mean grain yield of rice under treatment 0-5cm water depth was significantly lower than 10-15cm water depths (C.D. 0.90).

The red edge slopes were higher for nitrogen spray (0.05,) leaf colour chart based (0.04) and recommended dose plots (0.04) as compare to control (0.035) (Fig. 3). Nitrogen application through leaf might have been more effective in enhancing vegetative growth of rice which in turn caused higher red edge slope for the treatment. On the other hand, the soil applied nitrogen under water logged condition might have been lost due to denitrification and leaching. Nitrogen uptake might be higher for recommended dose and leaf colour chart plots as compared to control.

Conclusions

From the results it could be concluded that the adoption of L.C.C. critical value 4, N spray

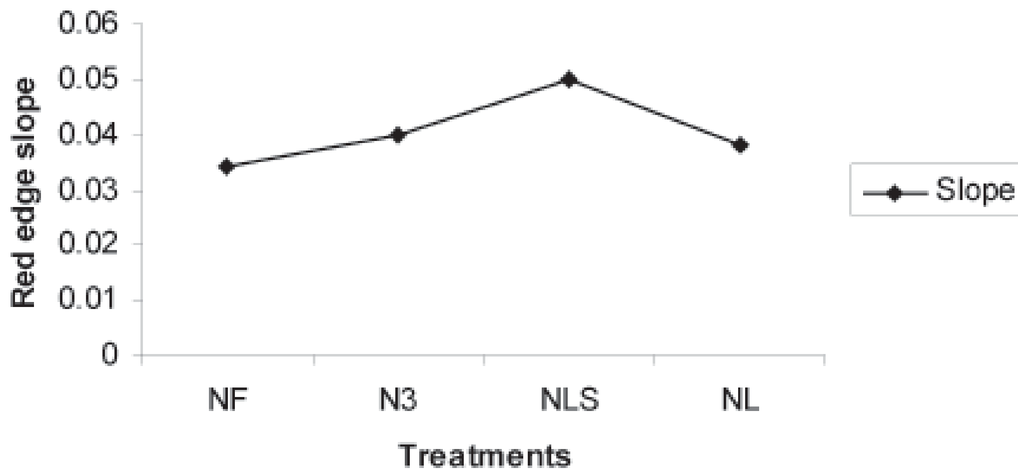

Fig. 3. Effect of different N treatments on red edge slope of rice

Table 4. Grain yield of rice cv. Puja under different water depths and N doses

Mean water depths (W)	Grain yields (t /ha)	Mean N doses	Grain yields (t /ha)
W_1 (10-15 cm)	4.49	N_F	3.22
W_2 (8-10 cm)	3.87	N_3	4.23
W_3 (5-8 cm)	3.78	N_{LS}	4.13
W_4 (0-5 cm)	3.52	N_L	4.50
C.D.	0.90	C.D.	0.73

N_F : Farmers' applied N dose (45 kg /ha); N_3: Recommended dose (60 kg / ha); N_{LS} : Nitrogen spray through leaf (32 kg /ha) and N_L: Leaf colour chart based (75 kg / ha) application

with L.C.C. timing and recommended dose of N were the optimum and best methods of N application for kharif season transplanted rice for the study area recording higher grain and straw yield and B: C ratio (2.23, 2.0,2.0 and 1.34 for cv. Samrat and 2.5, 2.53 and 2.54 for cv. Puja) compared to those of farmer's applied one or two times of N applications (1.36 for cv. Samrat and 1.96 for cv. Puja). The growth of rice in terms of 'red edge slopes' were higher for nitrogen spray (0.05,) leaf colour chart based (0.04) and recommended dose plots (0.04) as compare to control (0.035). Nitrogen application through leaf and split N application based on L.C.C. (amount and timings) might have been more effective in enhancing vegetative growth of rice reducing denitrification and leaching losses of N which in turn caused higher 'red edge slope' and yield for the treatments.

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