Economic analysis of N_2 use efficiency comparing conventional and leaf colour chart based urea application in *Boro* rice

M.K. Ikbal, M.A.R. Sarker[1], M.S. Rahman, M. Ahmed and U. Roy
Department of Agricultural Extension, Khamarbari, Dhaka, [1]Department of Agronomy, Bangladesh Agricultural University, Mymensingh

Abstract: A study was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during October/10 to February/11 to assess the efficiency of nitrogen application for *Boro* rice and appropriate amount of nitrogen to be top dressed on the basis of Leaf Colour Chart (LCC) compare to conventional system. The experiment contained 17 treatments including control, recommended N management and 15 LCC based N management treatments that were LCC 2.5, 3 and 3.5 and each of these contained 5 doses of N fertilizers (urea) that is 20, 25, 30, 35 and 40 N ha^{-1}top dressing. The experiment was conducted in randomized complete block design with three replications. LCC reading were taken on every 7 days from 14 days after transplanting up to flowering. Whenever LCC value dropped below the set critical level, nitrogen was top dressed. The result shows that the highest grain yield was produced when the land was fertilized with LCC 3.5 based nitrogen top dressing at the rate of 30 kg ha^{-1} followed by LCC 3.5 kg N ha^{-1} top dressing and recommended nitrogen management. The LCC 3.5 based top dressing at the rate of 30 kg N ha^{-1} was found profitable than rest of the two due to use of less amount on nitrogen fertilizer.
Key words: Economic analysis, urea application, leaf colour chart.

Introduction

Improved N management and balance fertilization are key components of the site-specific nutrient management approach developed by the International Rice Research Institute in partnership with the National Agricultural Research and Extension Systems in Asia. Field studies in major irrigated rice area have shown significant yield and profit increase with site-specific nutrient management approach over typical farmer fertilizer practice (Dobermann *et al*., 2004). Efficient fertilizer management gives higher yield of crops and reduces fertilizer cost (Hossain and Islam, 1986). So nitrogen fertilizer should be applied only after determining that nitrogen fertilizer will be beneficial. Appropriate diagnosis of nitrogen status in leaves is necessary to decide the need for top dressing fertilizer nitrogen. Leaf colour chart (LCC) is an alternative decision making tool to increase nitrogen use efficiency in rice (IRRI-CREMNET, 1998). But use increase application rates of N fertilizers in rice are very common among Bangladeshi farmers to attribute rice crop greenness and vegetative growth of the plant. But heavy application of nitrogen does not always give higher yield. Application of excessive nitrogen tends to cause damage due to crop lodging and this encourages the infestation of insect and disease (Bhardewaj *et al.,* 1970) Therefore, the present experiment was undertaken to evaluate the efficiency of LCC-based nitrogen management technique in comparison with recommended conventional split application of nitrogen considering economic point of view.

Materials and Methods

The study was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during October/10 to February/11 to assess the efficiency of nitrogen application for *Boro* rice and appropriate amount of nitrogen to be top dressed on the basis of LCC compare to conventional system. The experiment contained 17 treatments including control, recommended N management and 15 LCC based N management treatments that were LCC 2.5, 3 and 3.5 and each of these contained 5 doses of N fertilizers (urea) that is 20, 25, 30, 35 and 40 N ha^{-1}top dressing. The experiment was conducted in randomized complete block design with three replications where each of plot size was 4.0 m x 2.5 m having a space between blocks and plots were 0.75 m and 0.5 m respectively. The entire amount of TSP, MoP, gypsum and zinc sulphate were applied and incorporated into the soil at final land preparation. Later on nitrogen was top dressed in the form of urea. Thirty three days old seedling was transplanted at the rate of three $hills^{-1}$ with 25 cm x 15 cm spacing. All intercultural operations were done as and when necessary. LCC reading were taken on every 7 days from 14 days after transplanting up to flowering. Whenever LCC value dropped below the set critical level, nitrogen was top dressed. Five hills (excluding border hills) from each plot were selected randomly and tagged just after transplanting for measuring different agronomic data at 30, 45 and 60 DAT but grain and straw yields were recorded from the harvest of central 1 m^2 area in each unit plot. The nitrogen use efficiency measured agronomic efficiency of nitrogen (AEN) = (Grain yield in N fertilize plot - Grain yield in control plot / Quantity of N fertilizer applied in N fertilized plot) as described by Novao and Loomis (1981) and partial factor productivity of nitrogen (PFP-N) (Total grain yield (kg ha^{-1})/ Amount of applied N (kg ha^{-1}) as described by Cassman *et al*. (1996). The collected data were analyzed following the analysis of Variance technique and mean differences were adjusted by Duncan's Multiple Range Test (Gomez and Gomez, 1984).

Results and Discussion

Nitrogen use efficiency: Two indicators of N use efficiency were used in this study were agronomic efficiency of applied (AEN) and partial factor productivity of N (PFP-N). It was observed from the Table 1 that N was applied in recommended N management and LCC 3.5 based 35 kg N ha^{-1} top dressing and maximum grain yields were found in this treatment while agronomic efficiency was not maximum. In LCC 3.5 based 30 kg N ha^{-1} top dressing N was applied less than the above two treatments and grain yield was more or less similar with higher agronomic efficiency (11.44).

Table 1. Total amount of applied nitrogen, grain yield, agronomic efficiency of nitrogen (AEN) and partial factor productivity of nitrogen (PFP-N) for different nitrogen management techniques

Treatments	Applied N as urea (kg ha^{-1})	Grain yield (t ha^{-1})	Agronomic efficiency of nitrogen (AEN)	Partial factor productivity of nitrogen (PFP-N)
T_1= Control (No nitrogen application)	0	2.33	0	0
T_2= Recommended nitrogen management	220	4.5	9.86	20.45
T_3= LCC 2.5 based N top dressing (20 kg N ha^{-1})	130	2.84	3.92	21.85
T_4= LCC 2.5 based N top dressing (25 kg N ha^{-1})	163	3.48	7.06	21.35
T_5= LCC 2.5 based N top dressing (30 kg N ha^{-1})	130	3.10	5.92	23.25
T_6= LCC 2.5 based N top dressing (35 kg N ha^{-1})	152	3.25	6.05	21.38
T_7= LCC 2.5 based N top dressing (40 kg N ha^{-1})	174	3.69	7.82	21.21
T_8= LCC 3.0 based N top dressing (20 kg N ha^{-1})	130	2.92	4.54	22.46
T_9= LCC 3.0 based N top dressing (25 kg N ha^{-1})	163	3.55	7.49	21.78
T_{10}= LCC 3.0 based N top dressing (30 kg N ha^{-1})	195	4.15	9.33	21.28
T_{11}= LCC 3.0 based N top dressing (35 kg N ha^{-1})	152	3.46	7.43	22.76
T_{12}= LCC 3.0 based N top dressing (40 kg N ha^{-1})	174	3.82	8.56	21.95
T_{13}= LCC 3.5 based N top dressing (20 kg N ha^{-1})	130	2.97	4.92	22.85
T_{14}= LCC 3.5 based N top dressing (25 kg N ha^{-1})	163	3.70	8.41	22.70
T_{15}= LCC 3.5 based N top dressing (30 kg N ha^{-1})	195	4.56	11.44	23.39
T_{16}= LCC 3.5 based N top dressing (35 kg N ha^{-1})	228	4.52	9.61	19.83
T_{17}= LCC 3.5 based N top dressing (40 kg N ha^{-1})	174	3.90	9.02	22.41

Table 2. Cost and return analysis of different nitrogen management techniques for *Boro* rice

Treatments	Grain yield (t hac^{-1})	Straw yield (t hac^{-1})	Gross return (Tk. hac^{-1})	Net return (Tk. hac^{-1})	Benefit-cost ratio (BCR)
T_1= Control (No nitrogen application)	2.33	3.80	22440	4315	1.24
T_2= Recommended nitrogen management	4.50	4.69	40690	21245	2.09
T_3= LCC 2.5 based N top dressing (20 kg N ha^{-1})	2.84	4.11	26830	7925	1.42
T_4= LCC 2.5 based N top dressing (25 kg N ha^{-1})	3.48	4.19	32030	12927	1.68
T_5= LCC 2.5 based N top dressing (30 kg N ha^{-1})	3.10	4.28	29080	10175	1.54
T_6= LCC 2.5 based N top dressing (35 kg N ha^{-1})	3.25	3.91	29910	10873	1.57
T_7= LCC 2.5 based N top dressing (40 kg N ha^{-1})	3.69	5.09	34610	15441	1.81
T_8= LCC 3.0 based N top dressing (20 kg N ha^{-1})	2.92	3.87	27230	8325	1.44
T_9= LCC 3.0 based N top dressing (25 kg N ha^{-1})	3.55	4.90	33300	14197	1.74
T_{10}= LCC 3.0 based N top dressing (30 kg N ha^{-1})	4.15	4.70	37900	18605	1.96
T_{11}= LCC 3.0 based N top dressing (35 kg N ha^{-1})	3.46	4.77	32450	13413	1.71
T_{12}= LCC 3.0 based N top dressing (40 kg N ha^{-1})	3.82	4.30	34860	15691	1.82
T_{13}= LCC 3.5 based N top dressing (20 kg N ha^{-1})	2.97	4.12	27880	8975	1.48
T_{14}= LCC 3.5 based N top dressing (25 kg N ha^{-1})	3.70	4.71	34310	18207	1.80
T_{15}= LCC 3.5 based N top dressing (30 kg N ha^{-1})	4.56	4.80	41280	21985	2.14
T_{16}= LCC 3.5 based N top dressing (35 kg N ha^{-1})	4.52	4.90	41060	21567	2.11
T_{17}= LCC 3.5 based N top dressing (40 kg N ha^{-1})	3.90	4.05	35250	16081	1.84

Higher amount of N was applied in recommended N management and LCC 3.5 based 35 kg ha^{-1} top dressing and produced somewhat more grain yield but they showed poor performance in respect of partial factor productivity of N (PFN-N). In LCC 3.5 based 30 kg N ha-1 top dressing less amount of n was applied than above two treatments and grain yield was more or less similar but it provided the higher value of partial factor productivity (23.39). From the above discussion, it can be said that in LCC technique, maximum N was up taken by rice plant to convert it into dry matter for producing grains. Maximum utilization of N was possible due to proper synchronization of N top dressing and crop N demand. So it can be concluded that leaf colour chart can be used as an N management tool to achieve better nitrogen use efficiency without reducing yield. Barroga (1997) also reported that by applying the right amount of nitrogen at the right time on a weekly basis through the LCC, the rice crop efficiently converts the nitrogen into grains. This means more grains are produced per kilogram of nitrogen applied than that of the farmers' usual practice of applying fertilizer two or three times during the entire growing season.

Economic analysis: The highest cost of production was incurred for LCC 3.5 based 35 kg N ha^{-1} top dressing followed by recommended N management (Table 2). But maximum net return was obtained from LCC 3.5 based 30 kg N ha^{-1} top dressing followed by LCC 3.5 based 35 kg N ha^{-1} top dressing. Data of benefit-cost ratio showed that LCC 3.5 based 30 kg N ha^{-1} gave the highest BCR (2.14) followed by LCC 3.5 based 35 kg N ha^{-1}(2.11) and the recommended N management (2.09). These result indicated that LCC 3.5 based 30 kg N ha^{-1} top dressing was more profitable than recommended N management due to use of less amount of n fertilizer. Barroga (1997) reported that LCC based fertilizer application and farmer's practice both gave yields of 4.2 t ha^{-1} but former had a higher grain yield conversion of nitrogen per kilogram i.e. 22.4 kg

grain per kg nitrogen than that of the farmers' at only 9.9 kg grain per kg nitrogen. The farmer spent P. (peso) 3265 on nitrogen fertilizer to achieve this yield where as the LCC managed field incurred P. 2339 on cost of nitrogen fertilizer. Using LCC doubled grain yield conversion efficiency per kilogram and reduced cost of nitrogen by 30 percent. Obien (1998) also reported that leaf colour chart can generate savings of up to p. 1000 ha-1 in nitrogen fertilizer use.

From the above discussion it can be concluded that LCC can be used as a potential and better N management tool for greater nitrogen efficiency, higher grains yield, higher profit and net return in *Boro* rice and 3.5 based 30 kg N ha^{-1} is the best one over the rest of the treatments.

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