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PJBS

ISSN 1028-8880

Pakistan Journal of Biological Sciences

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Pakistan Journal of Biological Sciences 6 (19): 1685-1688, 2003
ISSN 1028-8880

A Comparative Study of Leaf Color Chart Based and Farmer's Practice of Nitrogen Fertilizer Application on Rice under On-farm Conditions of Bangladesh

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Abstract: An on-farm experiment was conducted to know the performance of Leaf Color Chart (LCC) based N application in rice compared with conventional farmers practice during aman season 2002 in nine farmer's field at Gazipur districts of Bangladesh. Nine rice genotypes were included in the experiment and each genotype was cultivated in each farmers plot. Basal application of fertilizer was made with P, K, S and Zn. Top dress of N was made according to the treatments. LCC based N application produced slightly higher but insignificant grain yield than conventional farmer's N application practice. N use efficiency was much higher in LCC based N application. 19-37 kg Nha^{-1} was saved in LCC and it reduces disease and insect infestation in rice. It plays a positive role on environment by reducing the use of agrochemicals.

Key words: Leaf color chart, farmer's practice, nitrogen use efficiency

INTRODUCTION

Determination of the optimum time of N application for rice cultivation is an important factor for obtaining increased N use efficiency and yield. In Bangladesh hudge effort is given to develop a suitable package for determination of the optimum time of N application. However, recreantly soil analysis based fertilizer application has been introduced but at a very limited scale. This method is very costly and needs technical knowledge and skill. Traditionally farmers use leaf color as a visual and subjective indicator of the rice crop's need for N fertilizer. When the leaves are pale or yellowish green rather than dark green, farmers believe the plants need more N. In research also, it has been found that leaf color intensity is directly related to leaf chlorophyll content and leaf N status (IRRI, 1999). A leaf color chart (LCC) thus developed from a Japanese prototype (Furuya, 1987) can help farmers to measure leaf color intensity. LCC is a simple, easy to use and inexpensive tool to determine the time of N topdressing for rice crops (IRRI, 2000). LCC can help in promoting need-based, variable rate N application to rice crops based on soil N supply and crop demand. It is an ideal tool to optimize N use, irrespective of the source of N applied-organic, biofertilizers, or chemical fertilizers. Wider farmer adoption of the LCC will minimize over-fertilization of rice, increase profitability and decrease fertilizer-related pollution of the environment (Balasubramanian *et al*., 1999). LCC based N management can save 0 to 53 kg N ha^{-1} in flooded rice and can reduce lodging problem, pest and disease incidence (IRRI, 2000). It is thus an eco-friendly tool in the hands of rice farmers. However, very little effort is given to test the effectiveness of leaf colour chart (LCC) for rice cultivation in Bangladesh. An experiment was, therefore, undertaken to investigate the effectiveness and profitability of LCC for rice cultivation in Bangladesh.

MATERIALS AND METHODS

An on farm experiment was conducted during Aman 2002 season at Sreepur Upazilla of Gazipur district. There were nine rice genotypes namely BR11, BR22, BR23, BRRI dhan30, BRRI dhan31, BRRI dhan32, BRRI dhan33, BRRI dhan39 and BR6110-10-1-2 were included in the experiment. Each variety was cultivated in one bigha plot and in dispersed locations. Thus 9 bigha lands of 9 farmers were included in the experiment. Each plot was divided into two equal sub plots. In all plots basal application of P, K, S and Zn were made with urea, TSP, gypsum and zinc sulphate @ 100, 70, 60 and 10 kg ha^{-1}, respectively at the time of final land preparation. According to farmer's practice N was applied as urea in one subplot of each variety with three equal splits at 15, 30 and 45 days after transplanting. In other sub plots LCC based N management practices were followed. Thirty to thirty five days old seedlings were transplanted with the plant spacing of 20 X 20 cm. Two to three seedlings were transplanted in each hill. Furadan 5 g was used twice (tillering stage and panicle initiation stage) to control stem

Table 1: Amount of N fertilizer (Kg N ha^{-1}) applied in LCC based and farmer's practiced N applied plots

	LCC based				Farmer's practice			
Varieties	1st top dress	2nd top dress	3rd top dress	Total	1st top dress	2nd top dress	3rd top dress	Total
BR11	15	15	10	40	23	23	23	69
BR22	15	20	15	50	23	23	23	69
BR23	15	20	15	50	23	23	23	69
BRRI dhan30	15	15	15	45	27	28	27	82
BRRI dhan31	15	15	15	45	27	28	27	82
BRRI dhan32	15	15	10	40	23	23	23	69
BRRI dhan33	15	20	15	50	23	23	23	69
BRRI dhan39	15	20	15	50	23	23	23	69
BR6110-10-1-2	15	15	10	40	23	23	23	69
Average				45.56				71.89

borer. Crops were harvested at maturity. Before harvest field days were conducted to show the impact of LCC based nitrogen application and obtain the farmers' opinion on the technology. Data were collected from randomly selected 3 parts of each sub plot. Grain yield was estimated by harvesting 3 X 2 m^2 area and was adjusted at 14% moisture content. The number of panicles per m^2 was determined by counting the panicles from randomly selected 1 m^2 area. The number of grains $panicle^{-1}$ was counted from randomly selected 10 panicles. Data were analysed following two factorial RCB design where N application method and variety were the two factors. The means were compared following F-test and DMRT.

Patial factor productivity (Pfp) of applied N was estimated from grain yield and N applied data described by Cassman *et al*. (1994) with the following formula:

$$Pfp = Y\ Nr^{-1}$$

Where

Nr = Amount of applied N (kg ha^{-1})

and Y = Total grain yield

N management in LCC plots: The youngest fully expanded and healthy leaf of a single plant was selected for leaf colour measurement. The colour of this leaf is highly related to the N status of rice plants. From each plot 10 leaves from 10 randomly selected plants that represent the planted area were selected. The colour of each selected leaf was measured by holding the LCC and placing the middle part of the leaf on top of a colour strip for comparison. If the colour of a rice leaf seems to fall between two colour shades, the mean of the two values were taken as the reading. The LCC readings were taken once at every 7 days, starting at 14 days after transplanting and continued the taking readings at 7 days intervals until the first flower appears. The critical leaf colour reading for N topdressing was 4. The average of the 10 LCC readings was calculated. When the average leaf colour reading falls below the set critical value, top dressing of N was done immediately to correct N deficiency. The amount of N fertilizer applied in both LCC based and traditional farmer's practiced plots at different growth stages of nine rice genotypes are presented in Table 1.

RESULTS AND DISCUSSION

Yield and yield components: Table 2 shows that grain yield difference of rice between leaf colour chart based and farmer's practice of N application was not significant. Over the nine rice genotype most of them increased yields by LCC accept BR23 and BRRI dhan32. On an average yield increase by the genotypes were 2.66%. Maximum yield increase was observed in BR22 and only this variety increased yield significantly (9.19%). The effects of LCC based and farmer's practice of N application on number of panicles/m^2, number of grains $panicle^{-1}$, percent sterility, 1000-grain weight and plant height were not significant (Table 2 and 3).

In our experiment rice yield was increased in LCC plots but this yield increase was not significant from farmer's practice of urea application. Insignificant yield increase by LCC was consistent over the genotypes except two. Balasubramanian and Morales conducted several experiment in Philippine, Vietnam, Indonesia and India and finally in 2000 reported that yield difference between LCC and farmers practice is insignificant. The experimental results of South Vietnam (1997-99) they reported that yield difference between farmers practice and LCC-3 was quit insignificant. The results of Maligaya, Philippines (1996-99) they reported that yield obtained from the farmers practice, SPAD-32N and LCC-4 was not significant. The experimental results of north Sumatra, Indonesia (1998) also reported that the yield difference in farmers practice and LCC-4 was not significant. In India (2000) also found same insignificant yield difference of rice between LCC based and farmers practice of N application. These results confirmed that LCC based N application slightly but insignificantly increased rice yield.

Table 2: Grain yield, number of panicles/m^2 and number of grains/panicle of different rice varieties as affected by urea application methods

	Grain yield (t ha^{-1})				Number of total panicles/m^2				Number of grains panicle^{-1}			
Variety	LCC based	Farmer's practice	Difference	%increase /decrease	LCC based	Farmer's practice	Difference	%increase /decrease	LCC based	Farmer's practice	Difference	%increase /decrease
BR11	4.63bc	4.46b	0.17ns	3.81	218.3bc	220.3cd	-2.0ns	-0.9	94.7ab	86.0c	8.7ns	10.5
BR22	4.88ab	4.46b	0.42*	9.19	246.0ab	253.3bc	-7.3ns	-2.8	105.7ab	84.0c	21.7*	26.2
BR23	4.52c	4.64ab	-0.12ns	-2.6	251.0ab	255.0bc	-4.0ns	-1.6	105.3ab	94.3bc	11.0ns	11.7
BRRI dhan30	4.76bc	4.46b	0.30ns	6.74	223.3bc	219.3cd	4.0ns	1.83	86.7b	92.3bc	-5.6ns	-6.5
BRRI dhan31	4.76bc	4.76ab	0.00ns	0	195.0c	202.3d	-7.3ns	-3.5	104.3ab	83.3c	21.0ns	25.3
BRRI dhan32	4.61bc	4.80ab	-0.19ns	-4.2	233.7b	219.3cd	14.4ns	6.85	111.3a	126.7a	-15.4ns	-12
BRRI dhan33	4.02d	3.88c	0.14ns	3.88	278.7a	307.0a	-28.3ns	0.65	84.7b	97.3bc	-12.6ns	-12
BRRI dhan39	3.73d	3.72c	0.01ns	0.54	248.7ab	262.7b	-14.0ns	-5	101.3ab	115.7ab	-14.4ns	-12
BR6110-10-1-2	5.14a	4.98a	0.16ns	3.21	222.3bc	227.0cd	-4.7ns	-2.2	103.7ab	104.7abc	-1.0ns	0
Average	4.56	4.46	0.10ns	2.66	235.2	240.7	-5.5ns	-0.8	99.7	98.3	1.4ns	1.81
	%CV=4.2, LSD (5%)=0.317				%CV=8.2, LSD (5%)=32.4				%CV=12.8, LSD (5%)=21.2			

Table 3: Percent sterility, 1000-grain weight and plant height of different rice varieties as affected by urea application methods

	%sterility				1000-grain weight (g)				Plant height (cm)			
Variety	LCC based	Farmer's practice	Difference	%increase /decrease	LCC based	Farmer's practice	Difference	%increase /decrease	LCC based	Farmer's practice	Difference	%increase /decrease
BR11	18.50 bc	21.21bc	-2.71ns	-14.65	23.66de	23.29d	0.37ns	1.56	101.7de	102.7c	-1.0ns	-0.98
BR22	20.80abc	26.31ab	-5.51ns	-26.49	19.89g	18.80g	1.09*	5.48	95.3f	96.0d	-0.7ns	-0.73
BR23	24.07ab	28.00ab	-3.93ns	-16.33	28.05b	28.73b	-0.68ns	-2.42	100.7e	100.7c	0.0ns	0.00
BRRI dhan30	20.63abc	22.75bc	-2.12ns	-10.28	21.95f	20.56f	1.39**	6.33	106.3c	108.3b	-2.0ns	-1.88
BRRI dhan31	27.04a	31.44a	-4.40ns	-16.27	25.95c	23.81d	2.14**	8.25	105.0cd	102.7c	2.3ns	2.19
BRRI dhan32	14.54c	15.61c	-1.07ns	-7.36	21.93f	21.58e	0.35ns	1.60	119.3a	113.0a	6.3**	5.28
BRRI dhan33	25.15ab	23.96abc	1.19ns	4.73	22.81d	22.99d	-0.18ns	-0.79	100.3e	100.7c	-0.4ns	-0.40
BRRI dhan39	22.08abc	20.22bc	1.86ns	8.42	24.40d	24.98c	-0.58ns	-2.38	99.7e	100.7c	-1.0ns	-1.00
BR6110-10-1-2	18.17bc	21.52bc	-3.35ns	-18.44	29.99a	30.47a	-0.48ns	-1.60	110.3b	109.7ab	0.7ns	0.63
Average	21.22	23.45	-2.23ns	-10.51	24.29	23.92	0.37ns	1.52	104.3	103.8	0.5ns	0.48
	%CV= 20.1, LSD (5%)=7.455				%CV=2.5, LSD (5%)=1.013				%CV=2.3, LSD (5%)=4.0			

ns = not significant, * = significant at 5% level and ** = significant at 1% level
In a column, figures having common letter is not significantly different at 5% level by DMRT

Table 4: Partial factor productivity of N of different Aman varieties obtained from different N application method

	Partial factor productivity of N		
Variety	LCC	Farmer's practice	Pfp of N increased (by LCC)
BR11	116	65	51
BR22	97	65	32
BR23	90	67	23
BRRI dhan30	106	54	52
BRRI dhan31	106	58	48
BRRI dhan32	115	70	45
BRRI dhan33	80	56	24
BRRI dhan39	75	54	21
BR6110-10-1-2	129	72	57
Average	102	62	40

Table 5. Cost analysis of different N application methods

Varieties	LCC based (Kg N ha^{-1})	Farmer's practice (kg N ha^{-1})	Per ha N saved (kg)	Per ha money saved (Tk)
BR11	40	69	29	378
BR22	50	69	19	248
BR23	50	69	19	248
BRRI dhan30	45	82	37	483
BRRI dhan31	45	82	37	483
BRRI dhan32	40	69	29	378
BRRI dhan33	50	69	19	248
BRRI dhan39	50	69	19	248
BR6110-10-1-2	40	69	29	378
Average	45.56	71.89	26.33	344

Table 6: Farmers' comments regarding the N application methods.

Characters	LCC based N application	Farmer's N application
Yield	Slightly Higher	Slightly lower
Insect infestation	Lower	Higher
Disease infection	Lower	Higher
Leaf color	Green	Dark green
Plant growth	Optimum	Higher
Number of leaf	Relatively lower	Higher
Sterility	Lower	Higher

Effect of LCC based and farmer's practice of N on yield components were studied in the experiment. Table 2 and 3 shows that number of panicles/m^2, number of grains/panicle, %sterility, 1000-grain weight and plant height was insignificantly affected by different N application method. Although the mean differences were not significant but it create a positive effect to minimize N use and maximize yield. Table 2 shows that number of total panicles$l$/m^2 was decreased by 5.5% in LCC based N applied plots. On an average number of grains/panicle was increased (Table 2) and % sterility was decreased by LCC (Table 3). Thousand grain weight and plant height slightly increased by LCC.

Yield and all yield contributing characters were significantly influenced by rice genotypes. Highest yield

was recorded by the genotype BR6110-10-1-2 in both LCC based and farmer's practice of N application. In addition to that this genotype has highest nitrogen use efficiency (Table 4). So this line might be a good genotype than that of the released varieties. Highest number of panicles/m^2 was recorded by BRRI dhan33 but number of grains/panicle was in the variety BRRI dhan32. Minimum and maximum sterility percentage was observed in the variety BRRI dhan32 and BRRI dhan31, respectively. Remarkable difference in 1000-grain weight was observed in both N application methods and highest 1000-grain weight was recorded by the genotype BR6110-10-1-2. Higher grain yield of BR6110-10-1-2 is the product of high 1000-grain weight. Highest plant height was recorded by the variety BRRI dhan32.

Nitrogen use efficiency: Partial factor productivity (Pfp) of N is a good index of determining nitrogen use efficiency. Higher Pfp value meaning higher nitrogen use efficiency. In our experiment Pfp of N of all rice varieties were higher in LCC based N received plots than the farmer's practice. Over the nine genotypes Pfp of N in LCC was 102 and in farmer's practice it was only 62 (Table 4). The difference of Pfp of N between two N application methods was 40. The highest difference was obtained from the genotypes BR6110-10-1-2 (57). This higher partial factor productivity was caused due to similar grain yield as that of farmer's practice but with lower N rate for the LCC method. Balasubramanian and Morales (2002) reported that the partial factor productivity of N for LCC was 93 compared to 62 in farmers practice. Panaullah *et al.* (1999) reported greater partial factor productivity in chlorophyll meter based N fertilization technique than those of the conventional N management methods.

Economic profitability: Economic profitability of using LCC was determined only for amount of urea use. Table 5 shows that 40-50 kg N was used in LCC based N applied plots over different rice genotypes. Where as in farmer's practice received 69-82 kg N ha^{-1}. Thus 19-37 kg N was saved over different rice genotypes from LCC used plots. These saved amount of N was equivalent to taka 248 and 378, respectively (Table 5). IRRI (2000) reported that LCC based N management can save 0-53 kg N ha^{-1} in flooded rice.

Farmers' comments on LCC: For obtaining farmers response/reaction on LCC a field visit program was organised. Hundreds of farmers were present in that field visit program. All farmer were visited both LCC based and farmer's practice of urea applied plots. After field visit most of the farmers opined that in LCC plots yield will be slightly higher than those of farmer's practice (Table 6). They also opined that disease and insect infestation and sterility percentage is higher in farmer's practice of urea received plots (Table 6). IRRI (2000) also reported that LCC based N management can reduce insect and disease infestation and lodging problem. In our experiment farmers gave their opinion only based on the visual appearance of the crops. Farmers comments reconfirmed the yield and yield component data. Lower requirement of pesticide in LCC due to lower pest infestation and optimum use of chemical N fertilizer reduce the probability of environmental pollution. Thus it plays a positive role for keeping environment friendly.

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