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OPTIMIZATION OF NITROGEN RATE FOR AROMATIC BASMATI RICE (*Oriza sativa* L.)

M. A. MANNAN[1], M. S. U. BHUIYA[2]
H. M. A. HOSSAIN[3] AND M. I. M. AKHAND[4]

Abstract

The experiment was conducted with different Basmati rice varieties at the Bangladesh Rice Research Institute (BRRI) farm, Gazipur during 1999 and 2000 T.aman season. Four rice genotypes (Basmati PNR, Basmati 370, Basmati 375 and Basmati-D) were tested with 0, 25, 50, 75 and 100 kg N/ha to determine the optimum N level as well as to find out the genotype having high yield potential. The plant height, tiller number, number of panicles, panicle length, spikelet sterility and straw yield increased with the increase of nitrogen levels upto 75 kg N/ha. Maximum plant growth at the highest level of N caused lodging of plant which increased spikelet sterility and lower number of grains per panicle and ultimately decreased grain yield. Genotype Basmati PNR having dwarf plant characteristics performed well at higher level of nitrogen (100 kg N/ha), while other genotypes having medium plant height responded well at lower level of nitrogen (52-56 kg N/ha).

Keywords : Basmati rice, nitrogen, aman season.

Introduction

Rice is the most dominant crop in Bangladesh since rice is the principal food for this country’s people. Coarse rice is normally used for daily diet but on special occasions, fine rice is preferred for its aroma and test. Among the fine rice genotypes, Basmati rice is the most popular one. Recently, aromatic Basmati rice has gained a wider acceptance in the Middle East and in Europe (Yoshihashi, 2005). The demand of Basmati rice in this country is increasing but grain yield is low. However, the price of fine rice, especially the aromatic is 2-3 times higher than that of coarse rice (Biswas *et al.*, 1992). Though yield is low but it requires less input compared to coarse rice.

Recommendation on nitrogen requirement for growing coarse rice is available, but in case of Basmati rice (aromatic and non-aromatic) such information is lacking. The present study was undertaken to find out the optimum level of nitrogen and to select high yield potential nitrogen responsive Basmati fine rice genotypes for cultivation in Aman season.

[1&4] Agronomy Division, BRRI, Joydebpur, Gazipur 1701, [2&3]Department of Agronomy, BAU, Mymensingh, Bangladesh.

Materials and Method

The experiment was conducted at BRRI farm, Gazipur during 1999 and 2000. The test genotypes, Basmati-PNR, Basmati 370, Basmati 375 and Basmati-D were grown under five levels of nitrogen viz. 0, 25, 50, 75 and 100 kg/ha in T. Aman seasons. Thirty-day old seedlings were transplanted on 15 August spaced at 20 cm x 15 cm in both the years. The unit plot size was 4m x 4m. The treatments were distributed in a split-plot design, placing nitrogen in the main plot and the genotypes in the sub plots. The soil of the experimental area was clay loam texture, organic carbon 0.95 %, total nitrogen 0.09 % and the soil pH is 6.16. The other nutrients were applied @ 40-40-10-4 kg P_2O_5, K_2 O, S and Zn/ha, respectively, through triple super phosphate, muriate of potash, gypsum and zinc sulphate during final land preparation. Urea was top-dressed in three equal splits at 15 DAT (days after transplanting), 30 DAT and at 5 days before panicle initiation stage (BRRI, 2004). The crop field was kept weed free by twice hand weeding over the crop period.

Five destructive sample hills were collected from each individual plot outside the harvested area for recording plant height, tillers/m^2, panicle number, panicle length, grains/panicle and 1000-grain weight. The Basmati PNR was harvested earlier (mid November) followed by Basmati 375 (late November) and Basmati-D (first week of December). For grain yield, 5.10 m^2 area was harvested from the center of the plot. The grain yield was adjusted to 14% moisture content and expressed in tons/ha. The straw was dried in the sun until complete drying and the weight was expressed in tons/ha. The grain and straw samples from every plot were analyzed for N concentration.

The optimum N dose for the tested fine rice variety was determined by regression the grain yield with the N rates: $Y = a + bN + cN^2$

Where, Y is rice yield (kg/ha), N is nitrogen dose (kg/ha), a is intercept (estimated yield without N application), b and c are coefficients, respectively (Saleque *et al.*, 2004). Differentiating Y with respect to N of the Eqn. (1) gives the nitrogen dose for the maximum yield. The estimated nitrogen dose for maximum yield

$$\text{or } N = -\frac{b}{2c}$$

and the equation for economic optimum dose of N

$$E = \frac{1 - b.En}{2c.En}$$

where, E = Economic optimum dose of nitrogen

$\mathrm{En} = \frac{\mathrm{PR}}{\mathrm{PN}}$ where, *PR* is price of rice and *PN* is price of nitrogen (CoIwell, 1994)

Results and Discussion

Effect of nitrogen on growth parameters

Plant height, tiller number and dry matter increased with the increase of nitrogen levels at different growth stages at 30 days after transplanting (DAT), 45 DAT and at 60 DAT (Table 1). At maturity, the tallest plant was found where higher amount of nitrogen was applied. Similarly, higher number of tillers and dry matter were observed at higher levels of nitrogen. The tiller and dry matter increased proportionally with the increase of nitrogen levels also found by Haque *et al.* (2004). However, excess nitrogen application makes the crop succulent and enhanced lodging during grain filling stage (Sidhue *et al.,* 2004).

The number of panicles, panicle length and percentage of spikelet sterility increased with the increase of nitrogen levels (Table 1). Increasing trend of panicle at the higher levels of nitrogen was also observed by BRRI (2002). The maximum number of grains per panicle was found with application of 25 kg N/ha and beyond that rate, grains panicle declined due to lodging of the crop during grain filling stage. However, Kumar *et al.* (2003) observed the highest number of grains per panicle upto 60 kg N/ha. The higher doses of nitrogen make the crop tall and increased vegetative growth that enhanced crop lodge during grain filling stage resulting higher spikelet sterility. This fact well agrees with the results obtained by Moriwaki (1999). Excess nitrogen application might have reduced carbohydrate content resulted an abnormal development of pollen grains as observed by Sharma and Singh (1999). However, no significant difference was found in 1000-grain weight due to the application of nitrogen (Table 1). Shivay and Singh (2003) also observed similar response. However, the individual grain weight is usually a stable varietal character and the management practice has less effect on its variation (Yoshida, 1981).

The straw yield increased significantly with the nitrogen rates upto 75 kg N/ha. There was no significant difference in straw yield between 75 and 100 kg N/ha, but 100 kg N/ha showed higher straw yield than other levels of N (Table 1). The vigorous crop growth for the nitrogen treatments might have resulted in higher straw yields of fine rice. These findings are also supported by Salam *et al.* (2004).

Table 1. Effect of differnet rates on N application on the growth parameters, yield components, grain and straw yields of Basmati rice (pooled).

Nitrogen level (kg/ha)	Plant height (cm) at maturity	Tiller (m^2) at different DAT			Dry matte (t/ha) at different DAT			Panicle number (m^2)	Panicle length (cm)	Grains/ panicle	Sterility (%)	100-grain wt (g)	Gram yield (t/ha)	Straw yield (t/ha)	N-uptake (kg/ha) in grain
		30	45	60	30	45	60								
0	111.15d	139d	223e	232e	0.47c	1.78e	2.95	189d	22.85c	63.ab	21c	19.02	2.01c	2.81d	13.49d
25	116.6c	188c	291d	306d	0.46c	2.37d	3.75c	208c	23.63b	67a	22c	19.17	2.43	3.25c	16.91c
50	119.22b	207b	325c	352c	0.56b	2.8c	4.23b	241b	24.39a	66a	25bc	19.03	2.80a	3.84b	20.05b
75	121.07ab	223a	353b	380b	0.67ab	3.19b	5.10a	257ab	24.84a	60b	31b	19.09	2.77a	4.34a	21.36a
100	122.03a	430a	384a	407a	0.72a	3.50a	5.34a	270a	24.81a	49c	41a	19.05	2.39b	4.66a	21.89a
CV(%)	1.8	5.4	4.7	3.3	7.9	10.6	3.6	7.7	3.1	11.8	14.8	2.1	6.7	6.2	6.8

Figures in a column followed by different letters differ significantly, whereas with common letter(s) do no differ significantly at 1% level of significance. DAT = Days after transplanting.

Table 2. Growth parameters, yield components, grain and straw yield of different Basmati rice genotypes (pooled).

Genotypes	Plant height (cm) at maturity	Tiller (m^2) at different DAT			Dry matte (t/ha) at different DAT			Panicle number (m^2)	Panicle length (cm)	Grains/ panicle	Sterility (%)	100-grain wt (g)	Gram yield (t/ha)	Straw yield (t/ha)
		30	45	60	30	45	60							
Basmati PNR	84.38c	201b	328b	348b	0.51c	2.73ab	4.08b	241b	22.81c	59b	22b	20.14a	2.76a	3.24c
Basmati 370	130.61a	187c	286c	312c	0.53bc	2.52b	4.12b	213c	24.68a	59b	30b	19.52b	2.24b	3.74b
Basmati-375	131.91a	280c	292c	314c	0.56b	2.62b	4.28ab	220c	25.09a	60ab	29a	19.77ab	2.33b	3.89b
Basmati-B	125.21b	217a	355a	377a	0.64a	3.07a	4.61a	258a	23.83b	65a	30a	16.94c	2.63a	4.26a
CV(%)	2.3	7.4	7.8	8.9	11.2	7.4	8.7	9.6	3.1	13.7	13.9	2.1	8.0	6.6

Figures in a column followed by different letters differ significantly, whereas, with common letter(s) do no differ significantly at 1% level of significance.

Effect of genope on growth parameters

The tallest plant was found in Basmati 375 followed by Basmati 370 and Basmati-D, while Basmati PNR was relatively short stature irrespective of growth stages (Table 2). The maximum number of tillers was found in Basmati-D followed by Basmati PNR. The tiller production of Basmati 370 and Basmati 375 was low. The findings of Mannan and Siddique (1991) had similarity with this result. However, the tiller productivity of rice depends on the genetic potentiality (Roy *et al.*, 2004). The dry matter productivity of Basmati-D was the highest and statistically followed by Basmati 375, while Basmati PNR and Basmati 370 gave lower amount of dry matter at 30 DAT and at the subsequent date after transplanting.

The high tiller productive genotype Basmati-D showed maximum number of panicles followed by Basmati PNR, while Basmati 370 and Basmati 375 showed low number of panicles irrespective of nitrogen levels (Table.2). The Basmati 375 exhibited the longest panicle, while Basmati PNR showed the shortest panicle. The Basmati-D showed the highest number of grains per panicle and was identical with Basmati 375. The rest of the genotypes gave almost similar number of grains per panicle. The spikelet sterility was high in all entries except Basmati PNR. The significant difference was found in 1000-grain weight among the genotypes due to genetic variability. Significantly heaviest individual grain was found in Basmati PNR and statistically followed by Basmati 375 and Basmati 370. The grain weight was lighter in Basmati-D (Table 2). However, 1000-grain weight is usually a stable varietal character (Yoshida, 1981). The Basmati-D produced the highest straw yield among the genotypes, whereas lowest yield was found in Basmati PNR which also showed lowest plant height (Table 2).

Effect of N concentration on N-uptake

Nitrogen uptake in grain and straw increased with increment of nitrogen levels upto 100 kg/ha. These results are supported by Miah and Panaullah (1999) where the application of nitrogen promoted the concentration of nitrogen in plant. The rate of N-uptake in grain was the lowest in the N control plots (Table 3). Among the test genotypes, the N-uptake of Basmati 370 was the lowest irrespective of N levels. Basmati-D uptakes more amount of nitrogen which is reflected on the production of more tillers and dry matter at different dates after transplanting and even more N was observed in grain. The N concentration and N uptake by grain and straw of Basmati PNR and Basmati-D were higher than the rest of the genotypes (Table 3).

Table 3. N concentration of different Basmati genotypes and N-uptake in grain and straw.

Genotypes	Nitrogen concentration (%)				N-uptake (kg/ha)			
	Grain		Straw		Grain		Straw	
	1999	2000	1999	2000	1999	2000	1999	2000
Basmati PNR	81	77	53	49	22.15 a	20.56 a	17.l0b	15.67d
Basmati 370	78	74	44	42	17.35d	16.95bc	16.95b	15.61b
Basmati 375	78	74	43	42	17.95 c	17.61 b	16.70 c	15.91 b
Basmati-D	82	78	45	44	21.40b	20.90 a	19.49 a	18.60 a
CV (%)					8.9	7.7	9.2	8.7

Figures in a column followed by different letters differ significantly, whereas with common letter(s) do no differ significantly at 1% level of significance.

Relationship of grain yield with genotypes and N levels

The grain yield of rice increased progressively with the increase of nitrogen rates upto 50 kg N/ha (Table 1). Addition of nitrogen beyond that rate decreased grain yield. Higher levels of nitrogen application increase tallness and make the crop more succulent and prone to lodge that decreased number of grains/panicle resulting lower grain yield. These findings are supported by Sidhue *et al.* (2004).

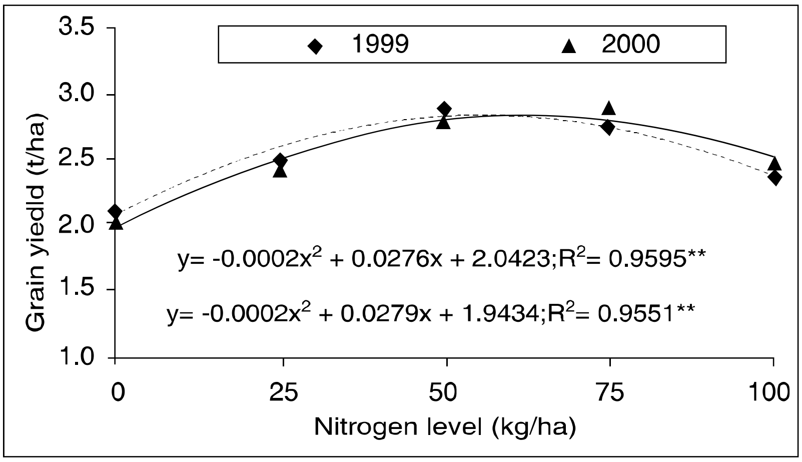

Fig. 1. Grain yield of rice as affected by nitrogen levels (Aman season)

The optimum level of nitrogen 69 -70 kg N/ha was estimated through the regression analysis (Fig. 1) for the cultivation of Basmati fine rice. The variation of grain yield due to application of nitrogen showed a quadratic regression equation. Among the test genotypes, the short stature Basmati PNR produced the highest grain yield and it was statistically identical with Basmati-D (Table 2). The comparatively high grain yield of Basmati PNR than Basmati-D was due to heavier individual grain weight. The low grain yield was recorded in taller genotypes Basmati 370 and Basmati 375 due to less number of panicles and those lodged around panicle initiation stage that led to decrease grains per panicle and increased spikelet sterility. Similar nature of response was also observed by BRRI (2002) in Aman season. The variation of grain yield of the rice genotypes at different levels of N was estimated through regression equation (Fig. 2). The estimated optimum dose of nitrogen for Basmati 370, Basmati 375 and Basmati-D were similar (52-56 kg/ha), but the Basmati-PNR required more amount of nitrogen (>119 kg N/ha). The higher nitrogen requirement of Basmati PNR might be due to short stature plant having intermediate type of tiller and dry matter production that enhanced the uptake of more nitrogen (Table 1). The findings of this study indicated that response of N was linear upto 75 kg N/ha might be owing to better N uptake leading to higher number of panicles and panicle length resulted yield increase. These findings confirmed the results of Shivay and Singh (2003) where maximum response was observed at 75 kg N ha (Salam *et al.*, 2004). Some genotypes had potentiality to produce better grain yield even without N (BRRI, 2004).

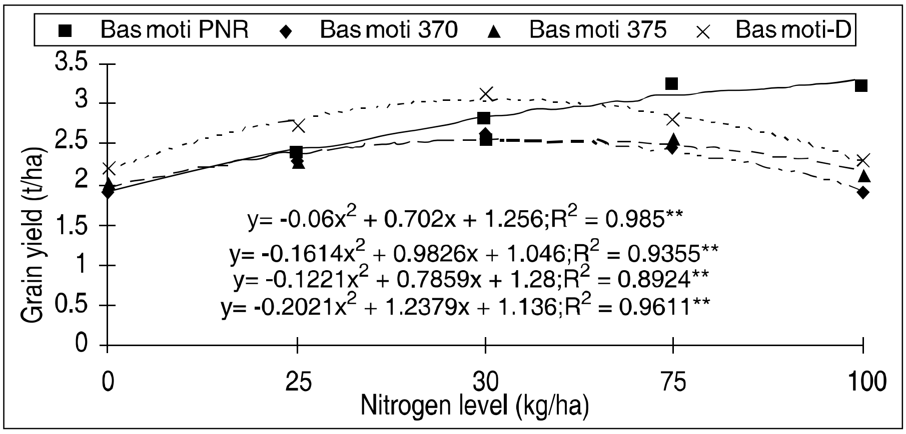

Fig 2. Grain yield of rice as affected by nitrogen (Aman season). Thus, the cultivation of short stature Basmati PNR rice, the optimum N requirement is higher (>100 kg N/ha), while other Basmati genotypes responded well comparatively at the low level of nitrogen 52-56 kg/ha to obtain maximum grain yield in Aman season.

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