YIELDING ABILITY OF AROMATIC RICE UNDER STACKING AND NON-STACKING CONDITIONS WITH DIFFERENT NITROGEN FERTILIZATION

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ABSTRACT

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A field experiment was conducted to study the effect of nitrogen fertilizer on yielding ability of indigenous aromatic rice cultivars under stacking and non-stacking conditions. Rice cultivars were grown during Aman season, 2002. There were four cultivars, namely, Shakkorkhora, Chinigura, Kalijira and Kataribhog, each with three levels of nitrogen fertilizer (0, 60 and 120 kg N ha^{-1}). At the time of heading the experimental plots were equally divided into two parts. The crop in the half of the plot was left on the fate of the nature and that in the other half of the plot was mechanically supported by stacking to prevent lodging. Under stacking condition with the application of 60 Kg N ha^{-1} the grain yields increased by 12%, 23%, 29% and 18% in Shakkorkhora, Chinigura, Kalijira and Kataribhog, respectively compared to control. With stacking yield was increased by 0.6% in Shakkorkhora, 25% in Chinigura, 18% in Kalijira and 11% in Kataribhog at 60 kg N ha^{-1} and by 18% in Shakkorkhora, 27% in Chinigura, 35% in Kalijira and 80% in Kataribhog at 120 kg N ha^{-1}. The grain yield increase under stacking condition was supported by the increase in the number of filled spikelets per panicle, 1000-grain weight and decrease in sterility. Under stacking condition even at high level of nitrogen (120 kg N ha^{-1}) the number of filled grain per panicle and 1000-grain weight increased remarkably. The highest grain yield was observed in plants with 60 kg N ha^{-1} under non-stacking condition. Stacking increased grain yield remarkably. Kataribhog with 120 kg N ha^{-1} produced 3.7 t ha^{-1} grain yield when provided artificial stacking, which was 2 t ha^{-1} under non-stacking condition. Under stacking condition, the cultivars Shakkorkhora, Kalijira and Kataribhog showed their highest yielding ability at 120 kg N ha^{-1}.

Key words: Nitrogen fertilizer, stacking, non-staking condition and aromatic rice.

INTRODUCTION

Among various nutritional requirements for production, nitrogen is the key element for its significant role in rice yield. Production potentials of rice are realized only when optimum growth conditions are provided. Adequate supply of nitrogen at all growth stages ensures proper development of the rice plant for prolific tillering, satisfactory panicle formation, spikelet development and proper grain filling (Van keulen, 1977).

Achieving high yields in rice requires increased biomass production and favorable partitioning to grains. Crop environmental conditions with high solar radiation during the growing season and abundant supply of N (Akita, 1989) favored accumulation of high amount of biomass and high yields provided varieties respond favorably to N. Without a strong thick culm and proper partitioning of assimilates, increased biomass production results in lodging and reduced grain yield (Vergara, 1988). Lodging is thus often a constrain to achieving higher yields for the currently available varieties when N supply is high (Settar *et al*., 1995). It is necessary for breeding research aiming at higher yields to develop plant type that is resistant to lodging at luxuriant supply of N.

For the development of high yielding aromatic rice varieties our indigenous aromatic rice cultivars may play a vital role as parent material because they are most adaptive to our environment. Although some research works were carried out and high yielding aromatic rice varieties were released by Bangladesh Rice Research Institute (BRRI), our indigenous cultivars were given less attention and their yielding ability at high levels of nitrogen input was not well studied. Therefore, the yielding ability of our indigenous aromatic rice cultivars at high level of nitrogen fertilizer needs to be investigated.

Considering the above facts, the present study was undertaken to explore the yielding ability of four indigenous aromatic rice cultivars at different levels of nitrogen under stacking and non-stacking conditions.

MATERIALS AND METHOD

A field experiment was carried out at the experimental field of Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur during the rainy season of 2002. The experimental site is located at the center of Madhupur tract ($24^o09'$ N latitude and $90^o26'$ E longitude) having an elevation of 8.2 meter from the sea level. The climate of the experimental site is sub-tropical in nature characterized by heavy rainfall during the months from June to September and scanty rainfall during winter with gradual fall of temperature. Average air temperature ranged from 30.18^oC (maximum) to 19.86^oC (minimum) and total rainfall recorded

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744.6 mm during the study period (August to December 2002). The soil type of the experimental field belongs to the shallow red-brown terrace type of Salna series. The soil is characterized by poor fertility and impeded internal drainage. Rice cultivars, namely Chinigura, Kalijira, Shakkorkhora and Kataribhog were grown with three levels of nitrogen fertilizer (0, 60 and 120 Kg N ha^{-1}). The experiment was laid out in a randomized complete block design.

Triple Super Phosphate, Muriate of Potash, Gypsum and Zinc Sulphate were applied as the sources of P_2O_5, K_2O, S and Zn, respectively. P_2O_5, K_2O, S and Zn were applied at the rate of 90, 50, 40, and 5 kg ha^{-1} respectively. All fertilizers except urea were applied and thoroughly mixed with the soil at the time of final land preparation. Urea was applied as top dressing in three equal installments, at active tillering stage (18 days after transplanting), at maximum tillering stage (35 days after transplanting) and before panicle initiation stage (50 days after transplanting). The seedlings were transplanted at 30 days after seeding. One seedling per hill was used maintaining 25 cm row to row and 10 cm plant to plant distance in well prepared land. Weeding, irrigation and application of pesticide were done as and when necessary. Standing water of 2 to 4 cm was maintained in the field until the crop attained hard dough stage.

At the time of heading the experimental plots were equally divided into two parts. Thus every part of the plot occupied 3.75 m^2 land area. The crop in the half of the plot was left on the fate of the nature (treated as 'non-stacking') and that in the other half of the plot was mechanically supported by stacking (treated as 'stacking') to prevent lodging. Bamboo sticks and plastic ropes were used for stacking. Mechanical supports were provided in such a fashion that the canopy architecture and light interception remained almost unaffected.

The total number of emerged panicle per hill was counted at maturity stage. The length of all the panicles of a hill was measured in centimeter from the collar (base mark) of the culm to the tip of the panicle. Both fertile and sterile spikelets per panicle were separately counted manually from all of the panicles of sample hill. From the filled grains of a hill, 1000 grains were randomly counted by Multi-auto counter and the weight of these grains was recorded.

From the middle portion of the plots the stacked and non-stacked hills were harvested separately and grain yield was recorded and adjusted with 14% moisture content. Harvest index (HI) was calculated by dividing the economic yield (grain) by the biological yield (grain + straw) from the same area.

The data were analyzed by partitioning the total variance by using MSTAT-C program. The treatment means were computed using Least Significant Difference test and interrelationship was worked out employing regression analysis.

RESULTS AND DISCUSSION

Rice grain yield is a function of the number of filled grains per unit area multiplied by the grain size. The number of grains or spikelets per unit area depends on the number of grains per panicle and the panicle density. On the other hand, lodging plays a great role for reducing the grain yield.

The number of panicle per hill

Irrespective of cultivars, increasing levels of nitrogen up to 120 kg N ha^{-1} significantly increased the number of panicle per hill (Table 1). Application of 60 kg N ha^{-1} increased panicle number by 1.4, 1.3, 1.3, 4.0 and 120 kg N ha^{-1} by 2, 3.2, 2.9, and 4.9 in Shakkorkhora, Chinigura, Kalijira and Kataribhog, respectively. The highest panicle number per hill was observed in Kataribhog with 120 kg N ha^{-1} (12.39) and the lowest in Shakkorkhora without N fertilization (6.45). Lodging did not show any substantial effect on panicle number. This might be due to that the lodging started after heading when the panicle number became stable.

Number of spikelet per panicle

Number of spikelet per panicle also increased with increasing levels of N (Table 1). Application of 60 kg N ha^{-1} increased spikelet number by 10, 19, 18, 14 and 120 kg N ha^{-1} by 14, 29, 32 and 27 in Shakkorkhora, Chinigura, Kalijira and Kataribhog, respectively. Among the cultivars, Kataribhog produced comparatively lower number of spikelets per panicle (107, 122 and 135 at 0, 60, 120 kg N ha^{-1}, respectively). On the other hand, Kalijira produced the higher spikelet number per panicle (175, 193 and 207 at 0, 60, 120 kg N ha^{-1} respectively).

1000-grain weight

1000-grain weight did not show any significant variation among the cultivars with different N levels (Table 1). But in general the 1000-grain weight reduced with the higher N levels (120 kg N ha^{-1}) compared to control. Under non-stacking condition the 1000-grain weight was slightly reduced, might be due to the poor grain filling rate. The 1000-grain weight is a stable varietal character because the grain size is rigidly controlled by the size of the hull (Yoshida, 1981). However, under stacking condition the 1000-grain weight was increased by 0.4, 0.8, 1.3, 2.2 % at 60 kg N ha^{-1} and by 10.7, 2.8, 0.7, 9.3 % at 120 kg N ha^{-1} in Shakkorkhora, Chinigura, Kalijira and Kataribhog, respectively. Momin (2003) reported that the grain size increased by less than 3% in mechanically lodging prevented cultivars. Kono (1995) reported the similar findings.

Table 1. Number of panicles per hill in four aromatic rice cultivars at three nitrogen levels under stacking and non-stacking conditions

Cultivar	N dose (kg ha^{-1})	Number of panicles $hill^{-1}$		Total Spikelet $panicle^{-1}$	1000-grain weight (g)	
		Stacking	Non-stacking		Stacking	Non-stacking
Shakkorkhora	0	6.08	5.94	129.00	11.70	11.84
	60	7.44	7.42	138.67	11.80	11.85
	120	8.16	8.72	143.00	10.74	11.89
Chinigura	0	6.74	6.63	123.67	13.17	13.36
	60	8.03	8.13	142.67	13.34	13.45
	120	9.93	9.69	153.00	12.56	12.91
Kalijira	0	6.77	6.63	175.00	11.31	11.35
	60	8.05	7.91	193.00	11.43	11.58
	120	9.62	10.17	207.33	11.12	11.20
Kataribhog	0	6.24	5.92	107.67	17.87	18.21
	60	10.21	10.39	122.33	17.53	17.92
	120	11.12	11.84	135.00	16.21	17.72
LSD (.05)		0.99	1.079	6.46	NS	NS
CV (%)		7.15	7.72	2.59	3.37	3.37

Number of filled grains per panicle

The cultivars also varied significantly in number of filled spikelets per panicle with different N levels (Table 2). Irrespective of cultivars, number of filled grain per panicle increased up to 60 kg N ha^{-1}, further increase in nitrogen levels filled grains per panicle decreased due to lodging. A similar result was found by Yoshida (1981) who reported that the decrease in the number of filled grains at high N levels due to lodging or culm bending. Number of filled spikelets per panicle ranged from 161.7 (Kalijira at 120 kg N ha^{-1}) to 91.93 (Kataribhog without N fertilization) under artificially stacking condition. But, under non-stacking condition the number of filled grains per panicle ranged from 142.2 (Kalijira at 60 kg N ha^{-1}) to 80.54 (Kataribhog at 120 kg N ha^{-1}).

Under stacking condition application of 60 kg N ha^{-1} increased filled spikelet number by 15, 18, 15, 12 % and 120 kg N ha^{-1} by 4.6, 16, 11 and 9 % in Shakkorkhora, Chinigura, Kalijira and Kataribhog, respectively. Under non-stacking condition application of 60 kg N ha^{-1} increased filled spikelet number by 13, 12, 2, 8 % and 120 kg N ha^{-1} by 7, 6, 5, and 11 % in Shakkorkhora, Chinigura, Kalijira and Kataribhog, respectively. Stacking increased the number of filled grain per panicle by 0.6, 5.8, 12, and 5% at 60 kg N ha^{-1} and by 10, 9.4, 14, and 19.4 % at 120 kg N ha^{-1} in Shakkorkhora, Chinigura, Kalijira and Kataribhog, respectively.

Sterility

Sterility percentage varied significantly among the cultivars with different N levels (Table 2). Sterility percentage was lower at control treatment compared to 60 and 120 kg N ha^{-1} in all the cultivars. Under non-stacking condition plants fertilized with 120 kg N ha^{-1} had the higher sterility percentage.

The sterility was greatly influenced by lodging. Increasing N rates increased the sterility percent; this might be due to lodging or culm binding at higher N levels as reported by Yoshida and Parao (1976). The environmental condition, particularly the availability of solar radiation and the supply of nutrient during the post- heading phase largely determine the ripening percentage (Akita, 1989). From the previous discussion it was found that, under non-stacking condition the light interception was highly disturbed and the translocation of assimilates towards grain was very much restricted, these might be a cause of higher sterility under non-stacking condition. Stacking reduced the sterility by 3, 22, 38, and 21% at 60 kg N ha^{-1} and by 21, 23, 30, and 36 % at 120 kg N ha^{-1} in Shakkorkhora, Chinigura, Kalijira and Kataribhog, respectively.

Grain yield

The effect of nitrogen fertilizer on grain yield was significant. Under non-stacking condition irrespective of cultivars, grain yield increased up to 60 kg N ha^{-1} and slightly increased also at 120 kg N ha^{-1} in Shakkorkhora, Chinigura and Kalijira but reduced in Kataribhog (Table 3). At 60 Kg N ha^{-1} grain yield of aromatic rice was recorded 2787, 2807, 2750 and 2975 Kg ha^{-1} in Shakkorkhora, Chinigura, Kalijira and Kataribhog, respectively, which were by 11.4, 14.4, 14 and 15.5% higher than those of control. While at 120 kg N ha^{-1} the grain yields were 2565 kg ha^{-1} in Shakkorkhora, 2608 kg ha^{-1} in Chinigura , 2441 kg ha^{-1} in Kalijira and 2063 kg ha^{-1} in Kataribhog, which were by 2.6, 6.3 and 1.2% higher in Shakkorkhora, Chinigura and Kalijira , respectively and 19.8% lower in Kataribhog than the control. The yield reduction in Kataribhog at high level of nitrogen might be due to lodging just 3 days after heading.

Table 2. Spikelet number, filled grain per panicle and sterility in four aromatic rice cultivars at three nitrogen levels under stacking and non-stacking conditions

Cultivar	N dose (kg ha-1)	Filled grain panicle-1		Sterility (%)	
		Stacking	Non-stacking	Stacking	Non-stacking
Shakkorkhora	0	100.50	100.41	22.87	22.17
	60	114.60	113.85	17.37	17.90
	120	104.14	93.59	27.17	34.53
Chinigura	0	100.38	99.55	18.83	19.50
	60	118.69	111.76	16.80	21.67
	120	116.53	105.61	23.83	31.00
Kalijira	0	139.61	138.83	20.22	20.67
	60	161.68	142.26	16.20	26.33
	120	155.13	132.27	25.17	36.17
Kataribhog	0	91.93	90.63	16.17	17.33
	60	103.40	98.25	15.45	19.67
	120	100.20	80.54	25.78	40.33
LSD (0.05)		5.69	6.424	2.62	1.705
CV (%)		2.87	3.48	2.29	4.92

Under stacking condition with the application of 60 Kg N ha^{-1} the grain yields obtained were 2802, 3511, 3262 and 3316 Kg ha^{-1} in Shakkorkhora, Chinigura, Kalijira and Kataribhog, respectively which were by 11.6, 22.7, 29.2 and 18% higher than those of control. Under stacking condition with the application of 60 Kg N ha^{-1} the grain yields increased by 11.6, 22.7, 29.2 and 18% in Shakkorkhora, Chinigura, Kalijira and Kataribhog, respectively. By stacking yield increased by 0.6% in Shakkorkhora , 25% in Chinigura, 18% in Kalijira and 11% in Kataribhog at 60 kg N ha^{-1} and by 18% in Shakkorkhora , 27% in Chinigura, 35% in Kalijira and 80% in Kataribhog at 120 kg N ha^{-1}. The grain yield increase under stacking condition was supported by the increase in the number of filled spikelets per panicle, 1000-grain weight and decrease in sterility.

Table 3. Yield in four aromatic rice cultivars at three nitrogen levels under stacking and non-stacking conditions

Cultivar	N dose (kg ha-1)	Grain yield (kg ha-1)		Grain yield increase under stacking		Harvest Index	
		Stacking	Non-stacking	kg ha-1	(%)	Stacking	Non-stacking
Shakkorkhora	0	2509	2500	9	0.36	0.44	0.45
	60	2802	2787	15	0.55	0.38	0.38
	120	3035	2565	470	18.34	0.35	0.31
Chinigura	0	2860	2453	407	16.58	0.44	0.40
	60	3511	2807	704	25.08	0.39	0.38
	120	3328	2608	720	27.59	0.32	0.26
Kalijira	0	2523	2410	113	4.70	0.40	0.39
	60	3262	2750	512	18.63	0.39	0.36
	120	3306	2441	866	35.48	0.34	0.27
Kataribhog	0	2808	2575	234	9.09	0.45	0.44
	60	3316	2975	342	11.50	0.40	0.37
	120	3713	2063	1651	80.01	0.38	0.23
LSD (0.05)		269.8	209.1	147.8	6.33	0.016	0.053
CV (%)		5.17	4.79	20.93	21.0	3.27	6.44

Harvest index

Harvest index (HI), also termed as co-efficient of effectiveness, is a good indicator to identify the potentiality of a crop to produce economic yield compared to biological yield. Irrespective of cultivars, under both stacking and non-stacking conditions the HI decreased with the increase in N levels, however the decrease was more distinct under non-stacking condition (Table 3).

The findings of the experiment can finally be summarized as i). Under natural growing condition the aromatic rice cultivars showed their highest yielding ability at 60 kg N ha^{-1}, and this yielding ability can be further increased by 0.6% in Shakkorkhora, 25% in Chinigura, 19% in Kalijira and 11% in Kataribhog by preventing lodging. ii). Under lodging preventing condition, except Chinigura the other three cultivars Shakkorkhora, Kalijira and Kataribhog showed their highest yielding ability even up to 120 kg N ha^{-1}. iii). As the indigenous aromatic rice cultivars Shakkorkhora, Kalijira and Kataribhog showed their highest yielding ability even at highest level of nitrogen (120 kg N ha^{-1}) application, these cultivars may be used as parent materials for the development of high yielding aromatic rice varieties.

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