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EFFECT OF NITROGEN ON YIELD, YIELD COMPONENTS AND CONTRIBUTION FROM THE PRE-ANTHESIS ASSIMILATES TO GRAIN YIELD OF THREE PHOTOSENSITIVE RICE (*ORYZA SATIVA* L.) CULTIVARS

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Abstract: The experiment was conducted in the Agronomy field laboratory of Bangladesh Agricultural University to find out the pre-anthesis contribution to grain yield in selected rice varieties (BR22,BR23 and Nizersail) of Bangladesh. Total tiller no./m^2, no. of effective tillers /m^2, spikelet no./panicle, % filled grain, 1000 grain wt, straw yield and grain yield varied significantly in different cultivars . Grain yield was highest in BR23 (5.08 t/ha) followed by BR22 (4.59 t/ha). Levels of N significantly influenced all the crop characters studied except 1000 grain wt. Increasing N level increased grain and straw yield. The interaction effect between cultivar and N was significant for effective tiller no./m^2, spikelet no./panicle, % filled grain, grain yield and % contribution to grain yield from pre-anthesis assimilates. Pre-anthesis assimilate contribution to grain yield was greatest with no N application (28% in BR22 and BR23), and was lowest at 120 kg N/ha (3% in Nizersail). The pre-anthesis assimilate contribution showed a negative relationship with increased N application. However, this relationship varied for different cultivars with BR 23 showing a greater capacity to mobilize pre -anthesis assimilates than BR22 and Nizersail.

Key words: Grain yield, nitrogen, *Oryza sativa* L., pre-anthesis assimilates, rice.

INTRODUCTION

Nitrogen is the key nutrient element, representing two-thirds or more of the total nutrient consumption in Asia.[1] The amount of N that a rice plant absorbs to produce a unit of grain yield is nearly constant at 19-21 kg N/t brown rice. Accordingly the plant must absorb a larger amount of N to produce a higher grain yield.[2]

For maximization of rice yield, proper agronomic management is very important. Among the management practices, soil fertilization, particularly nitrogen management is the most important. High yielding varieties (HYVs) are generally more responsive to nitrogen application and they show increased yield with increasing nitrogen level up to a certain limit. The yield of Transplant Aman rice (usually grown in the wet season, i.e from July to December) is lower than Boro rice (usually grown in the dry season i.e. from January to April) because of higher temperatures in the early stage and lower temperatures in the latter stages and also because of the lower response to fertilizer, especially N.

Transplanting Aman growing environment in Bangladesh represents the rainfed lowland rice (RLR) culture. The photosensitive group of rice varieties are grown in this ecosystem during the above mentioned period. High yielding varieties (HYVs) of rice cover about 40% of RLR area[3] in Bangladesh. Hence, 60% of the rice area is still planted with local photosensitive varieties (PS) even 20 years after HYV rice was introduced. In the wet season, only 24% HYVs are cultivated by the farmers.[4]

Grain yield of any cereal is determined by the dry matter produced before and after anthesis. Pre-anthesis assimilation varies with cultivars, availability of inputs, such as irrigation and fertilizers, weed and disease infestation.[6]

The assimilates stored in rice grain during ripening originate from two sources.[7] One is the pre-heading assimilates which are subsequently transferred to the grain during the ripening period. The other is the assimilates produced during the ripening period. Pre-anthesis assimilates may provide a significant contribution to the grain yield. However, information of pre-anthesis assimilates contribution to grain yield of rice under different N-doses during wet season in Bangladesh is not available. Therefore, the objective of this experiment was to examine the effect of pre-anthesis contribution to grain yield of three rice varieties under five N-levels.

METHODS AND MATERIALS

Two high-yielding and one local photosensitive varieties viz. BR22, BR23 and Nizersail were transplanted in the Agronomy field laboratory, Bangladesh Agricultural University, Mymensingh, Bangladesh during Transplanted Aman season, 1992. The experimental site was a medium highland (many places of the area remain submerged upto 6-8 months of the year by 1.8-2.5m water) with sandy loam texture having pH 6.65, organic matter 2.44%, total N 0.115%, available P (Olsen) 21.0 ppm and exchangeable K 0.43 meq/100 g soil which belongs to Order Inseptisol as per 7th approximation by USDA. Phosphorus, potassium, sulphur and zinc fertilizer were applied through triple superphosphate, muriate of potash, gypsum, and zinc sulphate at the rates of 90 kg/ha, 40 kg/ha, 60 kg/ha and 10 kg.ha, respectively, as per recommendation of BRRI.[8] All the phosphate, potassium, sulphur and zinc fertilizers and one-third of urea were applied in each plot at the time of final land preparation and were mixed thoroughly with soil. The rest two-thirds of urea was top-dressed in two equal splits, i.e.. one at active tillering stage and the other at panicle initiation stage at 30 and 55 days after transplanting respectively. The control plots received no nitrogen fertilizer. The experiment was laid out in split-plot design with four replications in a 5x4 m^2 plot, spaced at 25x15 cm using two seedlings/hill. Levels of nitrogen were 0,60,80,100,120 kg/ha. Main plot and subplot treatments were variety and levels of nitrogen respectively. Grain yield was measured at maturity by harvesting 5 m^2 from the centre of each plot. Yield components were recorded from 10 randomly selected hills from each plot.

Stem weight at anthesis was recorded by harvesting an area of 0.25 m^2 in each plot. The stems including leaves were dried at 85^{0}C for 24 hours and weighed separately. At pre-anthesis, stems were weighed together with leaves since leaves contributed little to grain yield from pre-anthesis assimilation.[9] Yoshida & Ahn[10] reported that the change in carbohydrate content of leaf blades, sheath and culm could account for upto 38% of grain carbohydirate and that the contribution varied considerably among varieties in rice. Contribution from pre-anthesis assimilate to grain yield was calculated according to Gallagher *et al.*[11] and also as suggested by Sadeque.[12]

Pre-anthesis contribution to grain yield

$$= \frac{\text{Stem weight at anthesis - stem weight at maturity}}{\text{Grain weight at maturity - grain wt at anthesis}} \times 100$$

The data were analysed following standard statistical procedures.[13]

RESULTS AND DISCUSSION

Number of Tillers /m^2

Total tillers/m^2 at harvest was markedly influenced by N (Table 1 & 2), indicating a positive linear relationship between tiller number to added No (Y=201.5 + 0.45X, R^2 =0.93**) within the range of N levels used. The tiller no./m^2 was significantly higher at 120 kg N/ha than at lower N levels. Among the varieties, BR22 produced the highest tillers/m^2. The difference was significantly higher ($p<0.05$) than BR23 and Nizersail. Jashim *et al*[14] also reported similar results for tiller production in rice.

Number of Panicles /m^2

Panicle/m^2 increased significantly with the increase of N supply (Table 1 & 2), but the varietal response to N was not similar. Panicles/m^2 of BR22 and BR23 increased significantly at higher rate of added N. In the case of Nizersail it increased up to 80 kg N/ha , then decreased. BR22 produced more panicles/m^2 than BR23 and Nizersail The results were consistent with those of Awan *et al.*[15] who reported that increased panicle number was due to N fertilizer.

Table 1: Effect of cultivar and N on yield components of rice during T. Aman season, 1992.

Treatment	No. of tillers/m^2	No. of Panicles /m^2	No. of Spikelets /panicle	Filled grain (%)	1000 grain weight (g)
Cultivar					
BR22	275.6a	243.1a	126.2b	85.17b	18.94b
BR23	250.9b	219.7b	145.5a	85.57a	25.13a
Nizersail	256.1b	189.8c	121.6c	83.10c	16.55c
N (kg/ha)					
0	212.3d	182.0e	112.1a	80.80d	19.57b
60	249.2c	214.5d	126.6d	85.04c	20.26b
80	268.7b	229.7b	133.2c	85.95a	20.09ab
100	275.2b	225.3c	139.3b	85.88a	20.11ab
120	299.0a	236.2a	149.3a	85.40b	21.00a

In a column, means followed by a common letter are not significantly different at 5% level by DMRT.

Number of Spikelets /panicle

Table 1 shows that spikelets /panicle in all rice varieties increased significantly as the N level increased, showing a positive significant linear relation between spikelets/panicle to added N ($Y=111.6+0.27X$, $R^2=0.996^{**}$) within the range of N levels used. In all rice varieties the highest no. of spikelets/panicle was observed at 120 kg N/ha. Spikelets/panicle was significantly different between the varieties. BR 23 produced higher spikelets /panicle than the other two varieties. Lower spikelets/panicle in Nizersails was one of the factors responsible for lower grain yield (Tables 1 and 2). The results were similar to those of Dixit & Singh[16] who reported higher spikelets/panicle with higher levels of added N.

Filed grain percentage

Similar to spikelet production, filled grain percentage increased significantly due to added N (Tables 1 and 2). However, in all varieties increases were significant only in the 0-60 kg N/ha range. Similar results were reported by Chandranath *et al.*[17] and Jennyc.[18] The percentage of filled grain spikelet is highly affected by variety, N management, soil and climate.[19]

Table 2: Effect of interaction between cultivar and N on yield components of rice during T. Aman season ,1992.

Plant Characters	Nitrogen level (kg/ha)	Variety		
		BR22	BR23	Nizersail
No. of tillers/m^2				
	0	227.5cA	201.5dB	208.0cAB
	60	266.5bA	234.0cB	247.0bAB
	80	279.5bA	253.5bA	273.0aA
	100	286.0bA	266.5bA	273.0aA
	120	318.5aA	299.0aA	279.5aB
No. of Panicles/m^2				
	0	201.5cA	175.5dB	169.0cB
	60	234.0bA	208.0cB	201.5abB
	80	247.0bA	221.0bcB	221.0aB
	100	253.5bA	234.0bA	188.5bB
	120	279.5aA	260.0aA	169.0cB
No. of Spikelets/Panicle				
	0	108.3eB	124.0bA	109.0eC
	60	122.5dB	139.8dA	117.5dC
	80	126.8cB	149.0cA	123.8cC
	100	133.8bB	154.3bA	130.0bC
	120	139.8aB	160.5aA	132.5aC
Filled grain (%)				
	0	81.7dB	79.6eC	81.8dA
	60	85.0cB	85.9dA	84.2bC
	80	86.2bA	86.4cA	85.3aB
	100	86.8aB	87.7bA	83.2cC
	120	86.8aB	88.3aA	81.1eC
1000 grain wt. (g)				
	0	17.75bB	24.64aA	16.31aB
	60	18.65bB	25.42aA	16.71aB
	80	18.13bB	25.55aA	16.58aB
	100	18.96bB	24.85aA	16.52aC
	120	21.19aB	25.20aA	16.63aC

Means in columns and rows followed by the same letter(s) are not significantly different at 5% level by DMRT. Lower case and capital letters indicate comparison within column and row respectively.

1000 grain weight (g)

N at varying levels had no significant effect on 100 grain weight in all rice varieties except BR22. In BR22 the 1000 grain weight is significantly greater at 120 kg N/ha. However, 1000 grain weight of BR22 and BR23 was significantly higher than that of Nizersail (Tables 1 and 2).. Tanaka *et al.*[20] reported a decrease in 1000 grain weight with increasing N supply, particularly in traditional varieties.

Grain yield

Both grain and straw yield increased progressively with increased N level in all rice varieties tested (Table 3). Grain yield response to added nitrogen was identical among the high and low yielding varieties within the range of N levels tested. A positive linear relationship existed between grain yield and added N in BR23 ($Y=3.39 + 0.024N$, $R^2=0.99^*$) and BR22 ($Y=2.40+0.297N$, $R^2=0.95^*$). In both these high yielding varieties, grain yield responded linearly up to 120 kg N/ha , while in Nizersail, N response in terms of grain yield was curvilinear. ($Y=2.76 + 0.0265N-0.0002N^2$, $R^2=0.9863^*$) with the grain yield increasing up to 60 kg N/ha and decreasing subsequently,. Many investigators have reported that grain yield of rice increased due to N. [4,21,22]

Table 3: Effect of cultivar and N on % pre-anthesis contribution of rice during T. Aman season, 1992.

Treatment	Stem wt. at anthesis (t/ha)	Straw yield at harvest (t/ha)	Grain yield (t/ha)	Pre-anthesis contribution (%)
Cultivar				
BR22	6.38b	5.82b	4.59b	14.52b
BR23	7.38a	6.60a	5.08a	17.01a
Nizersail	6.63b	6.39a	3.08c	7.81c
N (kg/ha)				
0	5.02d	4.34e	2.93d	23.07a
60	6.11c	5.46d	4.02c	15.73 b
80	7.00b	6.22c	4.45b	16.32 b
100	7.52b	7.16b	4.72b	7.17 c
120	8.33a	8.16a	5.04a	3.27d

In a column, means followed by a common letter are not significantly different at the 5% level by DMRT.

Straw yield

Similar to grain yield, straw yield in all rice varieties tested increased significantly due to N fertilization. Highest straw yield was observed at 120 kg N/ha (Tables 3 and 4). Among the varieties, BR23 and Nizersail produced significantly greater straw yield than BR22. The results agreed with those of Eaqub *et al.*[23] and other workers.[4,22]

Pre-anthesis assimilate contribution to grain yield

BR23 had a significantly greater stem weight at anthesis than BR22 and Nizersail (Table 3). Application of nitrogen increased stem weight at anthesis. This response was linear ($Y=4.832+0.0273X$, $R^2=0.97^{**}$) within the range of N levels tested. This result corroborates with BRRI's findings (BRRI 1992[22] and 1993[4]). These values correspond well with the values of stem weight at maturity and with those of stem and grain weight between anthesis and maturity (Tables 3 and 4).

Calculations have shown[11] that cultivar and levels of nitrogen significantly influenced the extent of pre-anthesis assimilate contribution to grain yield. The contributions from different cultivars to grain yield from pre-anthesis assimilation were 17.01% in BR23, 14.52% in BR22 and 7.81% in Nizersail (Tables 3 & 4). BR23 performed better with respect to stem contribution and grain yield than that of BR22 and Nizersail. Weng *et al.*[7] and Vorob'ev and Skazheinnik[24] reported similar results. The interaction effect between cultivar and nitrogen was significant on per cent contribution from pre-anthesis assimilation to grain yield (Table 4). The highest contribution was 28.20% in BR22 with no nitrogen. This decreased gradually due to N and the same trend was observed in Nizersail beginning with 12.9% contribution of stem to grain. In BR23, highest contribution was 28% with no nitrogen which did not significantly differ with the contribution at 80 kg N/ha. Overall results showed that the pre-anthesis assimilate contribution was highly negatively correlated with increased nitrogen rates ($Y=24.669-0.160X$, $R^2=0.88^{**}$). These results were supported by Prabakar *et al.*[25] Vorob'ev and Shazheinnik[24] and Balkema-Boomstra.[26] In this study, the calculated values of pre-anthesis assimilate contribution to grain yield were higher than expected in a normal growing environment of the crop. However, these levels were within reasonable limits as reported by Gallagher *et al.*[11] and Gent.[6] Another possible explanation for higher values was that in this calculation proposed by Gallagher *et al.*,[11] respiratory losses are not taken into account.

Results revealed that cultivars responded differently to applied N for pre-anthesis assimilate contribution to grain yield. BR23 was capable of contributing more to grain yield from pre-anthesis assimilation than BR22. The pre-anthesis assimilate contribution was lowest in Nizersail.

Table 4: Effect of interaction between cultivar and N on % pre-anthesis contribution of rice during T. Aman season, 1992.

Plant Characters	Nitrogen level (kg/ha)	Variety		
		BR22	BR23	Nizersail
Stem wt. at anthesis (t/ha)				
	0	4.18dC	6.01dA	4.89cB
	60	5.62cA	6.63cdA	6.07bA
	80	6.73bA	7.23bcA	7.03abA
	100	7.41abA	7.73bA	7.41aA
	120	7.95aB	8.28aA	7.76aB
Straw wt. at harvest (t/ha)				
	0	3.42dB	5.06cA	4.54cA
	60	5.00cA	5.57cA	5.70bA
	80	6.07bA	5.82cA	6.78aA
	100	6.87abA	7.35bA	7.26aA
	120	7.74aB	8.07aA	7.68aB
Grain yield (t/ha)				
	0	2.66bB	3.37dA	2.75cB
	60	3.66dB	4.81cA	3.58aB
	80	4.75cB	5.25cA	3.36abc
	100	5.42bA	5.70bA	3.06bcB
	120	6.20aA	6.26aA	2.65cB
Pre-anthesis contribution(%)				
	0	28.18aA	28.14aA	12.88aB
	60	17.08bA	19.62bA	10.48abB
	80	13.94bB	27.37aA	7.66bcC
	100	9.95cA	6.54cAB	5.03cdB
	120	3.43dA	3.37cA	3.02dA

Means in columns and rows followed by the same letter(s) are not significantly different at 5% level by DMRT. Lower case and capital letters indicate comparison within column and row respectively.

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