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EFFECT OF NITROGEN ON GROWTH, PRODUCTIVITY AND SEED QUALITY OF LONG GRAIN RICE

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Field experiment was conducted at the experimental farm of Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur during Aman season to optimize nitrogen requirement of long grain rice (var. BUdhan 1) in respect to high yield and seed quality. Seven levels of nitrogen fertilizer viz. 0, 20, 40, 60, 80,100 and 120 kg N ha^{-1} constituted the treatment variables. Application of nitrogen fertilizer significantly influenced morphological event of the variety where days required for expressing phenological events increased with the increase of nitrogen levels. Growth parameters like plant height (114.37 cm), tillers per hill (15.1) and dry matter accumulation were pronounced at higher level of nitrogen. However, plants with moderate level (60 kg ha^{-1}) of applied nitrogen showed better yield component of the variety where the highest number of panicle per hill (11.8), grains per panicle (140.5) filled grains per panicle (130.33) and bolder seed size were recorded with 60 kg N ha^{-1}. Better yield components of the variety obtained at 60 kg N ha^{-1} attributed to highest yield (4.43). Considering seed quality, seeds obtained from 60 kg N ha^{-1}showed significantly higher viability, germination and vigor indices. Therefore, it is desirable to collect seeds of BUdhan 1 with moderate level of nitrogen to ensure higher yield with better seed quality of BUdhan 1.

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INTRODUCTION

Rice (*Oryza sativa* L.) is the staple food for majority people of the world. Rice ranks the highest position among the cereal crops grown in Bangladesh and also rice accounts for 80% of the annual food grain production (Manik et al., 2016). It provides nearly 48% of rural employment, about two-third of total calorie supply and about one-half of the total protein intakes per person in the country. Rice sector also contributes one-half of the agricultural GDP and one-sixth of the national income in Bangladesh. Rice is grown on about 10.5 million hectares which remained almost stable over the past three decades. About 75% of the total cropped area and over 80% of the total irrigated area are covered by rice. Thus, rice plays a vital role in the livelihood of the people of Bangladesh. The population of Bangladesh is growing by two million every year and may increase by another 30 million over the next 20 years. Thus, Bangladesh will require about 27.26 million tons of rice for the year 2020. During this time total rice area is supposed to shrink to 10.28 million hectares. Therefore, it is urgently needed to increase rice yield at least 1 ton ha^{-1} by the year 2020 (Anon. 2011). Rice yield may be increased by modern varieties, appropriate cultural techniques including judicious application of nitrogenous fertilizers as well as use of high quality seed. Recently, Bangabandhu Sheikh Mujibur Rahman Agricultural University developed a short duration, long grain Aman rice variety (BUdhan 1) which has yield potential as high as 5 t ha^{-1}. This variety matures within 120 days having field duration only 90 to 95 days. Grain quality of this variety is superior as compared to many other rice varieties cultivated in the country. When, a new variety is evolved, it requires appropriate agronomic techniques to maximize its yield potential. Agronomic techniques like planting time and seedling age of the new variety already optimized (Hossain *et al*., 2009; Kabir, 2011), while efficient use of nitrogenous fertilizer for enhancing yield and seed quality of the variety yet to be determined. Nitrogenous fertilizer is essential input for rice cultivation. But higher dose of nitrogen causes excessive vegetative growth resulting in lodging and susceptibility to insect-pest and ultimately reduces yield and increases economic loss.

On the other hand, lower dose of nitrogen may drastically reduce the yield of rice. Therefore, it is imperative to determine nitrogen requirement of the variety for achieving its highest economic yield. Nitrogen affects not only growth and productivity of rice but also affects generously on seed quality. Nitrogen affects seed quality through affecting the growth and development of seed. As good quality seed plays a crucial role in realizing the full genetic potential of the variety (Sheshu and Dadlani, 1993), and its use can increase yield by 5 to 20% (Mew and Misra, 1994), it necessitates examining the effect of applied nitrogen on growth, productivity and seed quality of newly evolved rice variety. Hence, the present research work was undertaken-to determine optimum nitrogen requirement for newly developed long grain rice variety (var. BUdhan 1) and to assess the effect of different nitrogen doses on seed quality of long grain Aman rice.

MATERIALS AND METHODS

The experiment was conducted during Aman season of 2009 in lowland environment of the Bangabandhu Sheikh Mujibur Rahman Agricultural University. The location of the experimental site was 24.09^0 N latitude and 90.26^0 E longitudes with an elevation of 8.2 m from sea level. The soil of the experimental site was silty clay of shallow Red Brown Terrace soil under Salna series. The soil is low in nitrogen, phosphorus and organic matter contents. The experimental site is characterized by heavy rainfall during May through September and scanty rainfall during the rest of the year. Seven levels of nitrogen fertilizer viz. 0, 20, 40, 60, 80,100 and 120 kg N ha^{-1} formed the treatment variables. A randomized completely block design with three replications was adopted to set up the experiment. The size of each plot was 5 m x 4 m. Thirty days old seedlings were transplanted on 20 August 2009. Two seedlings were transplanted per hill with a planting configuration of 25 x 15 cm.

At the time of first ploughing, cow dung at 10 t ha^{-1} was applied. Besides a blanket dose of fertilizers 40-20-20-8 P K S Zn kg ha^{-1} was applied and thoroughly incorporated into the soil at the time of final land preparation. Nitrogen was applied as per treatment in the form of urea in three installments as top dressing. First top dressing was done at 7 days after transplanting (DAT), second at 25 DAT (corresponding to maximum tillering stage) and third at 45 DAT (corresponding to panicle initiation stage). Gap filling was done with the even aged seedlings within one week of transplanting. Three hand weeding were done to check weed infestation the crop field. One to two centimeter of standing water was maintained in the field till the hard dough stage of the crop. Plants were sampled five times from 30 DAT till harvesting at 15 days interval. At each sampling, five hills per plot were pulled out of the soil from the second row. After sampling, the plants were washed thoroughly and the roots were cut at the base. Plant height, number of tiller per hill and dry matter accumulation in the plant was determined. Plant height was measured from the base of the plant upto the tip of the tallest leaf or panicle after anthesis of each mother shoot and the means were calculated. The number of tillers in five hills was counted and the means of the each hill were recorded. For dry matter accumulation whole plant parts were collected from five hills from each sample and kept into separate bag and oven dried at 80° C for 72 hours and weighed. Grain yield of rice was determined harvesting a sample area of 5 m^{-2} from the middle of each plot by avoiding border effect. After harvesting, threshing, cleaning and drying, grains were adjusted to 14% moisture content. To determine moisture content of grains, 5 g sample was used. The sample grains were put in an infrared moisture meter (Model, F-1 A, Kelt electric laboratory, Tokyo, Japan) and the moisture percentage was recorded. Grain yield was adjusted to 14% moisture content by using the following formula.

$$\text{Grain yield at 14\% MC} = \frac{100 - \text{Sample MC}}{100 - 14} \text{ x Weight of grains at sample MC}$$

Where, MC = Moisture content

The crop was harvested upon maturity. When base of a panicle attain straw color, then the crop was considered as ready for harvest. Five continuous hills were selected from the harvest area randomly to determine yield components of the variety like number of tillers per hill, number of panicles per hill, number of grains per panicle, number of filled and unfilled grain per panicle and 1000 grain weight were recorded. Data on yield components were recorded from the sample plants. The seeds collected from each treatment level were preserved in plastic airtight container for determination of seed quality parameters. One hundred seeds from each treatment were used for viability test by tetrazolium reaction (ISTA, 2006). For germination test, one hundred seeds were used and replicated four times. Seed were placed in Petri dish containing filter paper soaked with distilled water. Then the Petri dishes were placed in an incubator at 300C till the completion of germination. Seedlings were counted every day and a seed was considered to be germinated as seed coat ruptured and plumule and radical came out up to 2mm in length. Final germination count was made according ISTA, (2006). Germination percentage was calculated by using the following formula:

$$\text{Germination (\%)} = \frac{\text{Number of seeds germinated}}{\text{Number of seeds tested}} \text{ x } 100$$

For dormancy evaluation, the difference between the germination test and tetrazolium test reflects the level of seed dormancy. Seedling shoot and root length was also measured at the end of the germination test. Ten seedlings from each Petridish were harvested and shoot and root length of individual seedlings was measured. The shoot and root were also dried at 70^{0}C for 72 hours for determination of seedling dry matter yield.

Vigor index was computed by using the following formula as suggested by Baki and Anderson (1973) and expressed in number.

$$\text{Vigor index} = \text{Germination (\%) x (Shoot length + Root length) in cm}$$

All data were analyzed by analysis of variance (ANOVA) using MSTAT package and the means were compared by DMRT

RESULTS AND DISCUSSION

Application of nitrogen exerted significant effect on different phenological events of newly developed long grain rice (cv. BUdhan 1). There was a general trend of increasing days required for flowering and maturity of the variety due to increase of nitrogen level (Table 1). The variety took nearly 56 days for first flowering, 61 days for 50% flowering and 101 days for maturity when it was fertilized with 120 kg N ha^{-1}. This might be due to higher doses of nitrogen fertilizer favored vegetative growth which in turn delayed the reproductive phase of the variety. Contrary, the time reduced to nearly 52 days for first flowering, 56 days for 50% flowering and 97 days to maturity where both of the crops was fertilized with 0 and 20 kg N ha^{-1}.

Table 1. Phenological events of long grain rice (cv. BUdhan 1) as influenced by applied nitrogen

Nitrogen dose (kg ha^{-1})	1st flowering (DAT)	50% Flowering (DAT)	Maturity (DAT)
0	52 c	56 c	97 b
20	52 c	56 c	97 b
40	52 c	56 bc	98 ab
60	53 bc	57 bc	99 ab
80	53 bc	58 bc	99 ab
100	54 b	59 ab	101 a
120	56 a	61 a	101 a
CV (%)	0.91	2.04	1.26

Means followed by same latter (s) in a column are not significantly different by DMRT

Effect of nitrogen on plant height was not significant in the early growth stage but it became distinct in the later stage under higher nitrogen level where 120 kg N ha^{-1} produced the tallest plant (114.37 cm). Similar result was also observed by Lakshnanan and Prasad (2004), Mazumder *et al*., (2019) and they reported that nitrogen fertilization had a tendency to increase plant height as nitrogen involves in cell division and cell elongation of plants.

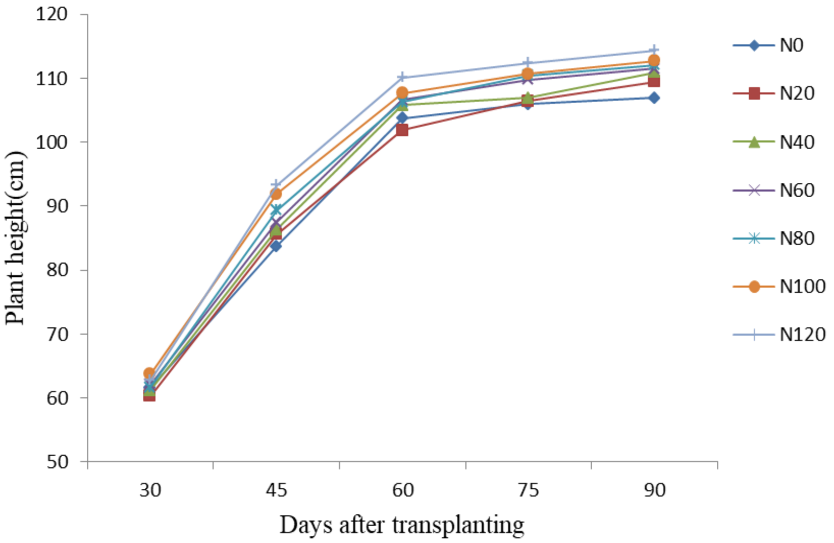

Figure 1. Effects of nitrogen dose on changes in plant height of long grain rice (var. BUdhan 1)

Tiller Dynamics

The number of tillers per hill was the lowest at 30 DAT in plants irrespective of nitrogen level. After that the numbers of tillers increased and it was maximum (15.1) at 45 DAT when nitrogen was applied as 120 kg N ha^{-1}. The number of tillers per hill decreased again over the treatment levels. Reduction of tiller number in the later stage of development might be due to tiller mortality as reported by Shivay and Singh (2003).

Dry matter production

Accumulation of dry matter in rice plants increased over time although it varied profoundly due to variation of nitrogen level (Figure 2). Dry matter accumulations in rice increased slowly at the earlier stage and then rapidly after 30 DAT and peaked at 90 DAT. In the earlier stage of growth, dry matter accumulation was statistically similar in case of all the treatment levels but at later stage of growth dry matter production differed significantly due to applied nitrogen. This might be due to higher balance between the photosynthesis and respiration of rice plants under higher level of nitrogen (Tanaka *et al.,* 1964). Among the nitrogen levels maximum dry matter was observed in plants treated with 120 kg N ha^{-1} and minimum was observed at 0 kg N ha^{-1}. This result indicates that higher nitrogen is required for maximum dry matter production of new rice variety.

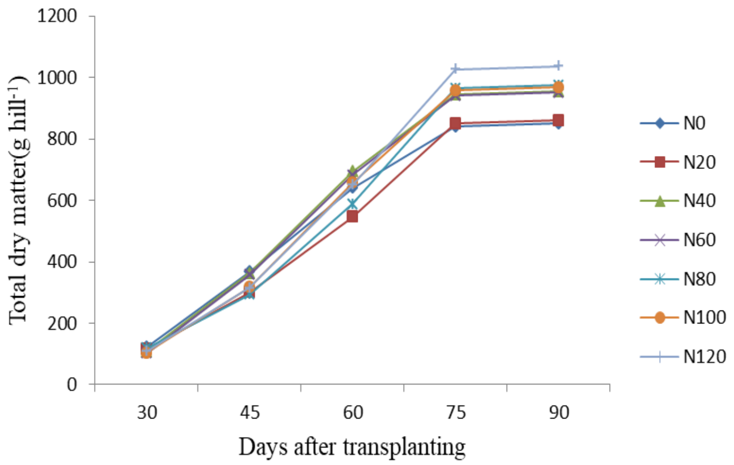

Figure 2. Pattern of dry matter accumulation in long grain rice (var. BUdhan 1) under different nitrogen levels

Tiller distribution

It is well established that nitrogen application markedly increased the tillering of rice (IRRI, 1988). The results presented in Figure 3 indicated that nitrogen level influenced significantly in tillers per hill of the variety (BUdhan 1). The crop received from 120 kg N ha^{-1} produced higher number (12.8) of tillers per hill although it was statistically similar with 40, 60, 80 and 100 kg N ha^{-1}. The lowest level of applied nitrogen produced lower number (9.6) of tillers per hill. Sing and Murayama (1963) showed similar results and concluded that number of tillers of plants increased with increasing nitrogen supply. The highest number (11.8) of productive tillers per hill was found at 80 kg N ha^{-1} which was statistically identical with 60 kg N ha^{-1} and the lowest number (6.8) of productive tillers per hill was found at 0 kg N ha^{-1} .Awan *et al.* (1984) found that the higher dose of N application increased the number of productive tillers per hill of rice. In this experiment, maximum number (5.3) of unproductive tillers per hill was recorded from the crop fertilized with 120 kg N ha^{-1} and it was statistically identical with the treatment 100 kg N ha^{-1}. The lowest number (1.7) of unproductive tillers per hill was found at 60 kg N ha^{-1} which was statistically similar with 80 kg N ha^{-1} which revealed that the variety requires lower nitrogen to check production of unproductive tillers per hill (Figure 3).

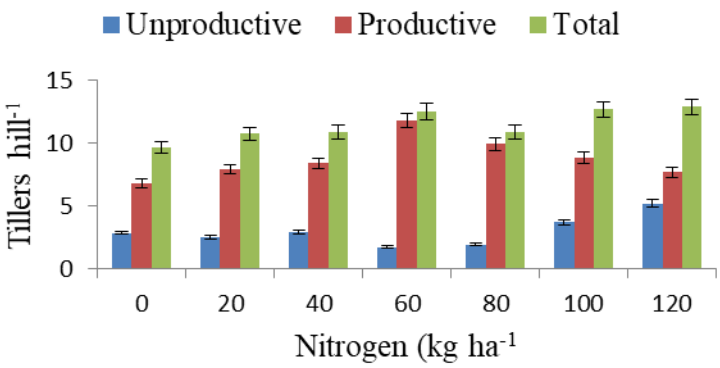

Figure 3. Pattern of tiller distribution in long grain rice (var. BUdhan 1) under different nitrogen levels

Yield components and yield

Grain yield can be described as the product of the number of panicles per unit area, the number of spikelets per panicle, percentage of filled spikelets and the 1000 grain weight (Wu *et al.,* 1998). The highest number of grains per panicle (140.50) was found from applied nitrogen 60 kg N ha^{-1} which was statistically identical to 80 kg N ha^{-1} (Table 2). The lowest number of grains (108.4) was found from the applied nitrogen 0 kg N ha^{-1} which was statistically similar with 0, 20, 40, 100 and 120 kg N ha^{-1}. The highest filled grains (130.3) were recorded from 60 kg N ha^{-1} which was similar to 80 kg N ha^{-1}. Lower number of filled grains per panicle was recorded from lower and higher level of nitrogen fertilizer which might be due to its increase in unfilled grains (Table 2). The highest number of unfilled grains per panicle (37.6) was found at 120 kg N ha^{-1} which was statistically identical to 100 kg N ha^{-1} (Table 2). The lowest (12.3) grains per panicle was found at 80 kg N ha^{-1}. Therefore, this variety requires moderate level of nitrogen fertilizer for minimization of unfilled grains per panicle as also observed by Panda and Rao (1991). The 1000 grain weight of the variety varied significantly due to different levels of applied nitrogen. The highest (31.7 g) grain weight of the variety was recorded from 120 kg N ha^{-1} which was similar to grain weight observed at 80 and 100 kg N ha^{-1}. Conversely, the lowest (26.6 g) grain size of the variety was recorded from 0 kg N ha^{-1} which was similar to grain size observed at 20 kg N ha^{-1}. Lower level of nitrogen decreased grain size significantly in accordance to Tanaka *et al.* (1968) who reported that 1000 grain increased with the increase of nitrogen levels. Grain yield is positively related with panicle number, grains per panicle and 1000 grain weight which increased with the increasing level of applied nitrogen. The highest yield (4.43 t ha^{-1}) was found at 60 kg N ha^{-1} which was similar to yields obtained from 40 and 80 kg N ha^{-1}. The lowest yield (2.96 t ha^{-1}) was recorded from the lowest nitrogen level (0 kg N ha^{-1}). The variety therefore produced better yield at moderate level of applied nitrogen which was attributed to its better yield components.

Table 2. Effect of different nitrogen doses on yield components and yield of long grain rice (var. BUdhan 1)

Nitrogen dose (kg ha^{-1})	No. of grains panicle^{-1}	No. of filled grain panicle^{-1}	No. of unfilled grain panicle^{-1}	1000 grain weight (g)	Yield (t ha^{-1})
0	104.8 b	80.6 c	33.6 b	26.6 c	2.96 c
20	110.7 b	96.5 c	26.6 c	27.9 bc	3.94 b
40	121.6 b	113.6 b	23.3 d	28.5 b	4.21 ab
60	140.5 a	130.3 a	12.3 f	30.5 a	4.43 a
80	132.4 ab	121.7 ab	16.6 e	28.9 b	4.26 ab
100	120.3 b	86.7 c	36.7 a	30.5 a	3.83 b
120	111.0 b	85.3 c	37.6 a	31.7 a	3.58 b
CV (%)	8.76	10.94	19.72	3.23	18.99

Means followed by same latter(s) in a column are not significantly different by DMRT.

Seed quality

In Bangladesh condition most of the farmers store seeds from their harvest for next season planting purpose. Therefore, quality of harvested seed is very important for cultivating crop in next growing season. The results pertaining to seed quality of the variety (BUdhan 1) revealed that nitrogen level had no effects on seed viability as more than 96% seeds exhibited viable under tetrazolium salt test. Different nitrogen level however, showed significant differences on germination and level of seed dormancy (Table 3). Maximum germination percentage (94.17%) was recorded from 80 kg N ha^{-1} and the lowest (89.33%) from 0 kg N ha^{-1}. Seed dormancy of freshly harvested variety (BUdhan 1) exists and it varied from 3.00% to 6.67% depending upon the level of applied nitrogen. Dormancy of seed increased with the increasing level of nitrogen. Thus maximum dormancy (6.67%) was observed at 0 kg N ha^{-1} and minimum dormancy (3.00%) was recorded from 80 kg N ha^{-1}. Basically, Indica rice shows either non dormant, moderate or strong dormancy according to their growing seasons where rice sown on Aman rice shows moderate to strong dormancy.

Table 3. Effect of different nitrogen levels on seed quality of the variety BUdhan1.

Nitrogen dose (kg N ha^{-1})	Viability (%)	Dormancy (%)	Germination (%)
0	96.00	6.67 a	89.33 c
20	97.50	5.50 b	90.00 bc
40	97.00	4.67 bc	92.33 ab
60	96.50	5.00 bc	92.50 ab
80	96.50	3.00 d	94.17 a
100	97.67	5.33 bc	91.33 bc
120	97.17	6.65 a	90.37 bc
CV (%)	1.28	12.57	1.44

Means followed by same latter(s) in a column are not significantly different by DMRT.

Table. 4. Effect of different nitrogen levels on seedling characteristics of BU dhan1.

Nitrogen dose (kg ha^{-1})	Shoot length (cm)	Root length (cm)	Seedling dry wt (mg)	Seedling vigor index
0	8.01 c	10.85 b	6.53 b	1685 c
20	8.34 bc	10.95 b	6.97 b	1733 c
40	8.41 b	12.25 ab	7.06 b	1908 bc
60	8.54 ab	13.17 ab	7.67 ab	2005 ab
80	8.84 a	14.36 a	8.22 a	2181 a
100	8.44 b	12.88 ab	7.50 ab	1945 b
120	8.3 b	12.36 ab	7.65 ab	1872 bc
CV%	9.8s	11.8	7.8	8.1

Means followed by same latter(s) in a column are not significantly different by DMRT

Seedling characteristics

The results of seedling characteristics of the variety (BUdhan 1) obtained from the harvested seeds differed significantly due to variation of nitrogen levels (Table 4). Maximum shoot length (8.84 cm) was recorded from the seedlings of seeds harvested from 80 kg N ha^{-1} which was statistically similar with 60 kg N ha^{-1}. Contrary, minimum shoot length (8.01 cm) was recorded from the seedlings of seeds harvested from 0 kg N ha^{-1} which was followed by 20 kg N ha^{-1}.

Significant differences also observed in case of root length of harvested seeds of BUdhan 1 due to variation of nitrogen levels. The highest root length (14.36 cm) was recorded from the seedlings of seeds harvested from 80 kg N ha^{-1} which was statistically significant with 40, 60, 100 and 120 kg N ha^{-1}. While the shortest root length (10.85 cm) was recorded from the seedlings of seeds harvested from 0 kg N ha^{-1} and it was statistically identical with 20 kg N ha^{-1}.Dry matter accumulation of seedling also varied significantly in the seedling of seeds due to variation of nitrogen levels. Maximum seedling dry weight (8.22 mg) was found from seedling of seeds harvested from 80 kg N ha^{-1} which was statistically similar with 60, 100 and 120 kg N ha^{-1}.

While the minimum seedling dry weight (6.53 mg) was found from seedling of seeds harvested from 0 kg N ha^{-1} followed by 20 kg N ha^{-1}. Results of seedling vigor index revealed that the maximum value (2181) was obtained from 80 kg N ha^{-1} and minimum value (1685) was recorded from 0 kg N ha^{-1} followed by 20 kg N ha^{-1}.

CONCLUSION

Results of present study revealed that 60 kg N ha^{-1} of BUdhan 1 is ideal in producing higher grain yield for better quality seed. Relatively, other higher or lower nitrogen levels reduced yield and seed quality of this variety. Therefore, it is desirable to collect seeds from moderate nitrogen level to ensure the higher seed yield and better seed quality of BUdhan 1.

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