

IMPACT OF NITROGEN ON GROWTH, YIELD AND SEED QUALITY OF BRRI dhan28

A Thesis

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IMPACT OF NITROGEN ON GROWTH, YIELD AND SEED QUALITY OF BRRI dhan28

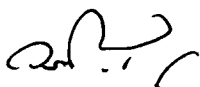
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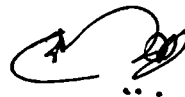
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DEDICATED
TO
THE ALL FARMERS OF BANGLADESH



ABSTRACT

Nitrogen is not only a major nutrient but most often the most limiting nutrient element for rice production. However the improper use of nitrogen fertilizer deteriorates growth, yield and declines seed quality of rice as well. The present study was conducted to determine optimum nitrogen doses and examine the effects of different doses of nitrogen on growth, yield and seed quality of BRRI dhan28. The experiment was laid out in a Randomized Complete Block Design (RCBD) with the experimental treatments include six doses of nitrogen $T_0 = 0 \text{ kg N ha}^{-1}$, $T_1 = 35 \text{ kg N ha}^{-1}$, $T_2 = 70 \text{ kg N ha}^{-1}$, $T_3 = 105 \text{ kg N ha}^{-1}$, $T_4 = 140 \text{ kg N ha}^{-1}$, $T_5 = 170 \text{ kg N ha}^{-1}$. Data on rice growth characters, yield contributing characters, and seed quality parameters were collected and analyzed statistically. Results showed that total number of tillers per m^2 increased significantly with increasing levels of N as was total dry matter production. At harvest the tallest plant (89.28 cm), tillers hill^{-1} (23.50), total dry matter hill^{-1} (76.59 gm^{-2}), were obtained from the higher dose of nitrogen T_5 (170 kg N ha^{-1}). Growth parameters were increased with the increased rate of nitrogen whereas yield contributing parameters were found superior with moderate doses of nitrogen with the treatment of 105 kg N ha^{-1} . Higher grain yield (3.92 t ha^{-1}), biological yield (7.29 t ha^{-1}) and harvest index (53.76) were obtained from 105 kg N ha^{-1} . Nitrogen application significantly influences seed quality in terms of speed of germination, vigor, viability and seed color. Nitrogen doses of 105 kg N ha^{-1} was therefore recommended for BRRI dhan28.

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The Author

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CHAPTER I

INTRODUCTION

Bangladesh has a long history of rice cultivation. Rice is grown throughout the country except in the southeastern hilly areas. The agro climatic conditions of the country are suitable for growing rice year-round. However, the national average rice yield is much lower (2.94 t/ha) than that of other rice-growing countries (BBS, 2016; IRRI, 2019). There are three rice-growing seasons in Bangladesh: aus, aman, and boro. The rainfed Aus, the rainfed Aman and irrigated Boro rice are cultivated in 10%, 51% and 39% in the total cropped area in Bangladesh, respectively (BADC, 2008). A BBS Report 2008 Aus, Aman and Boro produced 1.51, 9.66 and 17.76 million metric tons of rice.

There are many reasons for lower yield of rice and among these the most important is the indiscriminate and improper application of nutrients with unfavorable condition. Many factors determine the fertilizer efficiency for rice crop during cultivation such as soil, cultivar variety, season, environment, planting time, water management, weed control, time and methods of fertilizer application (De Datta, 1978; Paramanik *et al.*, 2015). Different chemical fertilizers are used in soil but nutrient stresses are increasing day by day. Major reasons are use of imbalance fertilizers and intensification of crop caused degradation of soil, increase soil acidity, depletion of surface and underground water, pollution of farm and non-farm environment, nutrient mining, arsenic and other heavy metal pollution. Among the improved cultural practices, to ensure proper growth, large amount of chemical fertilizers are applied in different crops field (Shakouri *et al.*, 2012). This is especially true for high yield potential rice varieties grown in Boro season where judicious amount of nitrogen supply is prime concern for satisfactory yield (Ahmed *et al.*, 1999).

Nitrogen is one of the most yield-limiting nutrients in rice production around the world, especially in tropical Asian soils and almost every farmer has to apply N fertilizer to get a desirable yield of rice (Saleque *et al.*, 2004). Judicious and proper use of fertilizers can markedly increase the yield and improve the quality of rice (Chaturvedi, 2005). Nitrogen absorbed by rice during the vegetative growth stages contributed in growth during reproduction and grain-filling through translocation (Bufogle *et al.*, 1997; Norman *et al.*, 1992). The proper use of N fertilizer could improve caryopsis weight of rice by improving the absorbing activity of the root in order to absorb more nutrients from the soil.

The increase in amount of N at the booting stage may provide sufficient N to rice plants during the late grain filling stage. This could help lessen threats posed by catabolism of structural protein in stem and leaves, thereby extending the life-span of green leaves by maintenance of high photosynthetic rate (Juan *et al.*, 2006). It is an essential constituent of chlorophyll and it increases leaf photosynthesis rate which promotes rapid growth of the crop. Thus well-supplied nitrogen enhances growth and improves the crop yield (Dobermann and Fairhurst, 2000). Efficient fertilizer management gave higher yield of crop and reduced fertilizer cost (Hossain and Islam, 2006).

Plant growth is seriously hampered when lower dose of nitrogen is applied, which drastically reduces the yield and deteriorate seed quality as well. It is also a fact that improper use of nitrogenous fertilizer, instead of giving yield advantage, may reduce the same (Adhikari *et al.*, 2018). Nutrient management strategy in seed crop may be somewhat different from normal grain crop. Panicle with a low percentage of sterile flowers permits the application of higher N doses of and seed supply systems contribute only 15-20% of total seed demand in the country. Use of

quality seed can increase rice yield by 12-15% at a given management practices (Gomosta, 2004).

Seed yield may be increased through proper nutrient management without sacrificing seed quality. Increasing rates of N fertilizer may increase the yield but reduce the quality of the grain (Conry, 1995; Gately and Kelly, 1987). However, both excess and insufficient supply of N is harmful to the rice crop and may decrease seed yield. An adequate N supply can increase as much as 60% rice production over control (Mikkelsen *et al.*, 1995. Excessive dose of N produces succulent plants and enhances the plants sensitivity to water and temperature stress, susceptible to lodging and pest and disease incidence and in consequence, give poor quality seed of rice (Balasubramaniyan and Palaniappan, 2007).

There is an apprehension that the application of imbalance nitrogen may deteriorate the growth, yield and seed quality of boro rice as BRRI dhan28, given the importance nitrogen fertilization on the yield grain it is necessary to know what is the best dose for each rice variety that combine seed yield increase yet no quality is compensated. Under these circumstances, the present study was undertaken with the objectives to determine the optimum dose of N on growth, yield and seed quality of boro rice cv. BRRI dhan28 under varying levels of N application.

Considering above situation the present study was under taken –

- To determine the impact of nitrogen at different doses on growth, yield and quality attributes of BRRI dhan28.
- To find out the optimum N dose for BRRI dhan28.
- To determine the various seed quality characters such as germination percentage, vigor, viability and appearance of BRRI dhan28.

CHAPTER II

REVIEW OF LITERATURE

The input of fertilizers is an inevitable and basic requirement of modern intensive rice farming because of increased demand of nutrients of the high yielding varieties. Of the fertilizers, nitrogen being an essential element deserves the vital position. Physiologically it plays the key role and has been considered as a yield limiting factor (Roger and Kulasooriya, 1980). Soil fertility is declining further due to intensive cropping and imbalanced use of fertilizers by the farmers (Biswas *et al.*, 2001; Dobermann and Fairhurst, 2000). Nitrogen is the key element in the production of rice and gives by far the largest response. It is an essential plant nutrient that plays a significant role in growth, yield and quality of rice. As a result, growth and yield of rice is also declining in many cases. Balance fertilization is, therefore, usually needed (Adhikari *et al.*, 2018). Considering the above point, available literatures were reviewed under impact of different doses of nitrogen application on boro rice to determine optimum doses for getting better growth, to yield and quality seed.

2.1.1. Impact of nitrogen on growth characters

2.1.1.1. Plant height

Adhikary *et al.*, (2018) found that N fertilizer significantly influenced crop characters where 80 kg N ha⁻¹ produced the highest plant height (113 cm).

Sarkar *et al.*, (2020) reported that the highest plant height was produced with the application of 100 kg N ha⁻¹.

Chamely *et al.*, (2015) reported that the tallest plant (86.40 cm) was recorded from BRRI dhan28 with 200 kg N ha⁻¹.

Chaturvedi (2004) observed that application of nitrogen fertilizer increased the plant height. The plant height 110.2 cm was recorded for urea.

Alam *et al.*, (2010) conducted an experiment on Boro season with cv. BRRI dhan29 and the tallest plant (79.0 cm) was observed in treatment T₆ (94 kg urea ha⁻¹ SA + 1% urea FA) which was statistically similar to all other treatments except T₁ and T₃. The shortest plant (65.6 cm) was recorded with T₁ (control) treatment.

Ahmed *et al.*, (2005) reported that among 5 levels, 80 kg N ha⁻¹ gave the highest plant height (155.86 cm) and the height decreased gradually with decreased levels of nitrogen fertilizer application.

Salem (2006) reported that the nitrogen levels had a positive and significant effect on growth parameters of rice plants. Increasing nitrogen levels up to 70 kg ha⁻¹ significantly increased plant height. The highest plant height was recorded about 92.81 cm with 70 kg N ha⁻¹.

Maske *et al.*, (1997) stated that plant height increased significantly with increased N level.

Meena *et al.*, (2003) reported that application of 200 kg N ha⁻¹ significantly increased the plant height (127.9 cm) of rice while they applied another dose, 100 kg N ha⁻¹.

Pot experiments were conducted by Wang *et al.*, (2002) to determine the effect of nitrogen levels no nitrogen, low nitrogen, medium nitrogen, high nitrogen and super high nitrogen on the growth of plants and leaves in hybrid rice Shanyou 64 and conventional rice Kinmaze. They found that the plant height increased with increasing nitrogen levels.

Dahattonde (1992) concluded that N fertilizer significantly enhanced the plant height.

Hussain and Sharma (1991) reported that application of nitrogen up to 140 kg ha⁻¹ increased plant height. At 80 kg and 120 kg N ha⁻¹ the variation in plant height was not significant. The highest plant height was obtained from 120 kg N ha⁻¹ and lowest one from the control.

A field experiment was conducted by Geethadevi *et al.*, (2000) in India to determine the effect of different nitrogen rates (0, 50, 100 and 150 kg ha⁻¹) and spacing (15 x 10 or 20 x 10 cm) on the growth and yield of hybrid rice. Among N rates, treatment with 150 kg N ha⁻¹ recorded the highest values for plant height (87.20 cm).

Idris and Matin (1990) noted that plant height of rice increased up to 120 kg N ha⁻¹ compared to the control and thereafter the height declined at 140 kg N ha⁻¹.

Experiments were conducted by Rajendran and Veeraputhiran (1999) to study the effects of 4 nitrogen levels (0, 75, 150 and 225 kg ha⁻¹) and 3 sowing rates in the nursery (10, 20 and 30 g m⁻²) on hybrid rice ADTRH1. Nitrogen was applied at 3 equal splits namely: 7 days after transplanting, active tillering and panicle initiation stages. Observation upon harvest revealed that plant height was found with 225 kg N ha⁻¹.

Vijaya and Subbaiah (1997) showed that plant height of rice increased with the application of USG and was greater with the deep placement method of application both N and P compared with broadcasting.

Lawal and Lawal (2002) disclosed that N (120 kg ha⁻¹) significantly increased plant height. A basal N application increased the plant height significantly.

Ebaid and Ghanem (2000) conducted a field experiment during the year of 1996- 97 to find out the productivity and also the plant height of Giza 177 rice (*Oryza sativa*), N fertilizer was

applied to the rice crop at the rate of 0, 96 and 144 kg N ha⁻¹ in urea form and they found that increasing N level up to 144 kg ha⁻¹ significantly increased plant height.

Ravisankar *et al.*, (2003) conducted a field experiment during the 2000 and 2001 rainy seasons in Port Blair, Andaman and Nicobar Island, India to study the effect of rice cv. Mansarovar cultivated under lowland conditions. The treatments comprised no N, 30 kg N ha⁻¹ at basal, 30 and 70 days after planting (DAP); 45 kg N ha⁻¹ at 30 and 70 DAP, 32 kg N ha⁻¹ at basal, 30 and 70 DAP and 25 kg N ha⁻¹ at panicle initiation stage, 4.5% controlled release N at 60% of the recommended dose and 6.0% controlled release N at 60% of the recommended dose. The longest plant at harvest (106 cm) was obtained with T₃ treatment.

Thakur (1993) observed that the highest plant height of rice was obtained from 120 kg N ha⁻¹ and the lowest one from the control.

Sahrawat *et al.*, (1999) found that nitrogen level significantly influenced plant height of rice. Increasing levels of nitrogen increased the plant height significantly up to 120 kg N ha⁻¹.

Chowdhury *et al.*, (1998) noted that the longest plant height of 112.1 cm was produced by nitrogen application at 100 kg ha⁻¹ and was followed by 75 kg ha⁻¹ due to the excellent vegetative growth of rice.

Mizan (2010) reported that the highest plant height (98.32 cm) was obtained from 160 kg N ha⁻¹ followed by 120 kg N ha⁻¹.

Singh and Singh (1986) reported that the plant height increased significantly with the increase in the levels of nitrogen from 27 to 87 kg N ha⁻¹. Deep placement of USG resulted in the highest plant height than piled urea.

2.1.1.2. Tiller number hill⁻¹

Khatun *et al.*, (2015) conducted an experiment at BRRI during boro season of 2010-2011 to determine the effect of nitrogen. The N control plots produced tiller number of 224 and 218 per m² in BRRI dhan28 and BRRI dhan29, respectively. In the BRRI dhan28 the absolutely urea treatment increased the number of tiller to 321 per m² followed by urea (+ CD treatment (313 m²)).

Khatun *et al.*, (2014) conducted an experiment at Bangladesh Rice Research Institute and reported that the N and variety interactions in relation to yield components were not significant ($f > 0.05$). At N-control treatment, BRRI dhan28 produced 205 panicle m⁻² compared to BRRI dhan29 (167). Receiving 50 kg N ha⁻¹, panicle m⁻² in BRRI dhan28 and BRRI dhan29 was 219 and 220 respectively. Increasing N rate increased panicle production in both the varieties. At 150 kg N ha⁻¹, BRRI dhan28 and BRRI dhan29 produced 290 and 268 panicle m⁻² which increased to 292 and 288 respectively with 200 kg N application. Application of 250 kg N ha⁻¹ increased panicle m⁻² abruptly to 314 in BRRI dhan28 and 338 in BRRI dhan29.

BRRI (2008a) conducted an experiment to study the comparative study of some promising lines with BRRI modern rice varieties to different nitrogen levels viz. 0, 30, 60, 90, 120 and 150 kg N ha⁻¹. It was reported that tiller production with N @ 120 kg ha⁻¹ produced significantly higher tiller than those of lower N levels. BRRI (2006) reported that the maximum tillers hill⁻¹ (10.2) was produced with 120 kg N ha⁻¹ compared to 90 and 0 kg N ha⁻¹ application.

Wang *et al.*, (2002) reported that the tiller number increased with increasing nitrogen levels.

Kumar and Subbaiah (2001) noted that application of DAP + urea resulted in the highest number of tillers m⁻².

Rajendran and Veeraputhiran (1999) observed that productive tillers m^{-2} increased as the N rate increased.

BRRI (2006) reported that the maximum tillers hill^{-1} (10.2) was produced with 120 kg N ha^{-1} compared to 90 and 0 kg N ha^{-1} application.

Lawal and Lawal (2002) carried out 3 field experiments during the rainy season of 1996, 1997 and 1998 in Nigeria to evaluate the growth and yield response of low land rice to varying N rates and placement methods. The treatment consisted of 4 N rates (0, 40, 80 and 120 kg ha^{-1}) and 2 fertilizer placement method of (deep and surface placement). They found that application of 80 kg N ha^{-1} significantly increased the number of tillers hill^{-1} .

Singh and Singh (2002) recorded that increasing levels of N significantly increased total tiller hill^{-1} .

Munnujan *et al.*, (2001) conducted a field experiment at Gazipur in 1993 to determine the effects of N fertilizer and planting density on growth and yield of long grain rice. Tillers plant^{-1} increased linearly with the increase in N fertilizer levels.

Idris and Matin (1990) noticed that the maximum number of tillers hill^{-1} was produced with 140 kg N ha^{-1} which was statistically similar to 60, 80, 100 and 120 kg N ha^{-1} . The minimum number of tillers hill^{-1} was obtained from the control treatment (0 kg N ha^{-1}).

2.1.1.3. Dry matter hill⁻¹

Xia *et al.*, (2007) reported that increased split application of N from control to 140 kg N ha⁻¹ increased dry matter accumulation (DMA) of different growth stages of Jinzao22 and Shanyou63 rice varieties and after that dose the DMA reduced due to the losses of N by volatilization.

Sing and Modgal (2005) noted that DMA and concentration and uptake of N increased with increasing level of N at all the stages of crop growth.

Miah *et al.*, (2004) noted that USG applied plots gave higher TDM compared to urea irrespective of number of seedling transplanted hill⁻¹.

Fu *et al.*, (2000) conducted a field experiment in Zhejiang Province, China to evaluate the N fertilizers (0, 100, 150, 180, 225, 270, and 300 kg N ha⁻¹ as urea, two-thirds top-dressed as basal and one third top dressed 7 days after transplanting, on dry matter and N partitioning in hybrid rice 518. They reported that higher N applications significantly increased dry matter partitioning of leaf at the vegetative stage. Partitioning of dry matter to leaves decreased as the N concentration in the leaves decreased. Leaf partitioning of absorbed N, compared to dry matter, was higher and varied little during early vegetative growth, but varied greatly from panicle initiation onwards, probably due to competition for N among leaves, stem and the developing panicle.

A field experiment was conducted by Geethadevi *et al.*, (2000) in Karnataka, India to determine the effect of different N rates (0, 50, 100 and 150 kg N ha⁻¹) and spacing (15 cm x 10 cm or 20 cm x 10 cm) on the growth and yield of hybrid rice. Among N rates, treatment with 150 kg N ha⁻¹ recorded the highest values for total dry matter per plant (57.08 g).

2.1.1.4. Crop growth rate

Anamul *et al.*, (2016) conducted an experiment at Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh during the rainy season of 2014 to assess growth, yield and nitrogen use efficiency of a new rice variety. The new rice variety (BUDhan 1) was treated with six levels of nitrogenous fertilizer in a randomized complete block design replicated three times. The nitrogen levels 0, 20, 40, 60, 80 and 100 kg N ha⁻¹ constituted the treatment variables. He observed that the lowest crop growth rate ($-25.96 \text{ g m}^{-2} \text{ day}^{-1}$) was recorded at 85 days after transplanting when crop was fertilized with 100 kg N ha⁻¹. Contrary, the highest crop growth rate ($33.99 \text{ g m}^{-2} \cdot \text{day}^{-1}$) was obtained when the crop was fertilized with 100 kg N ha⁻¹ at 45 days after transplanting. Crop growth rate was slower at the earlier stage of the variety. Slow crop growth rate at earlier stages of the rice variety might be due to lower leaf development which act as a main organ of photosynthesis on which growth rate depends

A field experiment was conducted by Das and Panda (2004) in Bhubaneswar, Orissa, India, to study the effects of N (0, 60, 120 or 180 kg ha⁻¹) and K (0, 40, 80 or 120 kg ha⁻¹) on the growth rate of hybrid rice 6102. N (urea) was applied as a basal dressing (25%), and as a top dressing at 18 days after transplanting (DAT; 50%) and at the panicle initiation stage (25%). K (K₂O) was applied during transplanting. Irrespective of treatment difference, Crop growth rate (CGR) was greater at 40-60 DAT and lower at 20-40 DAT. The increase in the N rate increased CGR. The highest CGR ($22.52 \text{ g day}^{-1} \text{ m}^{-2}$) was obtained with 80 kg K₂O ha⁻¹.

A field experiment was embellished by Valadabdi *et al.*, (2009) stated that nitrogenous fertilizer including 520, 400 and 280 kg urea ha⁻¹ showed that nitrogenous fertilizer significantly increased physiological growth indices in maize which indicate that the highest CGR ($31.2 \text{ gm}^{-2} \text{ day}^{-1}$).

Rahman *et al.*, (2007) conducted an experiment including four treatments viz. 0, 60, 80 and 100 kg N ha⁻¹. The data revealed that the highest CGR (15.26 gm⁻² day⁻¹) was produced when 100 kg N ha⁻¹ was applied on DAT. The CGR value increased along with LAI up to 60-90 DAT and there after decreased markedly. CGR values increased with the increase N level.

2.1.1.5. Relative growth rate

Sims *et al.*, (2012) found that nitrogen additions significantly increased RGR. Nitrogen addition increased relative growth rate because it simultaneously increased unit leaf rate, specific leaf area, and leaf weight ratio.

Bailu *et al.*, (2007) conducted an experiment in plastic greenhouses during 2003 and 2004 major the influence of nutrient elements: nitrogen, phosphate and potash, and their ratios of the nutrient solutions on the growth rate of pepper and eggplant seedlings. Two sets of nitrogen concentration; 25, 50, 75 and 100 ppm, and 100, 200 and 400 ppm were applied in different experiments, while phosphate and potash were in the following respective ratios (N:P:K): 1:0,4:1,2; 1:0,6:1,8 and 1:1,2:2,4. Significant differences of RGR were founded due to the N concentration at the nutrient solution. Statistically significant differences were found for both RGR components; NAR and LAR, at low nitrogen concentration (25 to 100 ppm).

2.1.2. Impact of nitrogen on yield contributing characters

2.1.2.1. Number of effective tillers hill⁻¹

Chamely *et al.*, (2015) found that the highest number of effective tillers per hill (12.57) was observed when nitrogen was used at the rate of 200 kg N ha⁻¹.

Kumar *et al.*, (1995) stated that an increase in N level from 80 to 120 kg N ha⁻¹ significantly increased total tillers hill⁻¹.

Ahsan (1996) stated that tillering is strongly correlated with nitrogen content of the plant. The incremental level of nitrogen increase the number of tiller hill⁻¹. Results showed that the highest number of tiller hill⁻¹ (31) was obtained at 150 kg N ha⁻¹ and declined with the lower level of nitrogen.

Alam *et al.*, (2010) reported that maximum number of effective tillers hill⁻¹ (12.7) was found in T₈ (94 kg urea ha⁻¹ SA + 3% urea FA) which was statistically identical to the treatments T₂, T₅ and T₇ with the values of 12.1, 11.3, 11.1, respectively. The lowest number of tillers hill⁻¹ (6.9) was found in T₁ (control).

Singh and Shivay (2003) evaluated that the effective tillers hill⁻¹ was significantly affected by the level of nitrogen and increasing levels of nitrogen significantly increased the number of effective tillers hill⁻¹.

Thakur (1991) concluded that the yield attributes of rice like number of productive tillers m⁻² and grain weight panicle⁻¹ increased with increasing levels of nitrogen.



Awan *et al.*, (2011) conducted an experiment to study the effect of different N levels (110, 133 and 156 kg N ha⁻¹) in combination with different row spacing (15 cm, 22.5 cm and 30 cm). They noted that maximum level of N (156 kg N ha⁻¹) produced maximum effective tillers irrespective of spacing.

Meena *et al.*, (2002) studied the response of hybrid rice to N (0, 100 and 200 kg ha⁻¹) and potassium application (0, 75 and 150 kg ha⁻¹) at the research farm of the IARI, New Delhi. They observed that application of N significantly increased the effective tillers.

Bayan and Kandasamy (2002) noticed that the application of recommended rates of N in four splits at 10 days after sowing, active tillering, and panicle initiation and at heading stages recorded significantly lower dry weight of weeds and increased crop growth viz. effective tillers m⁻².

Khatun *et al.*, (2014) reported that BRRI dhan28, the higher number of grains panicle⁻¹ was observed in 50 kg N ha⁻¹ followed by 100 and 200 kg N ha⁻¹. The number of grains panicle⁻¹ from 150 and 250 kg N ha⁻¹ was statistically similar. The lowest number of grains panicle⁻¹ was observed in control-N treatment. In BRRI dhan29, the higher number of grains panicle⁻¹ was obtained from 150 kg N ha⁻¹ followed by 50 kg N ha⁻¹ and 200 kg N ha⁻¹.

Jee and Mahapatra (1989) observed that number of effective tillers m⁻² were significantly higher with 90 kg N ha⁻¹ as deep placed USG than split application of urea.

Rama *et al.*, (1989) mentioned that effective tiller increased significantly when nitrogen level increased from 40 to 120 kg N ha⁻¹ as different modified urea materials and USG produced significantly higher effective tiller than split application of PU.

Azam (2009) conducted an experiment with 3 varieties and observed, in general, the number of total tillers hill⁻¹ was increased as the USG level increased but highest no. of total tillers hill⁻¹ was produced when 55 kg N ha⁻¹.

Tanaka *et al.*, (1964) reported that at a higher N level, rice plants have vigorous growth, high maximum tillers plant⁻¹ but lower percentage of effective tillers hill⁻¹.

Mirzeo and Reddy (1989) worked with different modified urea materials and levels of N (30, 60 and 90 kg N ha⁻¹). They reported that root zone placement of USG produced the highest number of tillers at 30 or 60 days after transplanting.

Tillering of rice plant is strongly influenced by nitrogen supply (IRRI, 1968; BRRI, 1989) and adequate nitrogen is necessary during tillering stage to ensure sufficient number of panicle bearing tillers (Hall and Tacket, 1962).

2.1.2.2. Length of panicle

Paramanik *et al.*, (2015) stated that Panicle length of BRRI dhan28 was influenced significantly by nitrogen levels the highest length was recorded with the recommended nitrogen fertilizer was applied as urea (N₁₀₀) which was statistically at par with N₇₅ (23.69 cm). The shortest panicle was recorded in N₀ (21.83 cm) which was statistically similar with N₅₀ (22.28 cm).

Alam *et al.*, (2010) found that the panicle length varied from 20.6 cm to 24.7 cm due to different treatments. The largest panicle was observed in T₂ (282 kg urea ha⁻¹ SA). The shortest panicle was obtained in T₁ (control) treatment.

Hasanuzzaman *et al.*, (2009) conducted an experiment to study the economic and effective method of urea application in rice crop. They noted that urea super granules produced longest panicle (22.3 cm).

Singh and Shivay (2003) found that increasing levels of nitrogen significantly increased the panicle length.

Meena *et al.*, (2002) observed that increase in nitrogen fertilizer application rate enhanced length and weight of panicles of hybrid rice.

Sen and Pandey (1990) carried out a field trial to study the effects of placement of USG (5, 10 or 15 cm deep) or broadcast PU @ 38.32 kg N ha⁻¹ on rice. They revealed that all depths of USG placement resulted in higher yield characters than broadcast PU; however, differences except for panicle lengths were not significant.

2.1.2.3. Number of grains panicle⁻¹

Masum *et al.*, (2010) reported that placement of N fertilizer in the form of USG @ 58 kg N ha⁻¹ produced the highest number of effective tillers hill⁻¹, filled grains panicle⁻¹ which ultimately gave the higher grain yield than split application of urea.

Lang *et al.*, (2003) found that the increase in nitrogen fertilizer application rate enhanced grains per panicle, effective panicles per plant, and total florets per plant.

Meena *et al.*, (2002) noted that increase in nitrogen fertilizer application rate enhanced number of grains and filled grains of hybrid rice.

BRRI (2006) found that increasing level of N increased the number of spikelet panicle⁻¹ of rice and the highest number of spikelet panicle⁻¹ (82.2) was obtained with 120 kg ha⁻¹ compared to 90 and 0 kg ha⁻¹ urea respectively.

Zohra *et al.*, (2012) observed that the number of grains panicle⁻¹ was varied significantly due to different level of USG.

Rajarathinam and Balasubramaniyan (1999) indicated that there was no appreciable change in grains panicle⁻¹ due to higher dose of N above 150 kg ha⁻¹. They also noticed an appreciable reduction in grains panicle⁻¹ at 250 kg N ha⁻¹.

Yoshida and Parao (1976) reported that in rice at higher nitrogen level the number of grain become decreased due to lodging.

Singh and Kumar (1983) stated that grain yield increased consistently with increasing N application up to 87 kg ha⁻¹ USG of granular urea produced the higher grain yield of than ordinary urea applied in three equal split dressings and other N sources.

Idris and Matin (1990) noted that the length of panicle of rice was highly related with the application of increased level of nitrogen. They also stated that panicle formation and elongation was directly related with the contribution of nitrogen.

Ehsanulla *et al.*, (2001) pointed out that the N level of 125 kg ha⁻¹ produced maximum number of grains panicle⁻¹.

Jee and Mahapatra (1989) observed that number of panicles m⁻² were significantly higher with 90 kg N ha⁻¹ as deep placed USG than split application of urea.

2.1.2.4. 1000-grains weight (TGW)

Maitti *et al.*, (2003) reported that the application of 140 kg N ha⁻¹ resulted in the highest increase in grain yield (by 76.2%), number of panicles (by 109.00%), number of filled grains per panicle (by 26.2%), and 1000-grain weight (5.80%) over the control.

Khatun *et al.*, (2014) found that TGW ranged from 19.4 to 20.4 g in BRRI dhan28 and from 18.8 to 19.5 g in BRRI dhan29, respectively (Table 1). The application of higher doses of N decreased TGW in both the varieties. BRRI dhan29 had lower TGW than BRRI dhan28 at a given N dose. BRRI dhan28 showed TGW of 20.3 g in N-control plots compared to 19.5 g in BRRI dhan29. Increasing N dose up to 200 kg ha⁻¹ had no significant effect on TGW, but the application of 250 kg N ha⁻¹ decreased seed weight significantly in both the varieties.

Meena *et al.*, (2002) reported that increase in N fertilizer application rate increased 1000-grain weight of hybrid rice.

Chopra and Chopra (2004) showed that N had significant effects on yield attributes such as plant height, panicle plant⁻¹ and 1000-grain weight. Cumulative effect of yield attributing and nutrient characters resulted in significant increase in seed yield at 120 kg N ha⁻¹ over 60 kg N ha⁻¹ and the control.

Khatun *et al.*, (2015) found that the individual effect of nitrogen sources (N) and the interactions of nitrogen sources (N) and variety (V) were insignificant for 1000-grain weight (TGW). BRRI dhan28, produced TGW of 22 g in all N treatments. In BRRI dhan29, it ranged from 22-24 g among the N treatments.

Naseem *et al.*, (1995) recorded lower 1000-grain weight in the control treatment than in the plots received fertilizer nitrogen.

Ali *et al.*, (1993) showed that weight of 1000 grains was higher when 100 kg nitrogen ha⁻¹ was applied in three equal splits at basal 30 days and 60 days after transplanting.

Rahman *et al.*, (1985) noted that there was a little relationship between nitrogen and weight of 1000 grains of rice.

A field experiment was conducted by Maiti *et al.*, (2003) during the boro season with the nitrogen fertilizer applied during transplanting, at the tillering and panicle initiation stages. They found increased number of higher number of panicles, number of filled grains panicle⁻¹, and grain-weight and grain-yield.

2.1.2.5. Grain yield and straw yield

Xie *et al.*, (2007) in his experiment found that the level of nitrogen application depends on the variety for obtaining the highest grain yield.

Khatun *et al.*, (2014) reported that the experiment included BRRI dhan28 and BRRI dhan29 and 0, 50, 100, 150, 200 and 250 kg ha⁻¹ N rates. Seed yield increased significantly in a quadratic fashion with the increase of N rate both in BRRI dhan28 and BRRI dhan29. Application of N fertilizer increased seed yield by about 3-4 t ha⁻¹ compared to control. The highest yield of 5.15 and 6.34 t ha⁻¹ was obtained with 150 kg N ha⁻¹ in BRRI dhan28 and BRRI dhan29 respectively.

Salam *et al.*, (2004) conducted an experiment to determine the level of nitrogen (0, 40, 80 and 120 kg N ha⁻¹) and the highest grain yield was recorded from the application of 80 kg N ha⁻¹.

Miah *et al.*, (2004) carried out an experiment with transplanted rice cv. BINA dhan 4. They found that the values of the parameters measured were higher with application of USG compared to application of urea.

Das (2011) found the highest grain yield (4.28 t ha^{-1}) of rice using the $240 \text{ kg prilled urea ha}^{-1}$ and the lowest grain yield (3.06 t ha^{-1}) using the no nitrogen application in a field trial with prilled urea.

Islam *et al.*, (2011) carried out an experiment on the effectiveness of NPK briquette on rice in tidal flooded soil condition. They found that NPK briquettes, USG and prilled urea (PU) produced statistically similar grain yield but gave significantly higher grain yield than N control.

Lin *et al.*, (2008) conducted an experiment to find out the effect of plant density and N fertilizer rates ($120, 150, 180$ and 210 kg N ha^{-1}) on grain yield and N uptake of hybrid rice. They observed that there was a better response to N fertilization, as increasing N application from 120 to 180 kg N ha^{-1} (by 50%) raised yield by 17%. Raising the application rate to 210 kg N ha^{-1} (by 75%) boosted yield by 24.1%.

Singh and Shivay (2003) found that increasing levels of N significantly increased the grain and straw yields.

Maitti *et al.*, (2003) reported that the application of 140 kg N ha^{-1} resulted in the highest increase in grain yield.

Dwivedi *et al.*, (2006) conducted a field experiments to evaluate the effects of nitrogen levels on growth and yield of hybrid rice. They found $184.07 \text{ kg N ha}^{-1}$ was the optimum rate for highest yield.

Mohanty *et al.*, (1989) observed that placement of USG in rice gave significantly higher grain and straw yields of 36% and 39% in dry and 17% and 18% in wet season, respectively than split application of PU.

Zaman *et al.*, (1993) found that USG consistently produced significantly higher grain yield than PU.

Dalai and Dixit, (1987) reported that nitrogen had marked effect both on yield and yield attributes of rice. They observed that grain and straw yields increased significantly at each successive level of N due to increase in the number of panicles, length of panicle, spikelet panicle⁻¹ and weight of 1000-grain.

Sarkar *et al.*, (2001) reported that application of nitrogen increased straw yield significantly up to 120 kg N ha⁻¹.

Nitrogen fertilizer was applied to the rice crop at the of 0, 96 and 144 kg N ha⁻¹ in urea form and the main results indicated that increasing nitrogen levels up to 144 kg ha⁻¹ significantly increased straw yield (Ebaid and Ghanem, 2000).

Meena *et al.*, (2002) resulted that application of nitrogen significantly increased grain and straw yields of hybrid rice up to the level of 200 kg N ha⁻¹.

Rajendran and Veeraputhiran (1999) suggested that grain yield increased as the N rate increased. The highest straw yield (13.1 t ha⁻¹) was found with 225 kg N ha⁻¹.

2.1.2.6. Biological yield

Gaudin (2012) carried out an experiment on the kinetics of ammonia disappearance from deep-placed urea super granules (USG) (granular form) in transplanted rice: the effects of deep placement USG application and PU fertilizer. He found that ammonia disappearance from the placement site is faster for the second application, and it appears that the rice roots took up ammonia at a higher concentration: 20 mM for the second application versus 10 mM for the first application.

Iqbal (2011) carried out an experiment on determination of the effects of five fertilizer application rates on vertical leaching from 30 cm and 60 cm soil layers and) found that during paddy growth, nitrogen losses from different nitrogen treatments varied 2.82-5.07% application of the urea compared to USG.

Mishra *et al.*, (1999) reported that apparent N recovery in rice also increased from 21% for PU to 40% for USG (granular form). Here Rice showed a greater response to N upon USG placement than split application of PU.

2.1.2.7. Harvest index

Sarker *et al.*, (2001) obtained the nitrogen response of a Japonica and an Indica rice variety with different nitrogen levels viz. 0, 40, 80 and 120 kg N ha⁻¹. They observed that application of nitrogen increased grain and straw yields significantly but harvest index was not increased significantly.

Khatun *et al.*, (2015) found that the main effect of nitrogen sources (N) was highly significant (0.05) for harvest index (Table 2). In both BRRI dhan28 and BRRI dhan29 the HI varied from

0.44 to 0.46. The N control plots gave the lowest HI in both the varieties. The application of N increased HI slightly.

Dwivedi (1997) noticed that application of nitrogen significantly increased the growth yield and yield components grain yield, straw yield as well as harvest index with 60 kg N ha⁻¹.

2.1.3 Seed quality characters

Khatun *et al.*, (2015) observed that the nitrogen sources and variety interactions and the individual effect of N showed insignificant on seed germination. But the individual effect of BRRI dhan29 gave significantly higher germination (%) compared to BRRI dhan28.

Bhattacharjee *et al.*, (2000) and Ovsecichuk (1980) who observed the maximum viability of freshly harvested bolder seeds produced under significant amount of nitrogenous fertilizer.

Hussain *et al.*, (2015) obtained the highest number of normal seedling (83.39%) was found when transplanting was done on 31 December. Contrary, the highest number of abnormal seedling (10.34%) with least number of dead seed (29.95%) was found in 15 January transplanting rice seed. Both germination (83.39%) and normal seedling (75.13%) was found when on 140 kg N ha⁻¹ applied with the lowest number of abnormal death seed.

Khatun *et al.*, (2014) found nitrogen application to rice seed crop did not impair seed quality in terms of germination, viability, vigour and seed color. The seed N concentration ranged from 0.94 to 1.31% in BRRI dhan28 and 0.85 to 1.07% in BRRI dhan29 among different N rates. The average seed protein of BRRI dhan28 (6.59%) was significantly higher than that of BRRI dhan29 (5.68%). Seed N and protein content slightly increased with the increase of N rate. Nitrogen application did not influence phosphorus and magnesium content in rice seed.

Miah *et al.*, (2012) observed the content of protein in grain was influenced significantly due to different doses, whereas the content of starch was not affected significantly by the different form and doses of urea. The highest protein and starch content were observed in USG₃₀₀ treatment and lowest were found in control. The result suggests that Urea super granules @ 240 kg ha⁻¹ may be suitable for boro rice cv. BRRI dhan28 for better growth, yield and seed quality.

CHAPTER III

MATERIAL AND METHODS

3.1. Experimental site

The field experiment was carried out during Boro season from January to May of 2019 at Professor Purnendu Gain Field Laboratory, Agrotechnology Discipline, Khulna University, Khulna. The experimental site under the agro-ecological zone Gangas Tidal Flood Plain (AEZ 13).

3.2. Climatic condition

The climate of the experimental site was characterized by low temperature and humidity during the Robi season and relatively high temperature, humidity, and heavy rainfall occasional gusty winds during the Kharif season.

3.3. Soil Condition

The soil of the experimental area was medium low land, fairly leveled, well-drained and silty loam. Soil samples from 0-15 cm depths were collected from experimental field. The analysis was done at Soil Resources and Development Institute (SRDI), Khulna.

Table: 1 Chemical Characteristics of the initial soil (0-15 cm) of the experimental plot

Name of the parameters	Initial soil range
Nitrogen (%)	0.17
Phosphorus (mg/g)	11.63
Potassium (mg/g)	0.47
Sulphur (mg/g)	96.44
Zinc (mg/g)	0.76
Boron (mg/g)	0.63
pH	7.9
EC (Electrical Conductivity) dSm ⁻¹	2.04
Organic matter (%)	3.66

Source: Soil Resources and Development Institute (SRDI) Daulatpur, Khulna

3.4. Planting material

BRRI dhan28, a high yielding variety of rice was used as a test crop in this experiment. The variety was released by Bangladesh Rice Research Institute, Joydebpur, Gajipur in 1994. The life span of this variety is about 140 days in Boro Season.

3.5. Experimental design

The experiment was laid out in a Randomized Complete Block Design (RCBD) with 4 replications and 6 treatments. The treatments were randomly distributed to the unit plot in each block. The unit plots were 4 m length and 2.5 m wide. The distance between replication to

replication was 1 m and 0.5 m distance was maintained by each plot to plot for avoiding fertilizer contamination.

3.6. Seed collection and sprouting

Seeds of BRRI dhan28 were collected from an authentic dealer of Khulna city. Healthy seeds were selected following the standard method. Seeds were immersed in water in a bucket for 24 hrs. These were then taken out of the water and kept in gunny bags. The seeds started sprouting after 48 hrs which were suitable for sowing in 72 hrs.

3.7. Raising of seedlings

A common procedure was followed in raising seedlings in the seedbed. The nursery bed was prepared by puddling with repeated plowing followed by laddering. The sprouted seeds were sown uniformly as possible. Irrigation was gently provided to the bed as and when needed. No fertilizer was used in the nursery bed.

3.8. Collection and preparation of initial soil sample

The initial soil samples were collected before land preparation from a 0-15 cm soil depth. The samples were collected through an auger from different locations covering the whole experimental plot and mixed thoroughly to make a composite sample. After the collection of soil samples, the plant roots, leaves, etc. were picked up and removed. Then the sample was air-dried and sieved through a 10-mesh sieve and stored in a clean plastic container for physical and chemical analysis.

3.9. Preparation of experimental field

The experimental land was ploughed on 16 January 2019 with the help of a power tiller, later the land was irrigated and prepared by three successive ploughings and cross-ploughings. Each ploughing was followed by laddering to have a good puddled field. All kinds of weeds and residues of the previous crop were removed from the field. The field layout was made on 26 January 2019 according to design immediately after final land preparation. Individual plots were cleaned and finally leveled with the help of a wooden plank. A plot size of 4 m x 2.5 m was maintained with plot to plot distances 0.5 m and block to block distances 1.0 m.

3.10. Fertilizer management

The number of fertilizer doses was added to each plot calculated from the recommended doses. Full doses of other fertilizer except urea was applied as basal doses at the time of final land preparation and thoroughly incorporated into the soil. The experimental plots were fertilized with K, Zn, and S @ 134.7, 7.5, 60 kg ha⁻¹ in the form of muriatic of potash (MOP), zinc sulfate, and gypsum, respectively (BRRI, 2010) as basal. Urea was top dressed in three equal installments at 20, 35, and 50 days after transplanting (DAT). The treatment was distributed to each plot according to the design.

3.11. Experimental treatments:

The recommendation rate is 100-120 ton N ha⁻¹ for BRRI dhan28 (BRRI, 2010). Treatment was considered of single factor like nitrogen as urea Level

$N_0 = 0 \text{ kg ha}^{-1}$ (Control)

$N_1 = 35 \text{ kg ha}^{-1}$ (30% of recommended dose)

$N_2 = 70 \text{ kg ha}^{-1}$ (60% of recommended dose)

$N_3 = 105 \text{ kg ha}^{-1}$ (90% of recommended dose)

$N_4 = 140 \text{ kg ha}^{-1}$ (120% of recommended dose)

$N_5 = 175 \text{ kg ha}^{-1}$ (150% of recommended dose)

3.12. Uprooting and transplanting of seedlings:

Forty days old seedlings were uprooted carefully and were kept in soft mud in shade. The seedbeds were made wet by application of water in the previous day before uprooting the seedlings to minimize mechanical injury of roots. Seedlings were then transplanted as per experimental treatment on the well-puddled plots on 02 February 2019. In each plot, three seedlings were given in each hill, and spacing between plant to plant and row to row maintained properly.

3.13. Intercultural operation

The crops were kept weed-free throughout the growing period. Two hand weeding was done to check weed infestation in the experiment field at 30 and 50 days after transplanting (DAT).

In the field 2-4 cm of standing water was maintained throughout the growing period until the grain filling stage.

Furadan 5G was applied at 21 DAT to control ufra and malathion @ 1.00 L ha^{-1} applied to control green leafhopper and thrips. Different cultural operations were carried out during the period of investigation.

3.14. Harvesting and post-harvesting operations

Data was recorded to determine different growth parameters starting from 45 DAT and continue till maturity. At each sampling data was recorded from five randomly selected hill were in each unit plot. To avoid the border effect, plant samples were taken from the inner rows.

The crops were harvested at their full maturity when 90% of the grain turns a golden yellow color. Total harvesting was done in one day. Before harvesting five hills were uprooted randomly from each plot for taking yield components data. The harvested crop of each plot was bundled separately, tagged properly, and brought to the clean threshing floor. Grain and straw yield was recorded as a whole plot basis.

3.15. Data collection

The necessary data on agronomic characters were collected from randomly five selected hills from each plot in the field and at harvest.

A. Growth parameters

I. Plant height (cm)

Plant height was measured from the base part of the tip of the tallest leaf or panicle of each plant of the sample and the mean of five hills was taken.

II. Tiller number per hill

Tiller number per hill was recorded from five hills and the means were calculated. Tiller with at least one leaf was counted. It includes both effective and non-effective tiller.

III. Dry matter per hill (g)

Five hills were uprooted from each unit plot at harvesting time; oven-dried 70⁰ C for 72 hours and weighed to calculate the total dry matter accumulation

IV. Crop growth rate

CGR was recorded from oven dried plant at five growth stages started from 45 DAT. Crop growth rate (CGR) was calculated by the formula given by Beadle (1987).

$$\text{CGR} = \frac{W_2 - W_1}{T_2 - T_1} \quad \text{g hill}^{-1} \text{ day}^{-1}$$

Where, W_1 = Dry weight of 1st time plant uprooting; T_1 = 1st time of uprooting

W_2 = Dry weight of 2nd time plant uprooting; T_2 = 2nd time of uprooting

V. Relative growth rate

RGR was recorded from the oven dry weight of plant started from 45 DAT. RGR was calculated by following formula given by Evans (1972).

$$\text{RGR} = \frac{\log W_2 - \log W_1}{T_2 - T_1} \quad \text{mg g}^{-1} \text{ day}^{-1}$$

B. Yield and yield contributing parameter

I. Number of effective tiller per hill

The numbers of tiller bearing panicle of five hills were counted and the mean was calculated. The panicle which was at least one grain was considered as an effective tiller.

II. Length of panicle (cm)

Panicle length was measured from the base node of rachis to the apex of each panicle. The length of each panicle from five selected hills was measured and means were calculated.

III. Number of grains per panicle

Grains were separated from each panicle and grain numbers per panicle were counted manually. The presence of food materials in the spikelet was considered as grain and the total number of grains present on each panicle will count and the means were calculated. It includes both filled and unfilled grains per panicle.

IV. 1000-grains weight (g)

Thousand clean dried grains from the seed stock of each plot were counted separately and weighted by an electric balance and adjustment at 14% moisture level. The moisture content was also measured with an electric moisture meter taking 10-12 grain from the sample.

V. Grain yield (t/ha)

Grain obtained from the whole basis was threshed and grains were dried and weighed. The weights were adjusted at a 14% moisture level. The dry weight of grains of each plot was

converted to kg/ha. Grain yield was measured using triple balance and convert the yield into 14% field moisture content (FMC).

VI. Straw yield (t/ha)

Total straw yield of the harvest area of each plot was determined. The sample straw of each plot was dried in an oven at 70⁰ C for 72 hours and converted the sample into a total straw yield. The weight was adjusted at 14% moisture levels.

VII. Biological yield (t/ha)

Grain yield and straw yield was all together regarded as biological yield. Biological yield calculated with the following formula:

$$\text{Biological yield (t/ha)} = \text{Grain yield (t/ha)} + \text{straw yield (t/ha)}$$

After recording data from five plant samples, the sample yield was included with the respective plot yield and finally converted in a hectare yield.

VIII. Harvest index (%)

The harvest index was computed as the ratio of economic yield (grain yield) to the biological yield (grain yield + straw yield). The harvest index (%) will calculate by the following empirical given formula Donald and Humblin (1976)

$$\text{Harvest Index (\%)} = \frac{\text{Grain yield}}{\text{Biological yield}} \times 100$$

C. Seed quality parameter

The quality of the freshly harvested rice seeds was assessed by seed germination, seed viability, and seedling vigor test.

I. Seed color

The seed color was determined by the Munsell Color Chart. In colorimetry, the Munsell color system is a color space that specifies colors based on three properties of color: hue (basic color), chroma (color intensity), and value (lightness). It was created by Professor Albert H. Munsell in the first decade of the 20th century and adopted by the United States Department of Agriculture (USDA) as the official color system for soil research in the 1930s.

II. Germination percentages

Germination percentage is an estimate of the viability of a population of seeds. Germination count was made according to ISTA (2006).

$$\text{Germination percentage (\%)} = \frac{\text{No. of Seeds Germinated}}{\text{Total No. of Seeds}} \times 100$$

For seed germination 24 petri-dishes were used according to per plots. In this method 2 layers of blotting papers were soaked with water and 25 seeds from each plots were placed on per plate. Time to time watering was done to keep the filter paper moist. Waited for about a week and counted the number of seeds germinated in each petri-dish. Calculated the germination percentages.

III. Vigour index

Seedling vigor was tested following two methods:

1. Speed of germination and
2. Seedling length measurement (Agrawal, 2005).

Vigour index = Speed of germination X Seedlings length

1. Speed of germination

The speed of germination (SG) was calculated from the number of germinated seedlings at the first-day after plating and kept counting every day until final count, when all the seeds germinated. The following formula is used to calculate the speed of germination (SG):

$$SG = \frac{\text{No. of normal seedling}}{\text{day of 1}^{\text{st}}\text{count}} + \dots + \frac{\text{No. of Normal Seedlings}}{\text{day of final count}}$$

2. Seedlings length measurement

Seedlings lengths were taken after 7 days of plating in petridishes. Five samplings were randomly selected from each plate and they were taken to cleaned place and measurements were taken by scale as cm from place of radicle emergences to top. Then total length was averaged by number of seed taken and in this way seedlings length measurements were done.



Data analysis

The recorded data were analyzed following the analysis of variance (ANOVA) technique by using a computer package program Statistical Tools For Agricultural Research (STAR). Treatment means were checked by the Duncun's New Multiple Range Test (DMRT) (Gomez and Gomez, 1984). Functional relationship between grain yield and nitrogen doses were determined using regression analysis.

CHAPTER IV

RESULTS AND DISCUSSION

The present study was conducted to evaluate impact of nitrogen on growth, yield and various seed quality characters of BRRI dhan28. The results of the experiment are presented and discussed in this chapter in the form of different figures, tables along with adequate interpretation wherever needed.

4.1 Crop growth characters

4.1.1 Plant height

Nitrogen (N) is the key element in the production of rice and gives by far the largest response in plant height which promotes entire growth and development of plant. Effect of N levels showed a significant effect on plant height for all growth stages. Regardless of treatment differences, plant height increased progressively up to maturity (Table 2). Nitrogen played a significant role on plant height for all growth stages except 45 DAT. At 45 DAT highest plant height (53.80 cm) was obtained from T₃ (105 kg/ha N) which was statistically at par with T₄ (140 kg/h N) and T₅ (170 kg/h N) and lowest plant height (42.90 cm) was obtained from control or T₀. At 60 DAT highest plant height was observed with T₅ (140 N kg/ha) and the similar trend were obtained from 75 DAT and harvest. As usual the lowest plant height was recorded from control treatment T₀.

These results consonance with the result of Chameley *et al.* (2015) who found that the tallest plant (86.40 cm) was recorded from BRRI dhan28 with 200 kg N ha⁻¹. Sarkar *et al.* (2020) reported that the highest plant height produced with the application of 100 kg N ha⁻¹. Paramanik

et al. (2015), Khatun *et al.* (2014), Sarker *et al.* (2017), Uddin *et al.* (2013) also found that the plant height was significantly increased with the increased dose of nitrogen.

Similar findings were observed through Meena *et al.* (2003), Sahrawat *et al.* (1999) and Thakur (1993) who observed higher plant height with the higher doses of nitrogen.

Table 2: Effect of different rate of nitrogen application on plant height of BRRI dhan28 rice at different days after transplanting

N doses (kg/ha)	Plant height (cm)			
	45 DAT	60 DAT	75 DAT	Harvest (90DAT)
0	42.90 b	71.25 b	73.00 c	73.58 c
35	43.95 b	76.15 ab	79.45 bc	79.58 bc
70	50.75 ab	79.95 ab	83.33 ab	83.58 ab
105	53.80 a	83.10 a	87.58 a	87.63 a
140	53.77 a	79.56 ab	86.85 a	88.09 a
170	55.56 a	84.47 a	88.64 a	89.28 a
CV (%)	7.28	5.41	3.48	3.46
SE (±)	2.58	3.03	2.04	2.05

In a column, same letter indicate statistically similar and different letter indicate statistically dissimilar results among the treatments. Where $T_0 = 0 \text{ kg N ha}^{-1}$, $T_1 = 35 \text{ kg N ha}^{-1}$, $T_2 = 70 \text{ kg N ha}^{-1}$, $T_3 = 105 \text{ kg N ha}^{-1}$, $T_4 = 140 \text{ kg N ha}^{-1}$, $T_5 = 170 \text{ kg N ha}^{-1}$.

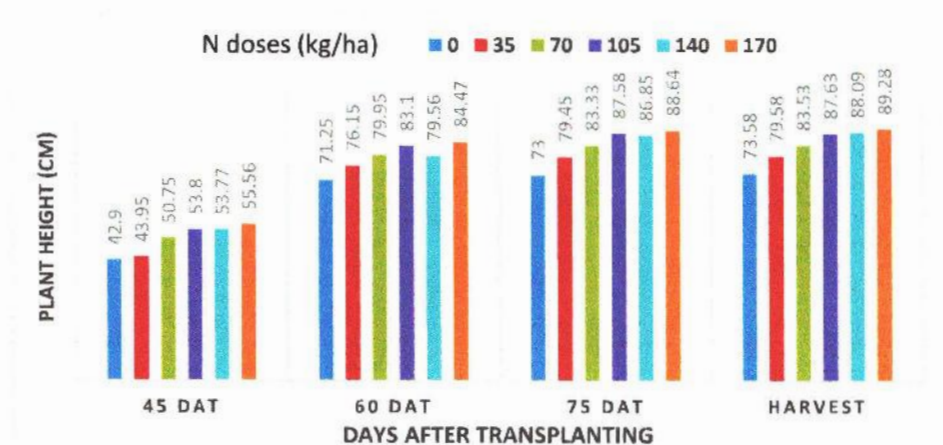


Figure 1: Effect of different doses of nitrogen on plant height of BRRI dhan28 rice at different DAT

Where $T_0 = 0 \text{ kg N ha}^{-1}$, $T_1 = 35 \text{ kg N ha}^{-1}$, $T_2 = 70 \text{ kg N ha}^{-1}$, $T_3 = 105 \text{ kg N ha}^{-1}$, $T_4 = 140 \text{ kg N ha}^{-1}$, $T_5 = 170 \text{ kg N ha}^{-1}$.

4.1.2. Number of tiller hill⁻¹

Tiller number hill⁻¹ was significantly influenced by the nitrogen levels at all growth stages (Table 3). At 45 DAT highest number of tiller per hill (13.50) was obtained with the application of treatment T_5 (170 kg N ha⁻¹) which was statistically similar with T_4 (140 kg N ha⁻¹) and the lowest number of tillers (7.50) hill⁻¹ was obtained due to control treatment. It indicates that number of tillers hill⁻¹ increases with the increase doses of nitrogen.

At 60 DAT, 70 DAT and harvest T_4 (140 kg N ha⁻¹) reported the highest number of tillers hill⁻¹ and control (T_0) recorded the lowest number of tiller hill⁻¹.

These findings are corroborate with findings of Adhikari *et al.* (2018) who reported that tillers number per hill increased with the increased dose of nitrogen and declined with the low coentration of nitrogen. Haque *et al.* (2016) reported that maximum number of tillers per hill

obtained with the application of 100 kg N ha⁻¹. Chamely *et al.* (2015) indicated that the higher number of tillers per hill was found with the application of 200 kg N ha⁻¹.

Neelam and Chopra (2000) also reported that the number of tillers increased upto 80 kg ha⁻¹ N application. BRRI (2006), Ahsan (1996), Kumar *et al.* (1995) and Idris and Matin (1990) reported a similar result that supports the present findings.

Table 3: Effect of different doses of nitrogen application on tiller number per hill of BRRI dhan28 rice at different days after transplanting

N doses (kg/ha)	Tiller number hill ⁻¹			
	45 DAT	60 DAT	75 DAT	Harvest (90DAT)
0	7.50 c	10.65 c	12.46 c	14.55 c
35	9.50 bc	13.80 bc	15.18 bc	15.55 bc
70	12.20 ab	17.15 ab	17.90 abc	20.30 abc
105	12.50 ab	18.10 ab	20.41 ab	21.50 ab
140	12.95 a	20.75 a	23.10 a	23.50 a
170	13.50 a	19.85 a	20.93 a	21.38 ab
CV (%)	13.11	15.29	13.56	14.39
SE (±)	1.05	1.81	1.76	1.98

In a column, same letter indicate statistically similar and different letter indicate statistically dissimilar results among the treatments. Where T₀ = 0 kg N ha⁻¹, T₁ = 35 kg N ha⁻¹, T₂ = 70 kg N ha⁻¹, T₃ = 105 kg N ha⁻¹, T₄ = 140 kg N ha⁻¹, T₅ = 170 kg N ha⁻¹.

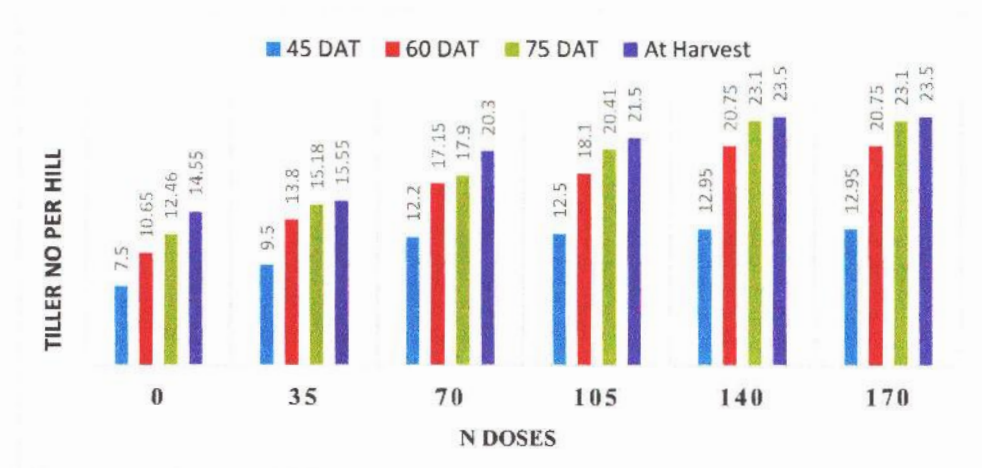


Figure 2: Effect of Different doses of nitrogen on number of tiller per hill of BRRI dhan28 rice at different DAT

Where $T_0 = 0 \text{ kg N ha}^{-1}$, $T_1 = 35 \text{ kg N ha}^{-1}$, $T_2 = 70 \text{ kg N ha}^{-1}$, $T_3 = 105 \text{ kg N ha}^{-1}$, $T_4 = 140 \text{ kg N ha}^{-1}$, $T_5 = 170 \text{ kg N ha}^{-1}$.

4.1.3 Dry matter hill⁻¹

Total dry matter (TDM) production indicates the production potential of a crop. A high TDM production is the first prerequisite for high yield. TDM of roots, leaves, leaf sheath + stem and or panicles of plants data were measured at 45, 60, and 75 and at harvest (Table 4). Dry matter hill⁻¹ was significantly influenced by the nitrogen levels at all growth stages except 45 DAT.

At 60 DAT highest dry matter (55.31 g) obtained with the application of treatment T_4 and the lowest was obtained from control or T_0 due to use of no nitrogen as treatment. Similar trend was observed at 75 DAT and at harvest where the highest number was obtained from T_4 and the lowest was found in control.

Accumulation of dry matter was very slow at early stage (45 DAT to 60 DAT) and increased progressively over time attaining the highest at harvesting time. Application of nitrogen caused

significant difference in the pattern of partitioning of dry matter of rice at all the growth stages where low nitrogen fertilizer levels triggers allocation of lowest dry matter to all plant parts (Haque *et al.* 2016). This finding was consonance with the Chaturvedi (2004) stated that dry matter production was increased with the DAT and the level of N upto 120 kg ha⁻¹ to 150 kg ha⁻¹.

Table 4: Effect of different doses of nitrogen application on dry matter per hill of BRRI dhan28 rice at different days after transplanting

N doses (kg/ha)	Dry matter hill ⁻¹ (g)			
	45 DAT	60 DAT	75 DAT	Harvest (90 DAT)
0	14.88	39.62 c	54.75 b	60.12 d
35	20.75	43.88 bc	61.81 ab	67.26 c
70	17.50	49.75 abc	69.13 a	72.00 b
105	17.25	50.62 abc	68.75 a	74.57 ab
140	17.62	55.31 a	71.56 a	76.59 a
170	19.75	52.62 ab	69.44 a	75.56 ab
CV (%)	24.29	10.15	6.47	2.77
SE (±)	3.08	3.49	3.01	1.39

In a column, same letter indicate statistically similar and different letter indicate statistically dissimilar results among the treatments. Where T₀ = 0 kg N ha⁻¹, T₁ = 35 kg N ha⁻¹, T₂ = 70 kg N ha⁻¹, T₃ = 105 kg N ha⁻¹, T₄ = 140 kg N ha⁻¹, T₅ = 170 kg N ha⁻¹.

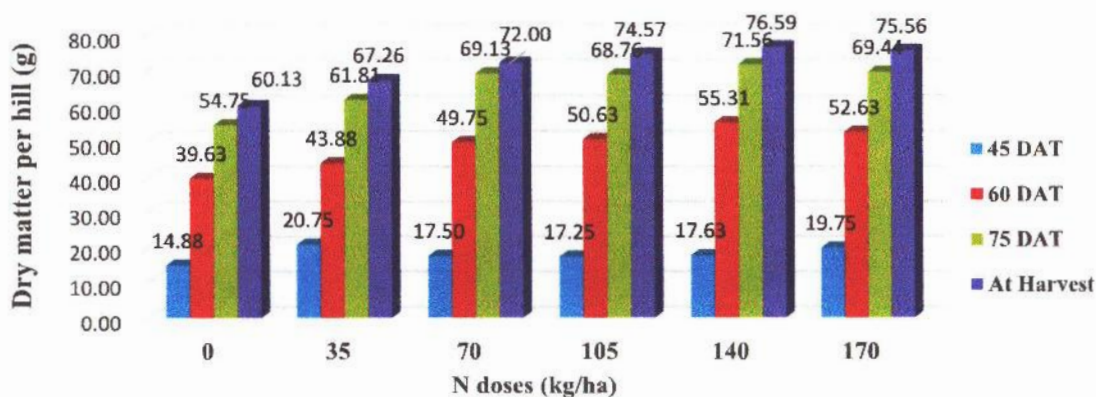


Figure 3: Effect of different doses of nitrogen on dry matter per hill of BRRI dhan28 rice at different DAT

Where $T_0 = 0 \text{ kg N ha}^{-1}$, $T_1 = 35 \text{ kg N ha}^{-1}$, $T_2 = 70 \text{ kg N ha}^{-1}$, $T_3 = 105 \text{ kg N ha}^{-1}$, $T_4 = 140 \text{ kg N ha}^{-1}$, $T_5 = 170 \text{ kg N ha}^{-1}$.

4.1.4 Crop growth rate (CGR)

Effect of nitrogen on crop growth was significantly affected at all growth stages (Table 5). The highest crop growth rate was obtained from T_5 and the lowest CGR was observed from control or T_0 . The rate of crop growth increased with the rate of nitrogen level. Anamul *et al.* (2016) stated that the trend of crop growth rate under different doses of nitrogen fertilizer illustrated that, crop growth rate of the variety was slow at early growth stage which became peaked at flowering stage and again declined towards maturity stage and showed even negative values. This above stated findings showed consonance with the result that obtained.

Table 5: Effect of different doses of nitrogen application on crop growth rate of BRRI dhan28 rice at different days after transplanting

N doses (kg/ha)	Crop growth rate (g hil ⁻¹ day ⁻¹)		
	45-60 DAT	60-75 DAT	75 DAT-Harvest (90DAT)
0	1.65	1.00	0.3575
35	1.54	1.19	0.3625
70	2.15	1.29	0.19
105	2.25	1.21	0.3875
140	2.50	1.08	0.3325
170	2.64	1.12	0.4075
CV (%)	22.31	21.55	59.36
SE (±)	0.32	0.175	0.143

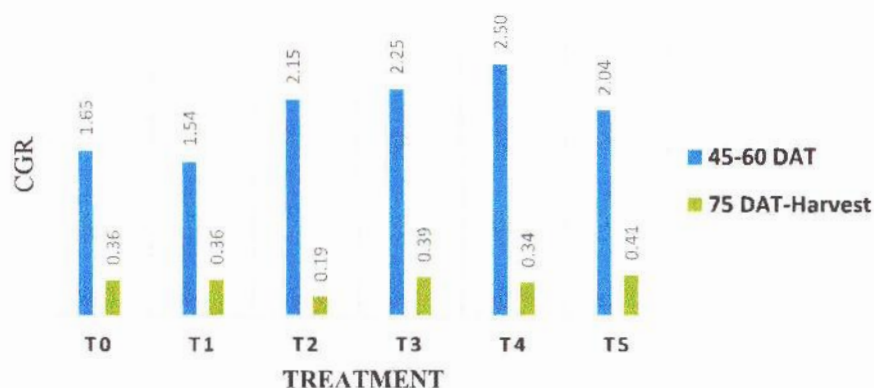


Figure 4: Effect of different doses of nitrogen on crop growth rate of BRRI dhan28 rice at Different DAT

4.2 Yield contributing characters

4.2.1 Panicle length

Panicle length was significantly influenced by nitrogen (Table 7). Results revealed that the highest panicle length (24.25 cm) was obtained with the treatment of T₄ which was statistically similar with T₃ and T₅. The lowest of panicle was recorded from control or T₀. Nitrogen plays a vital role on panicle elongation and formation as well as enhances the length of panicle with the adequate amount of N supply. With the increment of nitrogen level panicle length was increased.

The findings are consonance with the findings of Paramanik *et al.* (2015) who stated that panicle length of BRRI dhan28 was influenced significantly by nitrogen levels and the highest length (23.69 cm) was recorded with recommended nitrogen fertilizer was applied as urea (N₁₀₀) whereas the shortest panicle was recorded in N₀ (21.83 cm). Chamely *et al.* (2015) found highest length of panicle with the application of 200 kg N ha⁻¹.

Ahmed *et al.* (2005) also stated that higher N doses produces higher panicle length. Sarder *et al.* (1988) who have observed that the panicle length increased upto 120 kg N ha⁻¹. Meena *et al.* (2002), Shingh and Shivay (2003) also found that the increasing levels of nitrogen significantly increased panicle length.

Table 7: Effect of different doses of nitrogen on yield attributes of boro rice cv. BRRI dhan28

N Doses (kg/ha)	Length of panicle (cm)	No of effective tiller hill⁻¹	Total grains panicle⁻¹	Filled grains panicle⁻¹	Unfilled grain panicle⁻¹	1000 grain- weight (g)
0	20.05 c	12.61 c	84.25 b	76.02 b	8.49	21.03 b
35	21.35 bc	12.81 bc	89.73 b	84.33 b	5.40	21.36 b
70	21.82 b	14.31 abc	104.62 a	98.15 a	6.48	22.08 a
105	23.16 a	15.69 ab	106.72 a	99.15 a	7.57	21.92 a
140	24.25 a	16.69 b	113.87 a	105.37 a	8.24	22.17 a
170	23.71 a	16.45 a	113.55 a	108.08 a	5.47	22.07 a
CV (%)	2.55	8.84	5.53	4.71	54.41	0.84
SE (±)	0.40	0.92	3.99	3.71	2.67	0.12

In a column, same letter indicate statistically similar and different letter indicate statistically dissimilar results among the treatments. Where $T_0 = 0 \text{ kg N ha}^{-1}$, $T_1 = 35 \text{ kg N ha}^{-1}$, $T_2 = 70 \text{ kg N ha}^{-1}$, $T_3 = 105 \text{ kg N ha}^{-1}$, $T_4 = 140 \text{ kg N ha}^{-1}$, $T_5 = 170 \text{ kg N ha}^{-1}$.

4.2.2 Number of effective tiller hill⁻¹

Number of effective tillers per hill was significantly affected due to different nitrogen rates (Table 7). The highest number of effective tiller (16.69) was obtained from 140 kg N ha^{-1} which was statistically similar with 70, 105 and 170 kg N ha^{-1} . Medium number of effective tiller (12.61) was obtained from T_0 or control which showed statistically par with T_1 (12.81) and T_2 (14.31). This result showed that highest number of effective tiller was obtained with the

treatment of T₄ and the lowest number was obtained from T₀. It was observed that the number of effective tiller increased with the increasing level of nitrogen.

Adequacy of nitrogen probably favored the cellular activity during tiller formation and development, which led to increased number of effective tillers hill (Sarker *et al.* 2020). Ahmed *et al.* (2005) reported that number of effective tillers hill⁻¹ increased with the better management of nitrogen.

This finding was commensurated with the observation made by Pramanik *et al.* (2015) number of effective tillers per hill was increased with the increment of nitrogen level up to 75 kg N ha⁻¹ and thereafter decreased in 100 kg N ha⁻¹. Miah *et al.* (2012) found that effective tillers hill⁻¹ was affected by the doses of nitrogen as USG 240 kg N ha⁻¹.

Chopra and Chopra (2000) reported that the effective tillers per hill increased with the application of 80 or 120 kg N ha⁻¹.

Hair *et al.* (2000), Thakur (1991) and Tanaka *et al.* (1964) also reported similar results that increasing levels of nitrogen increased number of effective tiller hill⁻¹.

4.2.3 Total grains panicle⁻¹

Table 7 shows that the effects of different treatments on total grain panicle⁻¹. It was found that the total grains panicle⁻¹ statistically significant. The higher number of grain (113.87) panicle⁻¹ was resulted from T₄ which followed by T₅, T₃ and T₂ whereas the lowest number of grain (84.25) was obtained from T₀ or control which was statistically par with T₁ (89.73).

The results obtained for bearing grains panicle⁻¹ are in conformity with the findings of Ehsanullah *et al.*, (2001) pointed out that the N level of 125 kg ha⁻¹ produced maximum number

of grains panicle⁻¹. Zohra *et al.*, (2012) also observed that the number of grains panicle⁻¹ was varied significantly due to different level of USG.

4.2.4 Filled grains panicle⁻¹

Nitrogen sources showed significant variation on production of filled grains panicle⁻¹ (Table 7). It was found that filled grains panicle⁻¹ statistically significant. The highest filled grain (108.08) panicle⁻¹ was observed from T₅ which was statistically similar with T₄, T₃ and T₂. The lowest grain (76.02) panicle⁻¹ was observed from control or T₀.

Optimum amount of nitrogen fertilizer produces maximum number of filled grains and unfilled grains panicle⁻¹. The result agreed with the findings of Kumar *et al.* (1986) and Thakur *et al.* (1995) in that increasing level of nitrogen significantly increased the number of filled grains panicle⁻¹. This result was also commensurated with the observation made by Ahmed *et al.* (2005) stated that N fertilizer management significantly affected the number of grains panicle⁻¹. Maximum number of filled grains panicle⁻¹ was found more effective with the treatment of 20-40 kg N ha⁻¹

4.2.4. Unfilled grains panicle⁻¹

Unfilled grains panicle⁻¹ were non-significantly influenced by different doses of nitrogen (Table 7). The highest number of unfilled grain (8.49) panicle⁻¹ was found in the treatment with control or T₀ due to no N used in control. The lowest number of unfilled grain (5.47) was found in T₅. These findings were agreement with the Lawal and Lawal (2006) reported that adequate supply of nitrogen is essential for grain development of rice and to increase filled grains per panicle. These results are in conformity with the findings of Tayfee *et al.* (2012) who also found that nitrogen fertilization had no significant effect on unfilled percent of rice varieties.

4.2.5. 1000-grain weight (g)

Weight of 1000 grains is one of the most important parameter among the yield contributing characters and it was affected significantly by N application in the present study (Table 7). The highest 1000-grain weight (22.08) was obtained from the treatment of T₅ and the lowest 1000-grain weight (21.03) was recorded from T₀.

These findings are consonance with the Mohaddesi *et al.* (2011) stated that 1000 grain weight had significant effect with increasing nitrogen levels. The result was supported by BRRI (2006) that without nitrogen application increased the maximum number of unfilled grains panicle⁻¹ in boro rice.

4.2.6. Grain yield (t ha⁻¹)

Grain yield was significantly influenced by different doses of nitrogen (Table 8). The higher grain yield (3.92 t ha⁻¹) was obtained from the treatment of T₃ followed by the treatment of T₅ (3.81 t ha⁻¹). The yield recorded from T₄ (3.25 t ha⁻¹) was statistically at par with the treatment of T₂ (3.11 t ha⁻¹). The lowest grain (1.22 t ha⁻¹) was obtained from T₀ or control.

Increased doses of nitrogen helped to increase panicle length, effective tillers per hill, and filled grains panicle⁻¹ which ultimately enhanced the grain yield (Miah *et al.* 2012). This results consonance with the findings of Haque *et al.* (2016) found that the highest grain yield (5.36 t·ha⁻¹) was found when the crop was fertilized with 60 kg N ha⁻¹ followed by 80 kg N ha⁻¹ (4.99 t·ha⁻¹) and the lowest yield (3.29 t·ha⁻¹) was recorded from control. Similar result was attained by Singh and Singh (2005) who stated that each increment doses of nitrogen significantly increased grain yield. Idris and Matin (1990) reported that application of nitrogen increased the yield of

4.2.7 Biological yield (t ha^{-1})

Table 8 shows the effects of different treatments on biological yield. Biological yield was significantly influenced by different sources of nitrogen at 5% level of significance. The highest biological yield (7.29 t ha^{-1}) was obtained from T_3 which was statistically different from T_1 (5.11 t ha^{-1}) and T_0 (3.24 t ha^{-1}). The lowest yield (3.24 t ha^{-1}) was recorded from control or T_0 .

These results are in agreement with the findings of Shingh and Lallu (2005) who reported that each increment doses of nitrogen significantly increased biological yield (grain and straw yield) over its preceding dose. Ahmed *et al.* (2005) also reported that the effect of nitrogen dose on biological yield (t ha^{-1}).

4.2.8 Harvest index (%)

Harvest index is the ratio of straw yield and grain yield where the value is expressed in percentages (%). Results (Table 8) revealed that harvest index was significantly affected by different level of N application. The highest harvest index (53.76%) was resulted from T_3 statistically similar harvest index was found from the treatment of T_4 and T_5 . The lowest harvest index (37.59%) was resulted from T_0 or control.

This results accorded with the findings of Sarker *et al.* (2020) who stated that nitrogen management produced significant differences ($p < 0.01$) in respect of harvest index in aus rice. The highest harvest index (41.65) was found from the N_3 (112 kg N ha^{-1}) treatment and the lowest harvest index (35.32) was found from the control (N_0).

Table 8: Effect of different doses of nitrogen on yield and harvest index of boro rice cv. BRRI dhan28

N Doses (kg ha ⁻¹)	Grain yield (t ha ⁻¹)	Biological yield (t ha ⁻¹)	Harvest index (%)
0	1.22 b	3.24 d	37.59 c
35	2.46 c	5.11 c	47.85 b
70	3.11 b	6.26 ab	49.66 b
105	3.92 a	7.29 a	53.76 a
140	3.25 b	6.17 bc	52.73 a
170	3.81 a	6.98 ab	53.61 a
CV (%)	8.09	8.25	2.40
SE (±)	0.16	0.34	0.84

In a column, same letter indicate statistically similar and different letter indicate statistically dissimilar results among the treatments. Where T₀ = 0 kg N ha⁻¹, T₁ = 35 kg N ha⁻¹, T₂ = 70 kg N ha⁻¹, T₃ = 105 kg N ha⁻¹, T₄ = 140 kg N ha⁻¹, T₅ = 170 kg N ha⁻¹.

4.3 Seed quality parameters

4.3.1 Seed color

Different rates of N did not affect seed colors according to Munsell color chart. The seed color was 10YR (Yellow-Red) with value 7 and chroma 6-8. In that range of color chart refers to neutral value of seed color. Similar result was obtained from Khatun *et al.* (2014).

4.3.3 Vigor index

Vigor testing is important because it often gives a better prediction of field performance and is a more sensitive indicator of seed quality than the standard germination test (Younis *et al*, 1990).

Vigor index leads to the speed of germination along with the seedlings length. The seed lot with high nitrogen content absorbed water faster which accelerates the speed of germination of seed than seed with low nitrogen content. Nitrogen in seed content also initiates the seedlings length. These results showed (Table 9) vigor index was significantly affected by different levels of nitrogen. In BRRI dhan28 the highest speed of germination (25.26) was recorded from T₅ which was statistically at par with the treatment of T₄ and T₃ whereas the lowest speed of germination (23.13) was recorded from T₀ which was followed by the applied treatment of T₁ and T₂.

Along with this trend the highest seedling length (6.09) was obtained from T₃ which was statistically at par with the applied treatment of T₄ and T₅ whereas the lowest seedlings length (4.75) was obtained from T₀ or control which was showed statistically at par with the T₁ (4.90) and T₂ (4.97). The values which were resulted from speed of germination and seedlings length leads to the similar variation in vigour index. The highest vigour index (151.25) was observed in T₅ which was statistically similar to T₃ (146.01) and T₄ (144.26) and the lowest vigour index was obtained in T₀ (104) followed by T₁ (111.44) and T₂ (113.45).

This results are consonance with the findings of Yoshitaka Hara and Kazunobu Toriyama (1998) stated that nitrogen in seed content has a significant role on vigor index which may be achieved by an adequate application of a nitrogen to parent plants. The increase of seed nitrogen content absorbed water faster which leads to uniform seed germination.

CHAPTER V

SUMMARY AND COCLUSION

A field experiment was conducted at the Professor Purnendu Gain Field Laboratory, Agrotechnology Discipline during boro season with a view to examine the impact of nitrogen on growth, yield and seed quality of BRRI dhan28. The experimental treatments include six doses of nitrogen T_0 (0 kg N ha⁻¹), T_1 (35 kg N ha⁻¹), T_2 (70 kg N ha⁻¹), T_3 (105 kg N ha⁻¹), T_4 (140 kg N ha⁻¹), T_5 (170 kg N ha⁻¹). Results revealed that nitrogen sources had significant effect on plant height. Growths parameters increased with increased doses of nitrogen. The highest plant height was observed from T_5 (175 kg N ha⁻¹) at all growth stages. At harvest the tallest (89.28 cm) plant was recorded from T_5 treatment which was significantly greater than that obtained from the rest of the treatments used in the experiment and the shortest plant (73.58 cm) was recorded from the control (T_0) treatment. The highest number of total tillers hill⁻¹ (23.50) was found with the application of T_4 (140 kg N ha⁻¹) whereas the lowest number was tillers hill⁻¹ found in control or T_0 (0 kg N ha⁻¹).

Accumulation of dry matter increased progressively over time attaining the highest at harvesting time. The highest dry matter (76.59 g m⁻²) accumulation per hill was attained from T_4 (140 kg N ha⁻¹) and lowest dry matter (60.12 g m⁻²) was obtained from control. The highest crop growth rate (CGR) and relative growth rate (RGR) were observed from with the treatment of T_5 (170 kg N ha⁻¹) and T_0 (0 kg N ha⁻¹) treatment showed lowest CGR and RGR at all growth stages.

From the results higher yield parameters such as length of panicle (24.25 cm), number of effective tillers hill⁻¹ (16.69), total grains panicle⁻¹ (113.87), filled grains panicle⁻¹ (105.37) and thousand grain weight (22.17) were obtained with the treatment of T_4 (140 kg N ha⁻¹). Yield

parameters such as grain yield (3.92 t ha^{-1}), biological yield (7.29 t ha^{-1}) and harvest index (53.76) were obtained with the treatment of T_3 (105 kg N ha^{-1}). Though the yield parameters were found supreme with the T_4 (140 kg N ha^{-1}) while other yield attributes were obtained with the T_3 (105 kg N ha^{-1}). These differences might be due to except nitrogen other nutrients were applying as a basal dose and unavailability of other nutrients occurred with the increment of nitrogen doses.

Germination percentages of freshly harvested seeds did not significant difference due to different doses of nitrogen. Besides germination percentages of seed other seed quality attributes such as speed of germination, seedlings length and vigor index showed significant effect on different doses of nitrogen. The highest vigor index (151.25) was observed in T_5 (170 kg N ha^{-1}) which was statistically similar to T_3 (146.01) and T_4 (144.26) and the lowest vigor index was obtained in T_0 (104) followed by T_1 (111.44) and T_2 (113.45).

Although growth of the variety increased with increased nitrogen levels, assimilate mobilization towards yield and yield contributing characters were found superior with 105 kg N ha^{-1} of nitrogen application. Consecutively the highest grain (3.92 t ha^{-1}) and straw yield (3.37 t ha^{-1}) was obtained with the treatment of 105 kg N ha^{-1} (T_3). From the results it may be concluded that high dose of nitrogen performed best in the growth and dry matter accumulation whereas moderate dose of nitrogen (105 kg N ha^{-1}) was found best in the yield and yield contributing characters along with maintaining quality parameters in seed of BRRI dhan28.

CHAPTER VI

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