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Planting Time, Nitrogen Requirement and Mode of Nitrogen Application on Boro Rice (Var. BRRI dhan 29)

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Abstract:

Field experiment was conducted at Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur during dry season 2007 to identify the optimum planting time, level of nitrogen and mode of N application for high quality of rice seed production. Significant

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variation was observed among the treatments in respect of yield, yield contributing characters and seed quality properties of Boro rice (var. BRRI dhan 29). The tallest plant height (92.90 cm) was produced when transplanting was done on 15 December afterwards it decreased gradually with delaying in transplanting. The number of tillers per hill decreased gradually with the increase in planting time. The number (13.08) of tillers per hill was observed at 15 December transplanted rice seed and lowest (11.80) was recorded at 31 January seedling. The application of nitrogen promoted the development of tillers resulted the highest number of tillers per hill (13.40) was produced when the crop was fertilized with on 160 kg N ha^{-1} and the lowest (10.90) was obtained from 100 kg N ha^{-1}. More number of tillers per hill (12.65) was found when three split of nitrogen was done. But the number of panicles per hill gradually increased till 31 December planted rice resulted the highest number of panicles per hill (12.30) and the lowest (10.97) was on 31 January planted seedling. The number of panicles per hill also increased with the increased of N level up to 140 kg N ha^{-1} and further increase in N level decreased the number of panicle per hill. The highest number of panicles per hill (12.09) was produced when the crop was fertilized with 140 kg N ha^{-1} and the lowest (10.28) was obtained from 100 kg N ha^{-1}. The highest number of grains per panicle (147.45) was observed from 31 December transplanted rice and the lowest number of grains per panicle (140.83) was found from rice planted in 15 January. The number of grains per panicle increased with the increase of nitrogen up to 160 kg N ha-1. The highest number of grains per panicle (150.15) was recorded fertilized with 160 kg N ha-1 which was identical to treatment of 140 kg N ha-1 and lowest number (136.17) of grain per panicle was of 10 from 100 kg N ha-1. The highest number of filled grains per panicle (117.81) was observed in 31 December transplanting of rice. After that it decreased drastically and the lowest number of filled grains per panicle (103.19) was found in 31 January transplanting of rice seedling. Increased level of nitrogen increased the number of filled grains per panicle up to 140 kg N ha-1. The highest number of filled grains per panicle (118.58) was recorded in 140 kg N ha-1 followed by 160 kg N ha-1. The lowest (104.03) was recorded from 100 kg N ha-1. Filled grains per panicle of the variety increased with four split of nitrogen application. Higher number of filled grains of per panicle

(115.28) was found when 4 split of N was done. Crops planted in 31 December the highest 1000 grain weight (20.62g) was produced and the lowest 1000 grain weight (19.09g) was recorded in 15 December transplanted rice which was identical to grain weight of 15 and 31 January planted crop. The heavier grain (20.13g) was found at 140 kg N ha-1 and the smaller (19.27g) at 100 kg N ha^{-1}. The 1000 grain weight however was influenced significantly when one extra split of nitrogen were applied. The highest percentage (35.48%) of spikelet sterility was observed when the crop was planted on 15 January and the least number of spikelets sterility (21.13%) was recorded from the crop planted on 31 December. Similar trend was also observed in case of N level. Therefore, the highest sterility (31.23%) was found from the crops which received the highest amount of nitrogen (160 kg N ha^{-1}). However, mode of N application reduced spikelet sterility about 10% when 4 split was done. The highest grain yield (7.27 t ha^{-1}) was found at 31December transplanted crop fertilized with 140 kg N ha-1 at when 4 split of N was done. The lowest grain yield (3.44 t ha^{-1}) was obtained from 31 January transplanting with 100 kg N ha-1 when at 3 split of N application. In late transplanting and insufficient amount of nitrogen application reduced filled grains per hill and increased unfilled grains per panicle that resulted decrease in grain yield of rice. Soluble protein of Boro rice (var.BRRI dhan 29) influenced significantly due to planting time, N level as well as mode of N application. The highest total soluble protein (7.79 mg g^{-1}) was estimated from the seeds of 31 December 4 planted crop fertilized with 160 Kg N ha-1 spitted 4 times the lowest total soluble protein (4.50 mg g–1) was found from the seeds of 31 January planted crop treated with 100 kg N ha-1 when 3 split of nitrogen was done.

Key words: BRRI dhan 29, planting time, nitrogen, yield, seed quality

INTRODUCTION

Rice (*Oryza sativa* L.) is the dominant food to feed of the developing world. More than 90% of the world rice is produced and consumed in Asia (Hossain and Pingali, 1998). Half of the world populations choose rice as their food as it supplies about 75% of the calories and 55% of the protein in the average daily diet (Kenmore, 2003; Bhuiyan *et al*., 2004). The importance of rice is invariably recognized for its caloric values as well as nutritional status (Kenmore, 2003). It is the crop which can be grown all over the year under extremely wide range of environmental conditions. Although, the growth characteristic and yield components of rice are genetically controlled, maximum expression of these genetically characters depends on environmental conditions prevailing in the growing seasons. Planting time has a great influence on the growth, yield and yield contributing characters of rice (Islam *et al.,* 1999). Changes in transplanting time substantially change growth characteristics of rice varieties due to changes in temperature, relative humidity and pattern of rainfall distribution. In Boro season, rice crop suffers from low temperature during seedling stage and high temperature at reproductive stage. Besides temperature, Boro rice faces high relative humidity, high rainfall, hailstorm and other natural hazards at the time of reproductive and harvesting time. Such environmental conditions decrease grain yield and severely impair seed quality. Therefore, it is important to find out the optimum planting time of boro rice varieties to obtain higher grain yield with better seed qulity. The availability of nitrogen is also a major factor of crop production (Kramer, 1983). Nitrogen 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). On the contrary, plants grow very slowly when nitrogen is deficit. Nitrogen deficiency results in reducing plant height, tillering capacity, grains per panicle and ultimately decreases grain yield of rice. 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). The amount of nitrogen requirements of rice however, varied in different seasons, even at different growth stages of the plants are grown in the same season. Because, there are growth stages where nitrogen requirements are high and shortage of this input at those stages restrict drastically the growth, yield and seed quality of the crop. It is assumed that nitrogen requirement and mode of nitrogen application would influence Boro rice differently as it remains longer period in the field. Such effect of nitrogen nutrition on productivity and seed quality of Boro rice further might be affected by planting time of the season. Since information relating planting time, nitrogen requirement and mode of nitrogen application on yield and seed quality of rice grown in Boro season is not sufficiently available, the present study was undertaken: i) to determine optimum planting time and nitrogen requirement for higher yield and better seed of rice (var. BRRI dhan29) grow in Boro season and ii) to identify the proper mode of N application for quality seed production of boro rice.

MATERIAL AND METHODS

An experiment was conducted at the Experimental Farm of Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur under wetland condition during the dry season (Boro) of 2007. Three sets of treatments were considered in the experiment. First set was planting time of Boro rice viz. 15 December, 31 December, 15 January and 31 January. Second set was nitrogen levels viz. 100-120-140-160 kg N ha^{-1} while third set was mode of N application viz. three splits and four splits of N as top dressing. Forty days old rice (var. BRRIDhan 29) seedling was transplanted on specific dates using one seedling per hill at a spacing of 20 cm × 20 cm. Amount of nitrogen and mode of nitrogen application were practiced according to treatment combination. The design of the experiment was split plot with three replications where planting times were assigned in main plot, nitrogen level in sub-plot and mode of N application in sub-sub plot. Thirty five days old rice (var. BRRI dhan29) seedling was transplanted on specific date using one seedling per hill at a spacing of 20 cm × 20 cm. The crop was fertilized with four levels of nitrogen as per treatments and P, K, S and Zn were applied as par recommendation for rice (BRRI, 2004). All fertilizers except urea were applied as basal before the last harrowing during final land preparation. In mode of nitrogen application with three split, urea was top dressed in three equal splits at 7 days after transplanting (DAT), maximum tillering stage and the panicle initiation (PI) stage. While in mode of nitrogen application with four splits urea was top dressed at 7 (DAT), maximum tillering stage, the panicle initiation (PI) stage and 7 days after flowering. In order to keep the crop weed free it require to manual weedings through hand pulling. The first weeding was done on 15 and second on 30 DAT. Due to the shortage of rain water irrigation was applied during land preparation, transplanting and at different crop growth stages to avoid water stress. During crop growth the field was irrigated to maintain a thin layer (2-3 cm) of water although at maturity no standing water was allowed to stay in the crop field. Insecticides were applied time to time to control insect pest. Crop was harvested at proper maturity with sickle. Harvesting was done on different dates due to the variation of planting dates. An area of six square meters was harvested from the center of each plot to estimate the grain yield. The harvested samples were threshed using paddle thresher, cleaned the grains and dried to adjust at 14% moisture content. For yield attributes, plant height was recorded from 10 randomly selected plants from each plot. The height was recorded from base of the plant to tip of upper most spikelet of the panicle. Total number of hills from one square meter area was harvested and the numbers of panicles were counted. Twenty panicles were randomly taken from the sample and panicle length was measured from the neck to the top of the panicle. After counting the panicle number, all spikelets from the panicles were placed in a paper bag that has been properly labeled. The total grains were counted including filled and sterile spikelet. Thousand of grains were randomly selected and dried to 14% moisture content and then weighed in an electrical balance. The harvested seeds of each transplanting time were stored in plastic airtight container for determination of seed qualitative parameters.

Quality of fresh seed harvested rice seed were assessed by germination test, speed of germination, seedling vigor, seedling length, seedling dry weight, electrical conductivity test and soluble protein content as per following procedures. One hundred seeds harvested from different N levels of each planting time 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 30^0C till the completion of germination. Seedlings were counted every day and a seed was considered to be germinated as seed coat ruptured 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:

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

The speed of germination of seed sample was monitored by counting the germinated seedling at an interval of 24 hours and continued for twelve days. Co-efficient of germination and vigor index were calculated using the following formula (Copeland, 1976):

$$\text{Co-efficient of germination} = \frac{100(A1+A2+-----+Ax)}{A1T1+A2T2+------+AxTx}$$

Where,
A= number of seed germinated
T= Time corresponding to A
x = number of days to final count

Seedling vigor was calculated from a daily count of germinated seeds until it reached a constant value following the formula

$$\text{Seedling vigor} = \frac{\text{Number of normal seedlings (first count)}}{\text{Days to first count}} + ---- + \frac{\text{Number of normal seedlings (last count)}}{\text{Days to last count}}$$

Seedling obtained from standard germination test was used for seedling evaluation. Normal or abnormal seedlings are classified according to the rules of the Association of Official Seed Analyst (AOSA, 1981). Seedling shoot and root length was also measured at the end of the germination test. Ten seedlings from each Petri dish were harvested and shoot and root length of individual seedlings was measured. The shoot and root were also dried at 70^0C for 72 hours for determination of seedling dry matter yield. For electrical conductivity test 50 seeds were weighed and soaked in 50 ml of de-ionized water for 24 hours at 25 ± 1^0C (Ali *et al.*, 2005). After 24 hours, water of the beaker containing seeds was decanted in order to separate the seeds. The leachates conductivity was determined in $\mu s\ cm^{-1}$ by using a conductivity meter (Model-CM-30ET). Four replicates of measurements were made for each sample of seeds. Nitrogen content in the seeds was determined following micro Kjeldahl digestion colorimetric method at final harvest and protein content was calculated by multiplying the nitrogen content (%) in seeds by a factor of 5.95 (Juliano, 1972). All data were subjected to statistical analysis by analysis of variance (ANOVA). Microsoft EXCEL and MSTAT software programs were used wherever appropriate to perform statistical analysis. Functional relationships among the parameters were established through correlation analysis.

RESULTS AND DISCUSSION

Plant height

Transplanting time influenced significantly on the plant height of Boro rice (var. BRRIDhan 29). The tallest plant (92.90 cm) was observed when the seedling was transplanted on 15 December afterwards plant height of the variety decreased gradually as delayed in planting time. Thus, the shortest plant (91.23 cm) was recorded when the seedling was transplanted on 31 January (Fig. 1).

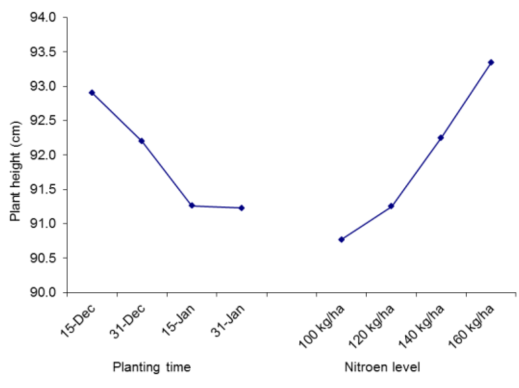

Fig. 1 Plant height of Boro rice (var. BRRIDhan 29) as affected by planting time and nitrogen levels

Shorter plants under late transplanted condition might be the resultant of sub-optimal growth of the variety due to low temperature regimes especially at seedling and vegetative stage. Fig. 2 showed that temperature during the seedling stage dropped to 10.65^{0}C which seriously shorten the height of the variety. This finding had the similarity with results obtained by Pathak et al. (2003) who found stunted growth of Boro rice at late sown condition due to low temperature.

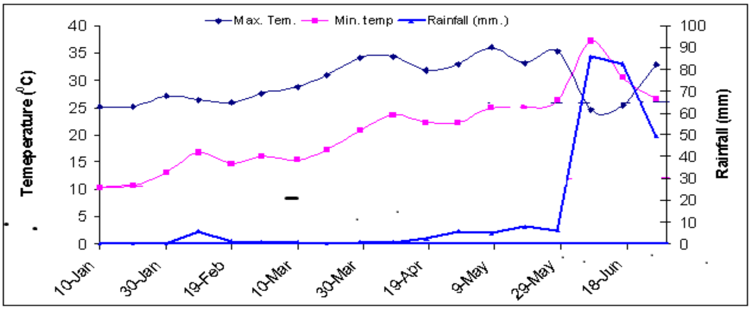

Fig. 2 Daily maximum, minimum temperature and rainfall during growing season of Boro rice (var. BRRI Dhan 29)

Increased nitrogen level increased significantly the height of the variety (Fig. 1). The variety attained at maximum height (93.34 cm) with the highest nitrogen level (160 kg N ha-1) and it was minimum (90.77 cm) with the lowest level of nitrogen (100 kg N ha-1). It happened because N is the constituent of chlorophyll and application of N at higher level increased leaf chlorophyll content which ultimately enhanced photosynthesis, dry matter production and growth of the plant. Besides, nitrogen influences on cell division and cell elongation and thus increases plant height of the variety.

Tillers per hill

Date of transplanting exerted significant influence on number of tillers per hill (Fig. 3). It was observed that the number of tillers per hill decreased gradually with the delaying of planting time. The highest number of tillers per hill (13.08) was observed at 15 December transplanting rice and the lowest (11.80) was recorded at 31 January seedling. It might be due to cold temperature prevailing at the time of tiller development which reduced number of tillers per hill. Almost similar finding was reported by Mannan (2005) in another variety of Boro season.

Number of tillers per hill increased significantly with the increase of nitrogen level. The application of nitrogen promoted the development of tillers. The highest number of tillers per hill (13.40) was produced when the crop was fertilized with 160 kg Nha-1 and the lowest (10.94) was obtained from 100 kg N ha-1 (Fig. 3.3). The findings of this study had the similarity with the finding of BRRI (2004) where the number of tillers per hill increased with the increase of nitrogen level. More number of tillers (12.65) per hill also observed from the 3 split planted crop. Number of tillers per hill of the variety (var. BRRIDhan 29) however did not vary significantly due to split application of nitrogen.

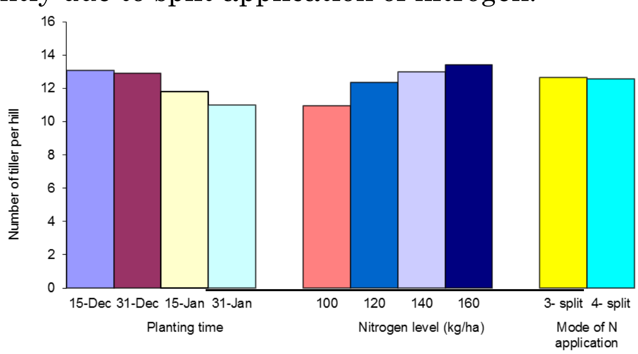

Fig. 3 Tillers per hill of Boro rice (var. BRRI Dhan 29) as affected by planting time, nitrogen level and mode of N application

Panicles per hill

Planting times differed significantly in bearing panicles per hill of the variety (var. BRRI Dhan 29). The highest number (12.30) of panicles per hill was recorded on 31 December transplanting and the lowest (10.97) was observed on 31 January transplanted crop (Fig. 4). Decrease in panicle bearing tillers after 31 December might be due to slow establishment of seedling due to low temperature which caused only few panicles to emerge. Similar findings were also observed by Hossain *et al.* (2002) in different varieties of Boro rice.

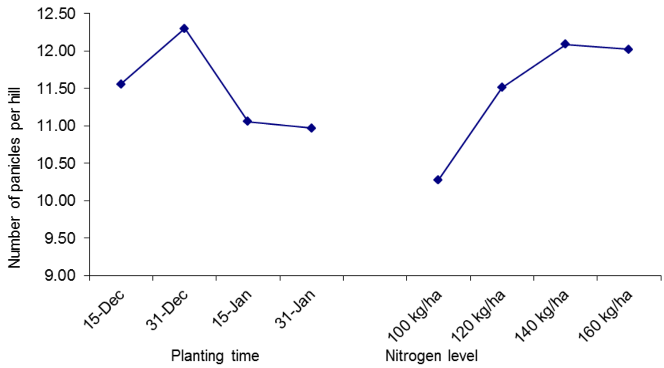

Fig. 4 Tillers per hill of Boro rice (var. BRRI dhan 29) as affected by planting time, nitrogen level and mode of N application

Number of panicles per hill of the variety varied significantly due to different level of nitrogen application (Fig. 4). The number of panicles per hill increased with the increased of N rates up to 140 kg N ha^{-1} and further increase in nitrogen level decreased the number of panicles per hill. The highest number (12.09) of panicles per hill was produced when the crop was fertilized with 140 kg N ha^{-1} and the lowest (10.28) was obtained from 100 kg N ha^{-1}. Adequacy of nitrogen probably favoured the cellular activities during panicles formation and development which led to increase number of panicle per hill. Similar response of nitrogen was also found by BRRI where maximum panicles per hill were found at higher levels of applied nitrogen.

Grains per panicle

The number of grains per panicle varied significantly with the variation of planting time of Boro rice variety (Table 1). The highest number (147.45) of grains per panicle was found from 31 December transplanted rice and it decreased significantly with the advancement of planting time. The lowest number (140.83) of grains per panicle was observed at late planted crop (31 January). The number of grains per panicle influenced significantly due to different level of nitrogen application (Table 1). It increased with the increase of nitrogen level and the highest number (150.15) of grains per panicle was produced when the crop was fertilized with 160 kg N ha^{-1} which was identical to treatment of 140 kg N ha^{-1}. The lowest number (136.17) of grain per panicle was obtained from 100 kg N ha^{-1}. Higher level of applied nitrogen enhanced the production of longer panicles which ultimately increased the production of grains per panicle. Mode of nitrogen application showed insignificant effect on number of grain per panicle.

Unfilled grains per panicle

Number of unfilled grains per panicle differed significantly due to different date of transplanting of Boro rice variety (Table 1). The highest number (37.64) of unfilled grains per panicle was recorded from 31 January transplanting crop and the lowest (29.64) was recorded from 31 December date of transplanting. The delay in transplanting of Boro rice variety (var. BRRI Dhan 29) increased unfilled grain per panicle because of poor seed setting due to frequent occurrence of cloudy hours at the grain filling stage.

Table 1. Effect of planting time, nitrogen level and mode of application on yield components of Boro rice (var. BRRI Dhan 29)

Management	Grains per panicle	Unfilled grains per panicle	Filled grains per panicle	1000 seed weight (g)
Planting time				
15 December	146.36b	33.16b	113.20b	19.78b
31 December	147.45a	29.64c	117.81a	20.62a
15 January	143.64c	31.10b	112.54a	19.74b
31 January	140.83d	37.64a	103.19b	19.09b
Nitrogen level (kg ha-1)				
100	136.17c	32.14b	104.03d	19.27b
120	141.85b	32.13b	109.72c	19.73b

140	150.13a	31.55b	118.58a	20.13a
160	150.15a	35.73a	114.42b	20.10a
Mode of N application				
3 split	145.27a	37.18a	108.09b	19.50b
4 split	143.87a	28.59b	115.28a	20.11a

Means in a column followed by same letter (s) are not significantly different at 5% level of significance by DMRT

The results also show that number of unfilled grain per panicle gradually decreased with increased level of nitrogen up to 140 kg N ha-1. The highest number of unfilled grain panicle-1 (35.73) was found at 160 kg N ha-1 indicate that this level of nitrogen was probably a case of over dose in respect of unfilled grain per panicle which might lead to yield loss. This fact well agrees with the results obtained by Moriwaki (1999) where the excessive amount of nitrogen application reduced the carbohydrate content and resulted in an abnormal development of pollen grains, which causes increased spikelet sterility. Mode of N application revealed that number of unfilled grain per panicle reduced when 4 split of nitrogen was done (28.59) as compared to 3 split of N application (37.18). Application of N as 4 splitting during post heading of rice might improve in grain filling which reduced unfilled grains per panicle of the variety.

Filled grains per panicle

Transplanting time of Boro rice significantly influenced on the number of filled grains per panicle. The highest number (117.81) of filled grains per panicle was observed in 31 December transplanted rice, after that it decreased and the lowest number (103.19) of filled grains per panicle was found at 31 January transplanting of rice seedling (Table 1). Such variability in filled spikelets per panicle is the resultant of variation in planting of the variety as it exposed the crop in different environmental condition of the season (Baloch *et al.*, 2006). Number of filled grains per panicle also varied significantly due to differences in nitrogen level. Increased level of nitrogen significantly increased the number of filled grains per panicle. The highest number (118.58) of filled grains per panicle was recorded in 140 kg N ha^{-1}. Contrary, the lowest number (104.03) of filled grains per panicle was recorded from 100 kg N ha^{-1}. Sufficiently supply of nitrogen might contribute to grain development which probably increased the number of filled grains per panicle with increased nitrogen level. The highest number of filled grains per panicle obtained from 140 kg N ha^{-1} perhaps indicated the demand-base nitrogen management. Similar result was also reported by BRRI of other variety in same season. Higher number of filled grains per panicle (115.28) was found when four split of N management. This might be due to rice plants require a large amount of nitrogen at the time of grain development. Top dressing during heading stage might contribute in improvement of grain which ultimately increased number of filled grains per panicle of the variety (Mannan, 2005).

1000 grain weight

Thousand grain weight of rice variety varied due to the variation of transplanting date in Boro growing season (Table 2). Crops planted on 31 December produced the highest grain weight. As the planting delayed, grain weight started to decrease, particularly when planted beyond 31 December. Probably due to late planting of the crop, the process of the grain filling was hampered that decreased individual seed weight. The heaviest 1000-grain weight (20.62 g) was obtained from 31 December transplanting and the lowest 1000-grain weight (19.09 g) was recorded from 15 December which was identical to grain weight found in 15 and 31 January. Similar results also reported by Mannan (2005) in rice of same growing season. The effect of different nitrogen level on 1000 grain weight of Boro rice was significant (Table 2). The results indicated that the heavier grain (20.13g) was found from 140 kg

N ha^{-1} and the lowest (19.27g) was recorded from 100 kg N ha^{-1}. Similar results also found by other authors (Mondel *et al*. 1987) who reported that the 1000 grain weight increased with the increasing of nitrogen rate as nitrogen has profound effect on seed development. One extra split application of nitrogen further improved grain size of the variety.

Spikelet sterility

The percentage of spikelet sterility varied significantly with the variation of transplanting time in Boro season (Fig 5). Sterility percentage increased with the delayed of transplanting time and the highest sterility percentage (36.48) was found in the late planted on 15 January crop. Late planted crop exprienced high temperature, high relative humidity and frequent rainfall during grain filling stage which might resulted in high sterility of the variety. Sterility percentage of the variety also increased at the highest level (160 kg N ha^{-1}) of nitrogen fertilizer due to excessive vegetative growth. One extra split application of N however reduced sterility percentage of the variety to a considerable level.

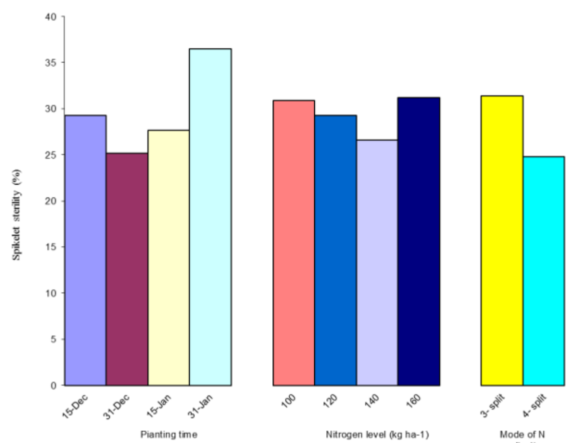

Fig.5 Spikelet sterility percentage of Boro rice (var. BRRIdhan29) as affected by planting time, N level and mode of N application

Interaction effect

Interaction effect of planting time, nitrogen levels and mode of nitrogen application on number of filled grains per panicle was significant (Table 2). The lowest number (96.70) of filled grains per panicle was found from 31 January transplanting fertilized with 100 kg N ha^{-1}. The highest number of filled grains (126.79) per panicle was observed on 31 December transplanted crop fertilized with 140 kg N ha^{-1}. This might be due to better interaction of brighter solar radiation and applied nitrogen throughout the growing period. Late planted rice seedlings got short period for vegetative growth and decreased filled grains per panicle of the variety. It presumably due to uniform and adequate supply of nitrogen to the growing plant especially at grain filling period. This was confirmed by the 4 split of nitrogen application with 140 kg N ha^{-1} which produced the highest number of filled grains per panicle (121.14).

Table 2. Interaction effect of planting time, nitrogen level and mode of N application on filled grains per panicle of Boro rice (var. BRRIDhan 29)

	Nitrogen levels (kg N ha^{-1})			
Planting time	100	120	140	160
15 December	107.50aC	114.58aB	117.55cA	113.17cB
31 December	107.34aD	113.18bC	126.73aA	123.99aB
15 January	104.59bD	110.69cC	119.43bA	115.42bB
31 January	96.70cD	100.42dC	110.60dA	105.25dB
Mode of application				
3 split	100.45bD	106.86bC	116.02bA	109.03bB
4 split	107.61aB	112.58aC	121.14aA	119.88aB

Means in a column followed by small letter (s) and in row by capital letter (s) are not significantly different at 5% level of significance by DMRT

Grain yield

Grain yield of Boro rice variety (var. BRRI Dhan 29) was significantly influenced by interaction of planting time, nitrogen rates and mode of N application (Table 3). The highest grain yield (7.27 t ha^{-1}) was found from 31 December transplanted seedling applied with 140 kg N ha^{-1} when 4 split of N was done. The lowest grain yield (3.44 t ha^{-1}) was obtained from 31 January transplanting Boro rice with 100 kg N ha^{-1} when 3 split of N was done. Late transplanting and insufficient amount of nitrogen application reduced filled grains per panicle that resulted decrease in grain yield of rice. These findings confirmed the results of BRRI where BRRI Dhan 28 produced lower grain yield under sub optimum applied nitrogen. The improvement of yield components of 31 December transplanted crop resulted in enhancement of grain yield of the variety. The 31 December planted crop stayed for long time in the field under bright sunshine days which perhaps maximized photosynthetic capacity of variety. Better photosynthesis and sufficient applied nitrogen in 31 December planted rice also improved filled grains percentage and enhanced the grain yield of the variety. Additional split application of nitrogen further improves the seed size of the variety. As a result, application of 140 kg N ha^{-1} with 4 split of N maximized the grain yield of the variety. Contrary due to lower nitrogen absorption, the late planted (31 January) crop with lower dose of applied nitrogen showed lower number of panicle; lower filled grains and higher number of unfilled grains and lower seed size which resulted in lower grain yield of the rice variety.

Table 3. Grain yield of Boro rice (var. BRRI Dhan 29) as affected by planting time, nitrogen level and mode of N application

Planting time	Nitrogen levels (kg ha^{-1})							
	100		120		140		160	
	3 split	4 split	3 split	4 split	3 split	4 split	3 split	4 split
15 Dec	5.30 bC	6.07aB	5.61bB	5.56bB	6.65aB	7.01aA	6.73aB	6.52bB
31 Dec	5.80 aA	6.01aB	5.83aC	6.26aB	7.05aB	7.27aA	6.12aB	7.13aA
15 Jan	5.21bC	5.23bC	5.61bC	5.90aC	5.89bB	6.63bA	5.73bB	6.59bA
31 Jan	3.44 cD	3.54cD	4.08cC	4.17bC	5.54bB	5.59cB	5.60bB	6.05bA

Means in a column followed by small letter (s) and in row by capital letter (s) are not significantly different at 5% level of significance by DMRT

Soluble Protein

Soluble protein of freshly harvested rice seed (var. BRRIDhan 29) influenced significantly by planting time, nitrogen level and mode of nitrogen application. Total soluble protein increased with the increase of N levels which was influence by different planting time and mode of nitrogen application (Table 4). The highest total soluble protein (7.79 mg g^{-1}) was found from the seeds of 31 December planted crop fertilized with 160 kg N ha^{-1} split 4 times. The lowest total soluble protein (4.50 mg g^{-1}) was found from the seeds of 31 January planted crop fertilized with 100 kg N ha^{-1} by 3 splitting of nitrogen. Similar observations were found in seeds of other crops as observed several authors (Zhao *et al.*, 1993; Mahboob *et al.*, 1992). As nitrogen is essential component of proteins, application of nitrogen increased protein content of seed which had generous impact on seed quality of field crops (Gadial *et al.* 1989).

Table 4. Interaction effect of different planting time, nitrogen level and mode of N application on grain protein (%) of BRRI Dhan 29

Planting Time	Nitrogen levels (kg ha^{-1})							
	100		120		140		160	
	3 split	4 split	3 split	4 split	3 split	4 split	3 split	4 split
15 Dec	4.55bC	5.12bB	5.08bB	5.56bB	5.56bB	6.05aA	6.35bA	6.89bA
31 Dec	5.73aC	6.06aB	6.15aB	6.50aB	6.54aB	6.91aB	7.17aA	7.79aA
15 Jan	5.28aC	5.55bC	5.77bC	6.18aB	6.13aB	6.66aB	6.76bB	7.22aA
31 Jan	4.50bC	5.36bB	4.96cC	5.54bB	4.95cC	5.55bB	6.15bA	6.49bA

Means in a column followed by small letter (s) and in row by capital letter (s) are not significantly different at 5% level of significance by DMRT

Seed Quality Assessment

It is important that quality seeds must be used as planting materials in order to increase rice productivity. Less quality seeds can often result in poor germination and poor seedling vigor resulting to lower crop growth and productivity. Quality of rice seed was assessed by different techniques viz. seed viability, germination, vigor index, seedling dry weight as well as electrical conductivity (EC) which are discussed below:

Seedling evaluation

Germination test of rice seed was carried out at 30^{0}C in a germinator. Significant differences were observed among the different transplanting dates in respect of germination percentage, normal seedling, abnormal seedling and dead seed. The highest germination (92.50%) and normal seedling (83.24%) were found when the crop was transplanted on 31 December. Afterwards, seed qualitative parameters of the variety decreased with delayed in transplanting (Fig. 6). The lower germination percentage of too late planted crop seeds were associated with the presence of higher number of dead seed (9.95%) as well as higher number of abnormal seedling (10.34%). Higher percentage of dead seeds and abnormal seedlings in the seed late planted crop might be due to higher moisture content of seed as well as high temperature prevailed at the time of seed maturation. Higher seed moisture contributed to poor seed viability as higher the seed moisture content lower is the seed longevity (Khandakar, 1983). Seed deterioration also occurred due to high rainfall during seed development and harvesting time of late planted crop in Boro season.

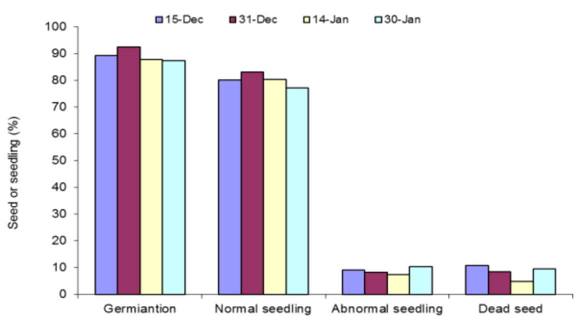

Fig. 6 Effect of different planting time on germination and seedling characteristics of Boro rice (var. BRRI Dhan 29) seed

Effect of different nitrogen level on germination percentage, normal seedling, abnormal seedling and dead seed was found significant (Fig. 7). Both germination and normal seedling gradually increased with increasing in nitrogen level till 140 kg ha^{-1} after that it decreased. The highest germination (94.15%) and normal seedling (85.21%) was found when 140 kg nitrogen was applied along with the lowest number of abnormal seedling (7.78%) and least number of dead seeds (7.82%) It might be due to bolder seeds were produced by the variety under optimum dose of nitrogen (140 kg ha^{-1}) which ultimately peaked germination percentage and higher proportion of normal seedlings.

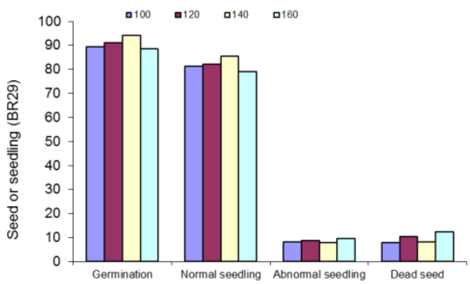

Fig. 7 Effect of different nitrogen level on germination and seedling characteristics of Bor rice (var. BRRI Dhan 29) seed

Increase in splitting of N further increased germination capacity and production of normal seedling by the variety. Application of N by four split increased germination and normal seedling considerably, over 3 split of nitrogen. The highest germination (84.44%) and normal seedling (82.54%) were found when 4 split of N was done (Fig. 8). It was possible because 4 split of N produced bolder seeds and maintained the highest viability at the time of harvesting. Better seed quality in well supplied N was also associated with higher seed protein content as there is positive relationship between protein and seed germination (Fig 9). Similar results are confirmed those of

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

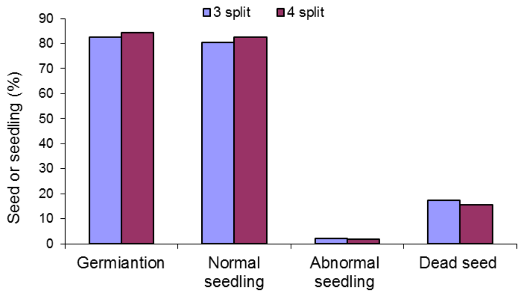

Fig. 8 Effect of different mode of N application on germination and seedling evaluation of Bor rice (var. BRRI Dhan 29) seed

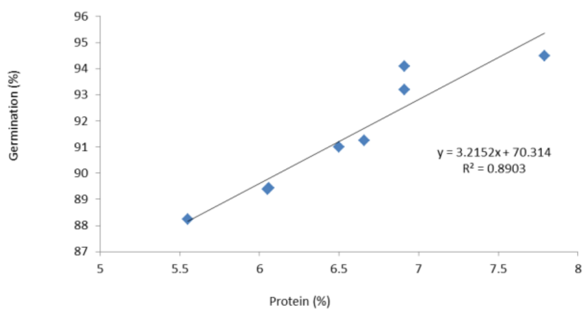

Fig.9: Relationship between protein and germination of Aman rice (Var. BR 29) under different management practices

Co-efficient of germination

Figure 10 shows co-efficient of germination at different planting time, different level of nitrogen and its method of application. Considering different planting time and different level of nitrogen, the highest co-efficient of germination was found at 31 December planted crop fertilized with 140 kg N ha^{-1}. Methods of N application also enhanced co-efficient of germination where the highest value (23.78) was found when 4 equal splits of N was done. The results revealed that application 140 kg N ha^{-1} with 4 split of N is ideal for 31 December planted rice as indicated by the faster germination of seeds as a consequence of improvement in seed vigor. Faster germination is prime concern as it determined the success of crop in the field (Yamauchi and Winn, 1996).

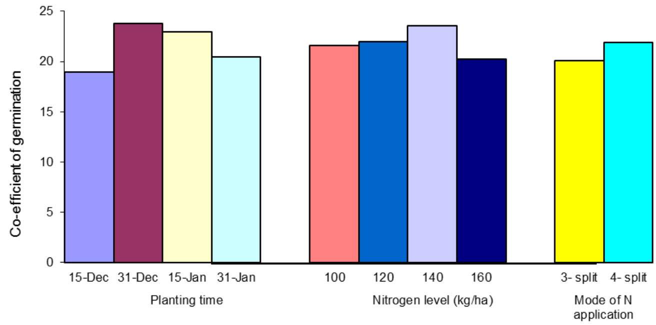

Fig. 10 Co-efficient of germination of Bor rice (var. BRRI Dhan 29) as affected by lanting time, N level and mode of N application

Seedling vigor

Planting time, nitrogen rate and mode of N application exerted profound effect on seedling vigor or germination rate of rice seed produced in Boro season (var. BRRIDhan 29). Germination rate increased with increasing of planting time up to 31 December planted rice along with increasing nitrogen rate up to 140 kg N ha^{-1} and afterwards it decreased (Fig 11). Thus the highest seedling vigor (9.33) was recorded in seeds of 31 December planted rice and the lowest (8.25) in seeds of 31 January planted rice. While at different nitrogen levels, the highest value (9.11) was found at 140 kg N ha^{-1} applied crop and the lowest (8.33) was found when seeds were harvested at 100 kg N ha^{-1}. In case of nitrogen split, higher seedling vigor (9.12) was recorded when 4 equal splits were done.

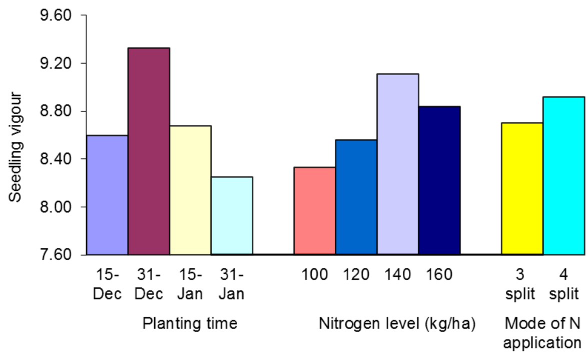

Fig. 11 Seedling vigour of Boro rice (var. BRRI Dhan 29) as affected by planting time, nitrogen level and mode of N application

Seedling dry weight

The results indicated that seedling dry weight increased with advance of planting time as well as increase in N rates up to a limit and after wards it decreased. The highest seedling dry weight (0.16 g) was found from the seeds obtained from 31 December planted crop and the lowest (0.10 g) from late planted crop (Fig. 12). Increased in seedling dry weight from 31 December planted crop at 140 kg N ha^{-1} was associated with the production of more number of bolder seeds as bolder seeds can supply more energy to growing seedling (Raveenaranath and Sing, 1991). The reverse is also true that seeds lower level of N and late planted crop showed lower seedling dry weight. Mode of N application also showed higher seedling dry matter (0.16 g) when 4 equal split was done.

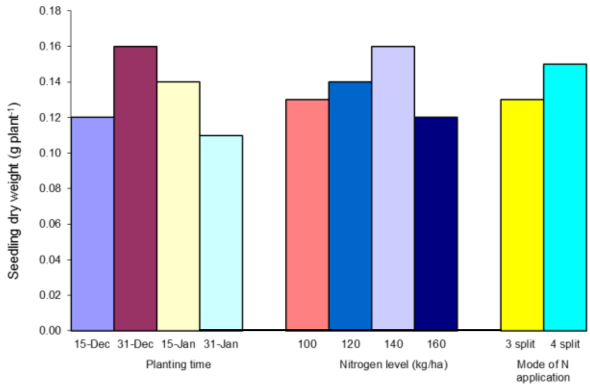

Fig. 12 Seedling dry weight of Boro rice (var. BRRI Dhan 29) as affected by planting time, nitrogen level and mode of N application

Electrical conductivity

Results obtained from electrical conductivity test showed significant difference due to planting times, different levels of N and mode of N application (Table 5). Seed leachate conductivity was the lowest (32.19 μScm^{-1}) in seeds of 31 December planted crop fertilizer with 140 kg N ha^{-1} when 4 split of N was done. Contrary, the highest value (40.53 $\mu S\ cm^{-1}$) was recorded from the treatment of 31 January planted crop fertilized with 100 kg N ha^{-1} under 3 split of nitrogen might be associated with its under developed seed. In under developed seed there is very possibility of having weak membrane which facilitated leakage from the seeds as it is shown negative relationship bewten electrical conductivity and seed germination (Fig. 13). Similar findings were also observed by (Chopra *et al*, 2004) in other variety (Pussa 44) of rice.

Table 5. Interaction effect of different planting time, nitrogen level and mode of N application on Electrical Conductivity value of Boro rice (var. BRRI Dhan 29)

Planting time	Nitrogen levels (kg ha^{-1})							
	100		120		140		160	
	3 split	4 split	3 split	4 split	3 split	4 split	3 split	4 split
15 Dec	38.34aA	38.53bA	37.49bB	38.75bA	35.14bC	32.79cD	36.36bB	34.86cC
31 Dec	38.06aB	39.77aA	36.96cC	39.42aA	35.75bD	32.19cE	36.71bC	38.20bB
15 Jan	38.43aA	37.79cB	37.89bB	37.60cB	34.63cD	34.09bD	35.63cC	38.48bA
31 Jan	38.00aB	39.78aA	38.96aBB	40.05aA	36.36aC	35.63aD	38.11aB	40.53aA

Means in a column followed by small letter (s) and in row by capital letter (s) are not significantly different at 5% level of significance by DMRT

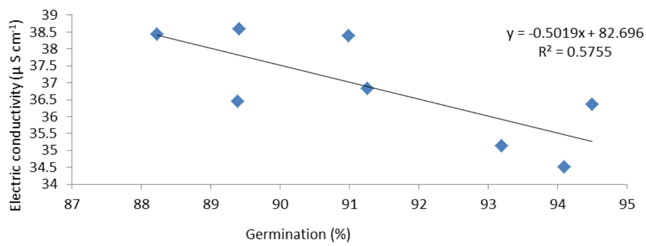

Fig.13: Relationship between germination and electrical conductivity of aman rice (Var. BR 29) grown under different management practices

CONCLUSION

Significant variation was observed among the treatments in respect of yield, yield contributing characters and seed quality properties of Boro rice (var. BRRI dhan 29). The highest number of grains per panicle (147.45) was observed from 31 December transplanted rice and the lowest number of grains per panicle (140.83) was found from rice planted in 15 January. The number of grains per panicle increased with the increase of nitrogen up to 160 kg N ha^{-1}. The highest number of grains per panicle (150.15) was recorded fertilized with 160 kg N ha^{-1} which was identical to treatment of 140 kg N ha^{-1} and lowest number (136.17) of grain per panicle was of 10 from 100 kg N ha^{-1}. Although mode of N application showed insignificant effect on grains per panicle. But the highest number (37.64) of unfilled spikelets per panicle was recorded on 31 January transplanting rice and the lowest (29.64) was observed in 31 December transplanting crop. The highest grain yield (7.27 t ha^{-1}) was found at 31December transplanted crop fertilized with 140 kg N ha^{-1} at when 4 split of N was done. The lowest grain yield (3.44 t ha^{-1}) was obtained from 31 January transplanting with 100 kg N ha^{-1} when at 3 split of N application. In late transplanting and insufficient amount of nitrogen application reduced filled grains per hill and increased unfilled grains per panicle that resulted decrease in grain yield of rice. The highest total soluble protein (7.79 mg g^{-1}) was estimated from the seeds of 31 December 4 planted crop fertilized with 160 Kg N ha^{-1} spitted 4 times the lowest total soluble protein (4.50 mg g^{-1}) was found from the seeds of 31 January planted crop treated with 100 kg N ha^{-1} when 3 split of nitrogen was done. Germination percentage increased gradually with the progression of planting time. 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. Four split application of N was found significantly superior to three split in terms of both germination percentage and production of normal seedling. Considering different planting time, the highest value of co-efficient of germination (23.08) was found at 31 December planting crop. Electrical conductivity (EC) differed significantly within the rice seed (var. BRRI dhan 29) found from different planting time and different levels of N and mode of N application. The lowest EC value (32.19 μS cm^{-1}) was recorded in seeds of 31 December planted crop fertilizer with 140 kg N ha^{-1} when 4 spilt of nitrogen were done. The highest value (40.53 μScm^{-1}) was recorded from the seed of 31 January planted crop with 100 kg N ha^{-1} at 3 spited plot which might be associated with its smaller sized seeds produced. In smaller size seeds, there is every possibility of having under developed seeds with poor membrane structure which facilitated leakage of solutes from the seeds. Germination percentage of Boro rice (var.BRRI 29) is positively correlated with soluble protein content in case of planting time as well as nitrogen level which indicate that higher the amount of soluble protein higher the germination percentage but negatively correlated with electrical conductivity.

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Appendix 1. Weather parameters of the experiment area Boro rice (var. BRRI Dhan29) in 2007

Month	Temperature (max.) ^0C	Temperature (min.)^0C	Rainfall (mm.)	Relative humidity (%)	Sunshine (hrs. day^{-1})	Cloudy (hrs. day^{-1})	Solar radiation (Cal.m^{-2})
10 January	25.06	10.45	0.00	87.60	4.55	3.65	233.81
20 January	25.13	10.65	0.00	62.86	7.55	2.67	311.34
30 January	27.10	13.00	0.00	72.24	6.63	3.57	252.90
9 February	26.42	16.77	5.68	86.80	3.92	7.28	248.00
19February	26.02	14.75	1.12	54.50	6.90	4.30	332.04
28 February	27.58	16.02	0.86	66.00	9.07	2.13	393.31
10 March	28.81	15.32	0.84	68.40	8.50	3.30	433.05
19 March	30.91	17.20	0.00	67.60	8.01	3.79	417.48
29 March	34.12	20.71	0.64	73.18	8.06	3.74	419.07
8April	34.25	23.66	0.76	73.10	8.08	4.48	4.37.22
18 April	31.87	22.28	2.42	74.20	6.40	6.10	384.56
28 April	32.93	22.32	5.84	77.80	6.11	6.39	315.14
8May	35.97	24.91	5.06	71.30	8.55	4.75	463.78
18 May	33.09	25.07	7.90	78.60	5.80	7.42	377.55
28 May	35.25	26.26	6.20	75.63	7.56	5.74	431.93
7June	24.59	37.20	85.90	3.66	9.94	307.42	32.05
17 June	25.48	30.45	82.30	3.43	10.17	300.53	33.33
27 June	32.78	26.60	49.40	74.70	5.53	8.07	368.07

Appendix 2. Effect of different planting time on yield and yield contributing characters of Boro rice (var. BRRI Dhan29)

Planting time	Plant height (cm)	Number of tiller hill^{-1}	Number of panicle hill^{-1}	Number of filled grain hill^{-1}	Number of unfilled hill^{-1}	1000- grain wt. (g)	Spikelet sterity (%)	Yield (tha^{-1})
15 Dec	92.90a	13.08a	11.56b	113.20b	33.16b	19.09b	29.29b	6.18
31 Dec	92.20a	12.96a	12.30a	117.81a	29.64b	20.62a	25.16cd	6.43
15 Jan	91.26a	11.82b	11.06c	112.54a	31.10c	19.74b	27.63bc	5.85
31 Jan	91.23b	11.00b	10.97c	103.19b	37.64a	19.78b	36.48a	4.67
$LSD_{0.5}$	6.161	0.5571	0.3283	5.240	2.509	0.8122	4.045	0.2708
CV%	3.56	9.09	7.85	6.51	9.95	2.93	2.96	9.05

Appendix 3. Effect of different nitrogen level on yield and yield contributing characters of Boro rice (var. BRRIdhan29)

Nitrogen (kgha^{-1})	Plant height (cm)	Number of tiller hill^{-1}	Number of panicle hill^{-1}	Number of filled grain hill^{-1}	Number of unfilled hill^{-1}	1000- grain wt. (g)	Spikelet sterity (%)	Yield (tha^{-1})
100	90.77c	10.94d	10.28b	104.03d	32.14b	19.27c	30.89a	5.08d
120	91.25bc	12.33c	11.51a	109.72c	32.13b	19.73b	29.28ab	5.38c
140	92.25ab	12.98b	12.09a	118.58a	31.55b	20.13a	26.61bc	6.43a
160	93.34a	13.40a	12.02a	114.42b	35.73a	20.10a	31.23a	6.25b
$LSD_{0.5}$	1.220	0.3749	0.5916	1.772	1.660	0.3653	4.253	0.1459
CV%	4.56	9.09	7.85	6.51	9.95	2.93	2.96	9.05

Appendix 4. Effect of different method of nitrogen application on yield and yield contributing characters of Boro rice (var. BRRIdhan29)

Method of application	Plant height (cm)*	Number of tiller hill^{-1}*	Number of panicle hill^{-1}*	Number of filled grain hill^{-1}*	Number of unfilled grain hill^{-1}*	1000-grain wt.*(g)	Spikelet sterity (%)	Yield (t ha^{-1}) *
3 splits	92.80	12.65	11.69	108.09	37.18	19.50	34.40a	5.69
4 splits	91.01	12.18	11.26	115.28	28.59	20.11	24.80b	5.88
CV%	4.56	9.09	7.85	6.51	9.95	2.93	2.96	9.05

* indicates at 0.05 level of significance by t test.

Appendix 5. Effect of different planting time on physiological properties of Boro rice (var. BRRIdhan29)

Planting time	Initial germination (%)	Speed of germination	Seed ling vigor	Seedling dry weight (g)	Normal seedling (%)	Abnormal seedling (%)	Dead seed (%)
15 Dec	87.26b	18.92c	8.60b	0.12d	80.13a	9.13b	10.73b
31 Dec	92.50a	22.94a	8.68b	0.16c	83.24b	8.26c	8.49c
15 Jan	87.78b	23.78a	9.33a	0.14a	80.33c	9.45b	10.74b
31 Jan	87.42b	20.45b	8.25c	0.11b	77.18d	10.34a	19.95a
LSD	0.241	0.15	0.08	0.00	0.29	0.07	0.14
CV %	1.47	3.33	4.47	2.02	1.85	3.70	3.66

Means in a column followed by same letter (s) are not significantly different at 5% level of significance by LSD

Appendix 6. Effect of different fertilizer doses on physiological of Boro rice (var. BRRIdhan29)

Nitrogen level (kgha^{-1})	Germination (%)	Speed of germination	Seedling Vigor	Seedling dry weight (g)	Normal seedling (%)	Abnormal seedling (%)	Dead/rotten seed (%)
100	89.42c	21.62b	8.33d	0.13b	81.27c	8.15c	8.3c
120	90.99b	21.56b	8.56c	0.14a	82.21b	8.77b	10.51b
140	94.15a	23.95a	9.11a	0.14a	85.21a	7.78b	7.82d
160	88.50d	20.25c	8.84b	0.12b	79.02d	9.48a	12.26a
LSD	0.24	0.15	0.08	0.01	0.29	0.07	0.14
CV %	1.47	3.33	4.47	2.02	1.85	3.70	3.66

Means in a column followed by same letter (s) are not significantly different at 5% level of significance by LSD

Appendix 7. Effect of different split application of nitrogen on physiological properties of Boro rice (var. BRRI Dhan29)

Method of application	Germination (%)	Co-efficient of germination	Seedling Vigor	Seedling dry weight (g)	*Normal seedling (%)	Abnormal seedling (%)	*Dead/rotten seed (%)
3 split	82.54	20.06	8.70	0.13	80.4	2.14	17.42
4 split	84.44	21.93	9.12	0.14	82.54	1.90	15.59
CV %	1.47	3.33	4.47	3.29	1.85	2.02	3.70

*Significant at 5% level of probability