EFFECT OF PLANTING DATES AND NITROGEN DOSES ON THE GROWTH AND YIELD OF *BORO* RICE CV. BRRI dhan45

BY

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Dedicated to

My

Beloved Parents

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CERTIFICATE

This is to certify that the thesis entitled **"Effect of Planting Dates and Nitrogen Doses on the Growth and Yield of *Boro* Rice CV. BRRI dhan45"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE in AGRICULTURAL BOTANY,** embodies the results of a piece of bonafide research work carried out by **MUHAMMAD TAHAZZAT ALI**, Registration number: **03-01143** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that any help or source of information, received during the course of this investigation has duly been acknowledged.

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ABSTRACT

The experiment was conducted at the experimental field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from November 2008 to May 2009 to study the effect of planting dates and nitrogen doses on the growth and yield of *Boro* rice. Cultivar BRRI dhan45 was used as the test crop in this experiment. The experiment comprised of two factors. Factor A: transplanting date: 3 dates; transplanting at 15 December 2008 – T_1; transplanting at 30 December 2008 – T_2 and Transplanting at 15 January 2009 – T_3. Factor B: Nitrogen level: 4 levels; 0 kg N ha^{-1} (control) – N_0; 80 kg N ha^{-1} – N_1; 100 kg N ha^{-1} – N_2 and 120 kg N ha^{-1} – N_3. The experiment was laid out in Randomized Complete Block Design with three replications. Data on yield contributing characters and yield were recorded. At 30, 50, 70 and 90 DAT and at harvest, the tallest plant (25.59 cm, 41.88 cm, 59.58 cm, 75.75 cm and 94.44 cm) was recorded from T_2, while the shortest plant (24.42 cm, 39.75 cm, 55.94 cm, 72.35 cm and 89.48 cm) was observed from T_1. The maximum number of effective tillers $hill^{-1}$ (12.13) was observed from T_2 and the minimum number (11.07) was recorded from T_1. The highest grain yield (5.91 t/ha) was found from T_2, whereas the lowest yield (5.12 t/ha) was recorded from T_3. At 30, 50, 70 and 90 DAT and at harvest, the tallest plant (27.09 cm, 43.84 cm, 61.21 cm, 78.38 cm and 95.36 cm) was observed from N_3, again the shortest plant (21.98 cm, 35.49 cm, 52.23 cm, 66.00 cm and 82.72 cm) was recorded from N_0. The maximum number of effective tillers $hill^{-1}$ (13.27) was found from N_3, whereas the minimum number (9.07) was obtained from N_0. The highest grain yield (6.44 t/ha) was obtained from N_2, while the lowest yield (3.50 t/ha) was found from N_0. At 30, 50, 70 and 90 DAT and at harvest, the tallest plant (28.17 cm, 45.47 cm, 63.77 cm, 86.26 cm and 98.87 cm) was found from the treatment combination of T_2N_3, whereas the shortest (21.00 cm, 33.80 cm, 49.97 cm, 82.33 cm and 80.87 cm) was observed from the treatment combination of T_1N_0. The maximum number of effective tillers $hill^{-1}$ (13.93) was recorded from the treatment combination of T_2N_3, again the minimum number (8.40) was found from T_1N_0. The highest grain yield (6.83 t/ha) was recorded from the treatment combination of T_2N_2 and the lowest yield (3.26 t/ha) from T_1N_0. It may be concluded that the growth, yield and yield contributing characters of BRRI dhan45 were greatly influenced by planting dates and nitrogen doses. The planting at 30 December and application of 100 kg N ha^{-1} may be recommended for maximum yield of BRRI dhan45 in SAU campus.

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Introduction

CHAPTER I

INTRODUCTION

Rice is the most important food for majority of people around the world. It is the staple food of about 3 billion people in Asia (Hien *et al.*, 2006). In Bangladesh, the geographical, climatic and edaphic conditions are favorable for year round rice cultivation. However, the national average rice yield (3.34 t ha^{-1}) is very low compared to that of other rice growing countries. For instance, the average rice yield in China is about 6.30 t ha^{-1}, Japan is 6.60 t ha^{-1} and Korea is 6.30 t ha^{-1} (FAO, 2002). The population of Bangladesh is increasing at an alarming rate and the cultivable land is reducing due to urbanization and industrialization resulting in more shortage of food. As it is not possible to have horizontal expansion of rice area, rice yield $unit^{-1}$ area should be increased to meet this ever-increasing demand of food in the country.

Very recently some new rice varieties have been developed in BRRI, Gazipur. The BRRI dhan45 is one of them and exceptionally high yielding, slender and has mild aroma of cooked rice. This variety however, needs further test under different planting times to interact with different environmental conditions of the season. Planting time for successful rice production widely depends on varietal duration, sensitivity to photoperiod, temperature, rainfall and other environmental factors (Rahman, 2003). In Bangladesh, planting of *Boro* rice starts from mid December and continues through January and even early February (Ahmed, 1976). Such longer period of planting time of *Boro* rice is associated with inconsistent rainfall, late harvesting of preceding crops, late receding of early or flash flood water and other socioeconomic factors (Zaman, 1986). It is assumed that late planting reduces vegetative phase which results reduced growth and yield of rice (Jhoun, 1989). Contrary, early planted *Boro* rice sometimes lodges due to over growth or other natural hazards prevailing in long growing season. It is therefore, essential to generate adequate information relating planting time of BRRI dhan45 to exploit its better growth and productivity during *Boro* season. Planting time affects not only growth and productivity of *Boro* rice but also affects generally on seed quality. Planting time affects seed quality through affecting seed growth and development as it provides different environmental conditions for seed development and maturation (Castillo *et al*., 1994).

Among the production factors affecting crop yield, nutrient is the single most important factor that plays a dominant role in yield increase if other production factors are not limiting. It is reported that chemical fertilizers today hold the key position to enhance crop production as high as 50%(BARC, 1997). Nutrient imbalance can be minimized by judicious application of different fertilizers. There is need to develop appropriate management technique to evaluate the performance and to assess the nutrient requirement for rice cultivation in the country. Among the fertilizers, nitrogen is essential for vegetative growth but excess nitrogen may cause excessive vegetative growth, prolong the growth duration and delay crop maturity with reduction in grain yield. Among the different elements nitrogen is universally needed for all crops. Many workers have reported a significant response of rice to nitrogen fertilizer in different soils (Bhuiya *et al*., 1989;

Hussain *et al.*, 1989). The efficient nitrogen management can increase crop yield and reduce production cost. An increase in the yield of rice by 70-80% may be obtained from proper application of N-fertilizer (IFC, 1982). Inadequate and improper applications of N are now considered one of the major reasons for low yield of rice in Bangladesh. The utilization efficiency of applied N by the rice plant is very low. The optimum dose of nitrogen fertilizer plays vital role for the growth and development of rice plant and its growth is seriously hampered when lower dose of nitrogen is applied, which drastically reduces yield; further, excessive nitrogen fertilization encourages excessive vegetative growth which make the plant susceptible to insect pests and diseases which ultimately reduces yield. So, it is essential to find out the optimum dose of nitrogen application for efficient utilization of these elements by the plants for better yield.

The BRRI dhan45 is a newly released variety of BRRI, which has higher yield potential as compared to existing modern varieties in T.Aman season. Considering these matters this research work was undertaken with the following objectives:

a. To evaluate the effects of different transplanting dates on the growth of BRRI dhan45.

b. To study the influence of nitrogen levels on the yield and yield components of BRRI dhan45.

c. To find out optimum planting date and nitrogen level for production of BRRI dhan45.

Chapter II
Review of Literature

CHAPTER II

REVIEW OF LITERATURE

Yield and yield contributing characters of rice are considerably depended on manipulation of basic ingredients of crop production. The basic ingredients include variety, environment and agronomic practices (planting density, fertilizer, irrigation etc.). Among the factors planting date and nitrogen doses play key role for manipulation of the growth and yield of rice. High yielding varieties (HYV) are generally more adaptive to appropriate planting time and nitrogen application and they produce higher yield with increasing nitrogen levels up to a certain limit with optimum planting time. The available relevant reviews related to planting date and nitrogen management in the recent past have been presented and discussed under the following headings:

2.1 Effect of planting time

Planting time for successful rice production widely depends on genotype, growth duration, sensitivity to photoperiod, temperature, rainfall and other environmental factors. Some literature related to planting time on growth and yield of rice are reviewed under the following headings:

2.1.1 Growth parameters

Vegetative growth of Indica rice is more affected by time of transplanting than that of other type of rice (Langfield and Basinski, 1960). Time of transplanting has profound influence on the performance of different cultivars of photo and thermo-sensitive in nature (Takahashi *et al.*, 1967). The time between July 15 and

August 15 is the best for transplantation of high yielding cultivars of transplant aman rice in Bangladesh (Islam, 1986). However, better results are obtained from early transplanting than late transplanting (Alim *et al.*, 1993; Hedayetullah *et al.*, 1994). Mildly photoperiod-sensitive cultivars had a reduced likelihood of encountering low temperature compared with photoperiod-insensitive cultivars. The benefits of photoperiod sensitivity include greater sowing flexibility and reduced water use as growth duration is shortened when sowing is delayed (Farrell *et al.*, 2006).

If photosensitive varieties are transplanted a little early, their vegetative growth extended which resulted more plant height and leafy growth. Due to increased plant height, such varieties lodge badly when transplanted early. As a result, the grain yield from such a crop is reduced drastically. On the other hand, when transplanting is delayed beyond normal period, the grain development is very poor which results in more quantity of under developed grains and ultimately severe reduction in yield (Kainth and Mehra, 1985). Flowering of rainfed lowland rice occurs within optimum time if sowing was conducted from May onwards up to the first week of August. However, sowing can be delayed up to the first week of August for rainfed lowland cultivars if there is any crop failure due to flooding at the beginning of the cropping season (Sarkar and Reddy, 2006).

The vegetative stage of rice may be extended due to low temperature (Vergara and Chang, 1985). In November planting of BR3 when the temperature was cool, the vegetative phase was extended by 50 days and the relative tillering rate reached its peak at 40 to 50 days after transplanting. In contrast with planting in July when the temperature was high, the relative tillering rate reached the highest value within 15 to 25 days after transplanting. In most cases, tillering rate decreases because of low temperature. So, appropriate planting time and the use of photoperiod-sensitive cultivars can be advantageous in a region in avoiding low temperature damage during reproductive development. Gohain and Saikia (1996) reported that earlier planting of high yielding varieties of rice around mid-July was the best. Late planting might have exposed the crop to relatively more adverse condition in terms of water stagnation at the tillering phase and low temperature at the reproductive phase which might have pulled down the yield compared to earlier planting.

In rice, the optimum leaf area index (LAI) at flowering and optimum crop growth rate (CGR) during panicle initiation has been identified as the major determinants of yield (Sun *et al.*, 1999). A combination of these growth variables explains variation in yield better than any individual growth variable (Gosh and Singh, 1998). Thakur and Patel (1998) reported that dry matter production, leaf area index, leaf area duration (LAD), crop growth rate (CGR), net assimilation rate (NAR) and relative growth rate (RGR) are ultimately reflected in higher grain yield of rice. Crop growth rate is the most critical growth attributes for rice yield under intensive management during the latter half of the reproductive period (Horie, 2001). The CGR at this stage critically affects final spikelet number by regulating spikelet degeneration, potential single-grain weight by determining husk size, and grain filling by forming active sinks and determining endosperm cell number at initial grain filling. Early plating of hybrid rice, exhibited the maximum total and effective tillers per hill, leaf-area index, leaf-area duration, dry-matter accumulation, relative growth rate, fertile spikelets per panicle, 1000 grains weight and straw yields (Nayak, *et al.,* 2003). Hundal *et al.* (2005) observed the significant linear and exponential relationships between leaf area index and aboveground biomass and yield of rice. Planting time had direct influenced on above attributes.

2.1.2 Yield parameters

Among the yield components grain size in rice is considered to be the most stable character (Matsushima, 1957). Little variation in single grain weight or grain size would further increase the grain yield potential of rice. Evidence suggests that increase in grain yield can be achieved through improvement of one or more than one of the yield components of rice.

Yield components like panicle per plant, grains per panicle and 1000 grain weight increase yield in modern varieties (Saha Ray *et al.*, 1993). Haque *et al.* (1991) reported negative association of 1000 grain weight and yield per plant in traditional varieties but positive association of yield per plant with number panicle per plant in modern varieties. Other reports revealed that number of panicles per hill, panicle length and 1000-grain weight were positively associated with grain yield of rice (Padmavathi *et al.*, 1996; Marwat *et al.*, 1994). Panwar *et al.* (1989) noticed that spikelet number was the main component character affecting the rice yield. Number of panicles per hill and number of spikelets per panicle had negative direct effects on grain yield (Padmavathi *et al.*, 1996). Surek *et al.* (1998) found that biological yield of rice had the highest direct effect on grain yield followed by harvest index and 1000 grain weight. Hossain and Haque (2003) stated that grains per panicle had the maximum positive direct effect on yield of rice followed by 1000 grain weight, panicle length and number of panicles per hill.

The highest grain yield was obtained from 15 July transplanting of rice. The highest grain yield was obtained due to cumulative effect of longer panicle, highest number of grains per panicle and 1000 grain weights (Salam *et al.*, 2004). Similar result was also reported by Rahman (2003). Islam *et al.* (2008) reported that direct wet-seeded rice produced 10% higher grain yield than transplanted rice and 31 December seeded rice produced the highest grain yield. Rice planted on 1 December significantly reduced the grains per panicle and January planted rice significantly reduced the panicle per unit area.

Different yield and yield parameters like number of tillers per hill, grains per panicle, 1000 grain weight and sterility were significantly affected by transplanting time. Basmati-385 and Super Basmati produced maximum paddy yield (5655 and 5612 kg/ha) when transplanted on July 1 and July 11, respectively. Minimum sterility was recorded in rice varieties 98901 (5.25%) and Super Basmati (5.08%) and maximum (13.08%) in PK 5261-1-2-1. Minimum sterility was observed in rice transplanted on July 21 followed by July 1, July 11 and July 31 (Akram *et al.*, 2004). Yield and spikelet sterility of rice in temperate

Kashmir was influenced by transplanting dates and nutrient management. Spikelet sterility was higher in rice transplanted on 30 June as compared with that on 15 June due to reduced growth phases and low temperature during reproductive phase. Further, increasing levels of N under delayed transplanted conditions increased spikelet sterility and reduced grain yield of rice (Singh *et al.*, 2005).

The higher the temperature and the longer the high temperature stress, the lower the pollen vigour and germination percentage, therefore, the less the seed setting rate and lower the yield (Zheng *et al.*, 2007). Two genotypes were grown at 30/24^{0}C day/night temperature in a greenhouse, in both genotypes one hour exposure to 33.7^{0}C at anthesis caused sterility. In IR64, spikelet fertility was reduced about 7% by per degree increase of temperature (Jagadish *et al.*, 2007). On the other hand, yield and quality of aromatic rice were superior when exposed to a lower temperature (day mean temperature 23^{0}C). Yield, filled grain rate, and number of filled grains per panicle reduced significantly under the highest temperature (day mean temperature 30^{0}C). The highest temperature also increased the chalkiness score, and reduced milled rice, head rice, amylose content, alkali value, eating and aroma scores, and gel consistency (Xu *et al.*, 2006).

Spikelet sterility of rice results from low temperatures during panicle development. However, this temperature alone cannot fully explain the fluctuations in sterility observed in the field, since the susceptibility of rice plants to low temperature often changes according to its physiological status during sensitive stages. Low water temperature (below 20^{0}C) during vegetative growth significantly increased the sterility. Low air temperature during vegetative growth also significantly increased the sterility, but this effect was diminished by warm water temperature even at low air temperature. There was a close and negative correlation between sterility and water temperature during vegetative growth (Shimono *et al.*, 2007). These results suggest that temperatures before panicle initiation change the susceptibility of a rice plant to low temperatures during panicle development which results in spikelets sterility.

Planting date had a major effect on grain yield. Grain yield at one location in southwest Louisiana was highest (8600 kg ha^{-1}) when rice was planted in late March, and grain yield (6500 kg ha^{-1}) decreased linearly as planting was delayed until early June (Linscombe *et al.*, 2004). Patel *et al.* (1987) also reported that grain yield of rice markedly declined with delayed planting.

2.2 Effect of nitrogen management

Among the factors that are responsible for growth, yield and yield contributing characters of rice, nitrogen management is very important for the production of modern varieties. Some information regarding effect of nitrogenous fertilizer and their application are reviewed under the following headings:

2.2.1 Growth parameters

Plant height

Mishra *et al.* (2000) carried out a field experiment in 1994-95 in Bhubaneswar, Orissa, India, and reported that rice cv. Lalate was given 76 kg N ha^{-1} as USG at 0, 7, 14 for 21 days after transplanting (DAT), and these treated control. N

0, 7, 14 for 21 days after transplanting (DAT), and these treated control. N increased plant height, panicle length, N up take and consequently the grain and straw yields of lowland rice.

Prasad *et al.* (1999) conducted an experiment on growth of rice plants as influenced by the method of seeding, seed rate and split application of nitrogen and reported that plants were generally tallest with N applied 25% at 15 days after sowing, 50% at active tillering and 25% at panicle initiation stages.

Vijaya and Subbaiah (1997) showed that plant height, number of tillers, number and weight of panicles, N and P uptake, dry matter and grain yield of rice increased with the increasing USG size and were greater with the deep placement method of application both N and P compared with broadcasting.

Sharma (1995) reported in an experiment that split application of nitrogenous fertilizer increased the plant height significantly compare to the basal nitrogen application.

Reddy *et al.* (1990) reported a significant effect of nitrogen on plant height in rice with 120 kg N ha^{-1} in three split dressings at tillering, panicle initiation and booting stages.

Wagh and Thorat (1988) observed that (30+30+10+10) kg N ha^{-1} applied at 4 days after transplanting, maximum tillering, primordial initiation and flowering, respectively produced the longest plant.

Singh and Singh (1986) reported that plant height increased significantly with the increase in the level of nitrogen from 27 to 87 kg ha^{-1}. Deep placement of USG resulted in the highest plant height than prilled urea (PU).

Singh and Singh (1986) worked with different levels of nitrogen as\USG, sulphur coated and PU @ 27, 54 and 84 kg ha^{-1}. They reported that number of tillers m^{-2} increased with increasing nitrogen fertilizer.

Akanda *et al.* (1986) at the Bangladesh Agricultural University, Mymensingh observed that applying nitrogen in three splits 20 kg at basal, 40 kg at active tillering and 20 kg at panicle initiation stage had no significant effect on plant height.

Akanda *et al.* (1986) found that the tallest plants were produced when 80 kg N ha^{-1} was applied in three splits (20 kg at basal, 40 kg at active tillering and 20 kg at maximum tillering).

Reddy *et al.* (1985) reported that 120 kg N ha^{-1} applied in three split dressings at transplanting (50%), tillering (25%) and panicle emergence stage (25%) gave longer plant in two equal split dressings at transplanting and tillering or in a single dressing at transplanting.

Number of tillers

Geethadevi *et al.* (2000) conducted an experiment with four splits application of nitrogen and found that higher number of tillers, filled grains $panicle^{-1}$ and higher grain weight $hill^{-1}$ for split application of nitrogenous fertilizer at 120 kg N ha^{-1}.

Islam *et al.* (1996) reported that number of effective tillers hill^{-1} increased with increasing nitrogen level upto 150 kg Nha^{-1} and split application was more effective compare to basal application during transplanting.

Shoo *et al.* (1989) reported that nitrogen application upto 120 kg ha^{-1} at transplanting or in two equal split dressing at transplanting and tillering stages increased the total number of tillers hill^{-1}.

Hussain *et al.* (1989) reported that 150 kg N ha^{-1} in split application increased the number of total tillers hill^{-1}. They also observed that nitrogen application date had significant effect on tiller production of aman rice.

Wagh and Thorat (1988) reported that 30+30+10+10 kg N ha^{-1} applied at 8 days after transplanting, maximum tillering, primordial initiation and flowering, respectively produced the highest number of tillers hill^{-1}.

Akanda *et al.* (1986) observed that application of nitrogen in three splits 20 kg at basal, 40 kg at active tillering and 20 kg at panicle initiation stage gave the highest number of total tillers hill^{-1}.

Reddy *et al.* (1985) reported that 120 kg N ha^{-1} applied in three split dressing at transplanting (50%), tillering (25%) and panicle emergence stage (25%) gave higher number of total tillers hill^{-1} than in two equal split dressings at transplanting and tillering or in a single dressing at transplanting.

Dry matter content

Xie *et al.* (2007) reported that increased split application of nitrogen from control to 140 kg 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 nitrogen by volatilization.

Singh and Modgal (2005) noted that dry-matter accumulation (DMA) and concentration and uptake of nitrogen increased with increasing level of nitrogen at all the stages of crop growth. Split application of nitrogen with its heavier fractions (1/3+1/3+1/3) at tillering and panicle initiation stages resulted in higher dry-matter accumulation, and higher nitrogen concentration of rice. They also noted that the rice plants accumulated nearly 15% of the total absorbed nitrogen, up to tillering, 50% up to panicle initiation and 85–90% up to heading.

Number of 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 effective tillers m^{-2}. Islam *et al.* (1996) reported that number of effective tillers hill^{-1} increased with increasing nitrogen level and split application was more effective compare to basal application during transplanting.

Shoo *et al.* (1989) reported that the number of effective tillers hill^{-1} was the highest with 150 kg N applied in 2-3 splits at tillering, panicle emergence and flowering stages.

Wagh and Thorat (1988) reported that nitrogen 30+30+10+10 kg N ha^{-1} applied at 8 days after transplanting, maximum tillering, primordial initiation and flowering, respectively produced the highest number of effective tillers $hill^{-1}$.

Akanda *et al.* (1986) observed that applying nitrogen in three splits 20 kg at basal, 40 kg at active tillering and 20 kg at panicle initiation stage gave the highest number of bearing tillers $hill^{-1}$.

Panicle length

Rao *et al.* (1997) showed that nitrogen application at 50 kg ha^{-1} at tillering, 25 kg ha^{-1} at panicle initiation and 25 kg ha^{-1} at booting stage produced the longest panicle.

Patel and Mishra (1994) carried out an experiment with rice cv. IR36 and was given 0, 30, 60 or 90 kg N ha^{-1} as Muossorie rock phosphate-coated urea, neem cake-coated urea, gypsum coated urea, USG or PU. The coated materials as incorporated before transplanting and USG as placed 5-10 deep a week after transplanting and urea as applied in 3 split doses. They showed that N rate had no significant effect on panicle lenght, percent sterility and harvest index.

Sen and Pandey (1990) reported that the application of USG or PU @ 38.32 kg N ha^{-1} gave higher yield than broadcast PU and there were no significant differences in panicle length.

Reddy *et al.* (1987) observed from an experiment that panicle length increased with 120 kg N ha^{-1} in three split at tillering, panicle initiation and booting stages.

Latchanna and Yogeswara (1977) reported that the longest panicle was obtained when N was applied in three split dressings 1/3 at planting, 1/3 at tillering and 1/3 at panicle initiation.

Number of grains

Faraji and Mirlohi (1998) reported that plant height, number of tillers per unit area and days to heading and maturity increased with the increase of rate of N fertilizer application at 60, 90, 120 or 150 kg N ha^{-1}, were given before transplanting or in 2 or 3 splits while grain yield and panicle number increased with up to 120 kg N ha^{-1} but decreased were decreased with increasing N.

Kapre *et al.* (1996) reported that USG has favourable effects on rice. They also observed from a study with 8 slow releasing fertilizers that grain yield, straw production, panicle $hill^{-1}$, grains $panicle^{-1}$ and 1000-grain weight increase significantly with USG and sulphur coated urea (SCU).

Surendra *et al.* (1995) conducted an experiment during rainy season with nitrogen level @ 0, 40, 80, 120 kg ha^{-1} and sources, of nitrogen, USG and urea dicyandiamide @ 80 kg ha-^{1}. They showed that USG and urea dicyandiamide produced more panicle $hill^{-1}$, filled grains $panicle^{-1}$, panicle weight and grain yield than PU @ 80 kg N ha^{-1}. Nassem et al. (1995) indicated that percent grains remained unchanged in response to different levels but a significantly lower 1000-grain weight was recorded in the control treatment than in the plots received nitrogen fertilizer.

Tantawi *et al.* (1991) stated that split application of nitrogen markedly increased yield and the highest yield obtained from the triple splits. They also observed that split application resulted in greater number of panicles, heavier grains and more grains panicle^{-1}.

Thakur (1991) reported that total spikelets panicle^{-1} was the highest when 40%, 30% and 20% nitrogen was applied as basal, at maximum tillering and panicle initiation stages, respectively.

Thakur (1991) studied the influence of levels, forms of urea and method of application of nitrogen in rice during *Kharif* season. He observed that yield attributes attributes and grain yield differed significantly due to the levels and sources of nitrogen applied. Placement of nitrogen at 60 kg ha^{-1} through USG produced the highest number of panicle unit^{-1}.

Kamal *et al.* (1991) conducted a field experiment in *Kharif:* season of 1985 and 1986 on rice cv. Joya with different forms of urea and level of nitrogen @ 29.58, 87 kg ha^{-1}. They reported that total tiller varied significantly due to forms in 1995, but during 1996 there was no significant variation. PU was significantly inferior to the other forms. The highest number of tillers was produced in treatment where USG was applied.

Rama *et al.* (1989) observed that the number of grains panicle^{-1} were significantly higher @ 40, 80 or 120 kg N ha^{-1} as USG applied as deep out a field trial to study the effect of placement of USG (5, 10 or 15 cm deep) and broadcast PU on rice yields of tall long duration Mashuri and dwarf, short duration Mashuri. They revealed that Mashuri had significantly higher yield, panicles m^{-2}, panicle length and weight, grains $panicle^{-1}$ and 1000-grain weight than Mashuri, probably due to Mashuri's long duration. All depths of USG placement resulted in higher yield characters than broadcast PU; however, differences except for panicle lengths were not significant.

Rama *et al.* (1989) mentioned form their earlier study that the Urea super granules (USG) significantly produced higher number grains $panicle^{-1}$ than split application of prilled urea.

Reddy *et al.* (1987) reported that total number of spikelets $panicle^{-1}$ increased with 120 kg with N ha^{-1} in three split dressings at tillering, panicle initiation and booting stages.

Akanda *et al.* (1986) observed that applying nitrogen in three splits 20 kg at basal, 40 kg at active tillering and 20 kg at panicle initiation stage gave the highest number of grains $panicle^{-1}$.

Weight of 1000 grains

Subhendu *et al.* (2003) conducted a field experiment during *kharif* season at Hyderabad, India. They found that the application of nitrogen (120 kg N ha^{-1}) as urea in equal splits during transplanting, tillering, panicle initiation and 50% flowering resulted in the highest 1000 grain weight (22.57 g).

Ali *et al.* (1992) reported from their earlier findings that 1000 grain weight was the highest when 100 kg N ha^{-1} was applied in three equal splits at basal, 30 and 60 days after transplanting.

At the Bangladesh Agricultural University, Mymensingh, Akanda *et al.* (1986) reported that the weight of 1000-grain was the highest when 80 kg N ha^{-1} was applied in three splits such as 20 kg ha^{-1} basal, 40 kg ha^{-1} at active tillering and 20 kg ha^{-1} at panicle initiation stages.

2.2.2 Yield parameters

Grain yield

Bowen *et al.* (2005) conducted 531 on-farm trials during the *Boro* and *aman* seasons in 7 districts of Bangladesh from 2000-2004. The results showed that UDP (Deep placement of urea super granule) increased grain yield by 1120 kg ha^{-1} and 890 kg ha-1 during the *Boro* season and *aman* season, respectively.

Miah *et al.* (2004) carried out an experiment with transplanted rice cv. BINA dhan4. They found that the values of the parameters of urea. Rahman (2003) worked out an experiment at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh, during the aman season with three levels of USG viz. one, two and three USG/4 hills providing 40, 80 and 120 kg N ha^{-1}. He found that two USG/4 hills produced the higher grain and straw yield (5.22 and 6.09 t ha^{-1}, respectively).

Ikeda *et al*. (2003) stated the efficiency of the non-split fertilizer application to the rice variety 'Koshihikari' was evaluated in order to dispense with top dressing and improve the recovery rate of fertilizer in pneumatic direct sowing culture of rice on a submerged paddy field in Aichi Prefecture, Japan. The fertilizer used in this study, which was a combination of a linear-type coated urea and a sigmoidal-type coated urea, was found effective in this cultivation system. Results also showed that nitrogen recovery rate, yield rate and quality were improved with this system. The accumulative nitrogen release rates of the combined fertilizer were 40% at panicle formation stage, 80% at heading stage and 95% at maturity stage. Furthermore, the nitrogen release pattern was adapted for the growth phase of this cultivation system.

Jaiswal and Singh (2001) conducted an experiment with USG and PU both at 60 and 120 kg ha-1 under different planting methods. They found that transplanting method with urea super granules proved to be the best for maximum grain yield (4.53 t ha^{-1}).

Angayarkanni and Ravichandran (2001) conducted a field experiment at Tamill Naru from July to October, 1997 and found that split application of nitrogen for rice cv. IR20, treatment applying 16.66% of the recommended N as basal, followed by 33.33% N at 10 DAT, 25% N at 20 DAT and 25% N at 40 DAT recorded the highest grain yield e.g. 6189.4 kg ha^{-1}.

Ehsanullah *et al.* (2001) when work with split application of nitrogenous fertilizer and reported that nitrogen as split application at different growth stages significantly affected grain yield.

Ahmed *et al.* (2000) revealed that USG was more efficient than PU at all respective levels of nitrogen in producing all yield components and in turn, grain and straw yields. Placement of USG @ 160 kg N ha^{-1} produced the highest grain yield (4.32 t ha^{-1}) which was statistically identical to that obtained from 120 kg N ha^{-1} as USG and significantly superior to that obtained from any other level and source of nitrogen.

Geethadevi *et al.* (2000) showed that four split applications of 150 kg Nha^{-1} nitrogen in KRH-1 recorded the maximum yield, as well as increased growth and yield components.

Suerkha *et al.* (1999) found that N application in four equal splits, the last at flowering improved the grain yield as well as nutrient uptake.

Asif *et al.* (1999) noticed that application of 60 : 67 : 67 or 180 : 90 : 90 kg NPK ha^{-1}, with N at transplanting and early tillering or a third each at transplanting, early tillering and panicle initiation resulted in higher grain yield with the higher NPK rates. Split application of N gave higher yields than a single application.

Thakur and Patel (1998) reported that the highest grain yield (3.84 t ha^{-1}) was recorded with the application of 80 kg N ha^{-1} in three split rates with 5 t FYM ha^{-1} and 60 kg N ha^{-1} in three split rates with 5 t FYM gave 3.81 t ha^{-1}.

Islam *et al.* (1996) reported that grain yield was increased with increasing nitrogen level and split application was more effective compare to basal application during transplanting.

Vaiyapuri *et al.* (1995) stated that application of 100 kg N ha^{-1} in three splits 25% basal + 50% tillering stage +25% panicle initiation gave the highest yield (5.88 t ha^{-1}).

Panda and Mphanty (1995) observed that grain yield was the highest with 60 $kgha^{-1}$ applied 30 kg at transplanting and 15 kg each at 21 and 75 days after transplanting.

Das and Singh (1994) reported that grain yield and N use efficiency by rice were greater for deep placed USG than for USG broadcast and incorporated or three split applications of PU.

Chaudhary *et al.* (1994) reported that Basmati rice gave the highest grain yield when fertilized with 124 kg N ha^{-1} in three equal split dressings at transplanting, 20-25 days after transplanting and 40-45 days after transplanting.

Channabasavanan and Setty (1994) found that rice yield was the highest when N was applied in different splits between sowing, tillering, panicle initiation and panicle emergence.

Avasthe *et al.* (1993) reported that the highest grain yield of 5.64 t ha^{-1} was obtained when N was applied in two equal split at transplanting and 7 days before panicle initiation or half of the N at transplanting + ¼ at late tillering + ¼ at panicle initiation.

Rabinson (1992) reported that among 12 different split application treatments, grain yield ranged 4.2-5.9 t ha^{-1} and was the highest with application of three equal splits (Basal application, panicle initiation stages and heading stages).

Nair and Gautam (1992) found that grain yield was higher when 60 kg N was applied at initiation, or 50% at transplanting + at tillering + 25% at panicle initiation stages than when all was applied at transplanting or at tillering.

Mongia (1992) reported that grain yield was the highest with 60 kg N ha^{-1} with the application in three split application (50% basal + 25% at flowering + 25% at the flag leaf stage).

Roy and Peterson (1990) reported that application of 40 to 50 percent N at ten days after transplanting, 25-30% at 21 days after transplanting and the rest at the panicle initiation stage were desirable.

Wagh and Thorat (1988) observed that N application date had significant effect on grain yields. Nitrogen application as 30+30+10 kg N ha^{-1} applied at 8 days after transplanting, maximum tillering, primordial initiation and flowering, respectively, produced the highest grain yield.

Park and Lee (1988) reported that brown rice yield of cv. Seomginbyeo increased significantly with up to 100 kg N and was the highest with 20% of N applied 25 days before heading.

Kim *et al.* (1987) stated that the highest rice grain yield was obtained from a basal application of 30 kg N ha^{-1}, three top dressing 32 and 15 days before heading and a final topdressing of 10 kg N ha^{-1} 10 days after heading.

Khander *et al.* (1987) stated that 90 kg N ha^{-1} as application in two split dressing and in a single dressing at transplanting gave yields of 5.47, 5.19 and 4.16 t ha^{-1}, respectively.

Paturde and Rahate (1986) observed that significant increase in grain yield of rice was obtained due to split application of N as 40 kg N ha^{-1} at transplanting, 20 kg N ha^{-1} at panicle initiation and 20 kg N ha^{-1} at the heading stage.

Straw yield

Subhendu *et al.* (2003) conducted a field experiment during *kharif* season at Hyderabad, India. They found that the application of nitrogen (120 kg Nha^{-1}) as urea in equal split during transplanting, tillering, panicle initiation and 50% flowering resulted straw yield is 5322 kg kg ha^{-1}.

Ehsanullah *et al.* (2001) conducted an experiment with application of nitrogenous fertilizer as split at different growth stages and reported that split application significantly affected straw yield.

Hussain *et al.* (1989) stated from their study that straw yield was increased with split application of nitrogenous fertilizer in rice filed compare to basal application of nitrogen.

Salam *et al.* (1988) reported that straw yield was the highest with split application of nitrogen and also application of nitrogen at tillering stage it was more effective than basal application.

Paturde and Rahate (1986) reported that straw yield was the highest due to N application in split, the rates of 40 kg N ha^{-1} at transplanting, 20 kg N ha^{-1} at panicle initiation and 20 kg ha^{-1} at heading stage.

Harvest index

Mondal and Swamy (2003) found that application N (120 kg ha^{-1}) as urea in equal split during transplanting, tillering, panicle initiation and flowering resulted in the highest number of panicles, number of filled grain $panicle^{-1}$,1000-grain weight, straw yield and harvest index.

From the above presentation of the review of literatures it may be said that rates of nitrogen fertilizer have decisive influence on the crop performance of rice. The above review suggested that a considerable amount of work is still to be carried out in order to evaluate the effect of nitrogen Management on performance of rice.

Chapter III
Materials and Methods

3.1.3 Climate

The geographical location of the experimental site was under the subtropical climate, characterized by three distinct seasons, winter season from November to February and the pre-monsoon period or hot season from March to April and monsoon period from May to October (Edris *et al.*, 1979). Details of the meteorological data of air temperature, relative humidity, rainfall and sunshine hour during the period of the experiment was collected from the Weather Station of Bangladesh, Sher-e Bangla Nagar, Dhaka and has been presented in Appendix II.

3.2 Test crop and its characteristics

BRRI dhan45 was used as the test crop in this experiment. This variety was developed at the Bangladesh Rice Research Institute (BRRI),Gazipur. It is recommended for *Boro* season (November to February). Average plant height of the variety is 100 cm at the ripening stage. The grains are medium fine and white. It requires about 145 days in an average for completing its life cycle with an average grain yield of 6.5 t ha^{-1} (BRRI, 2010).

3.3 Experimental details

3.3.1 Treatments

The experiment comprised of two factors.

Factor A: Transplanting date: 3 dates

T_1– Transplanting at 15 December 2008

T_2– Transplanting at 30 December 2008

T_3– Transplanting at 15 January 2009

Factor B: Nitrogen level: 4 levels

N_0–0kg N ha^{-1} (control)

N_1–80 kg N ha^{-1}

N_2–100 kg N ha^{-1}

N_3–120 kg N ha^{-1}

As such there were 12 treatments combinations viz. T_1N_0, T_1N_1, T_1N_2, T_1N_3, T_2N_0, T_2N_1, T_2N_2, T_2N_3, T_3N_0, T_3N_1, T_3N_2 and T_3N_3.

3.3.2 Experimental design and layout

The experiment was laid out in two factors Randomized Complete Block Design with three replications. The layout of the experiment was prepared for distributing the combination of date of transplanting and level of nitrogen. Thus, there were 36 unit plots each of 4 m × 3 m size. The 12 treatments of the experiment was assigned at random in 12 plots of each block, representing a replication (Figure 1).

3.4 Growing of crops

3.4.1 Raising seedlings

3.4.1.1 Seed collection

The seeds of the test crop i.e. BRRI dhan45 were collected from Bangladesh Rice Research Institute (BRRI), Joydevpur, Gazipur.

3.4.1.2 Seed sprouting

Healthy seeds were selected by specific gravity method, The seeds were immersed in water bucket for 24 hours and then they were kept tightly in gunny bags after taking the bucket. The seeds started sprouting after 48 hours and were sown after 72 hours.

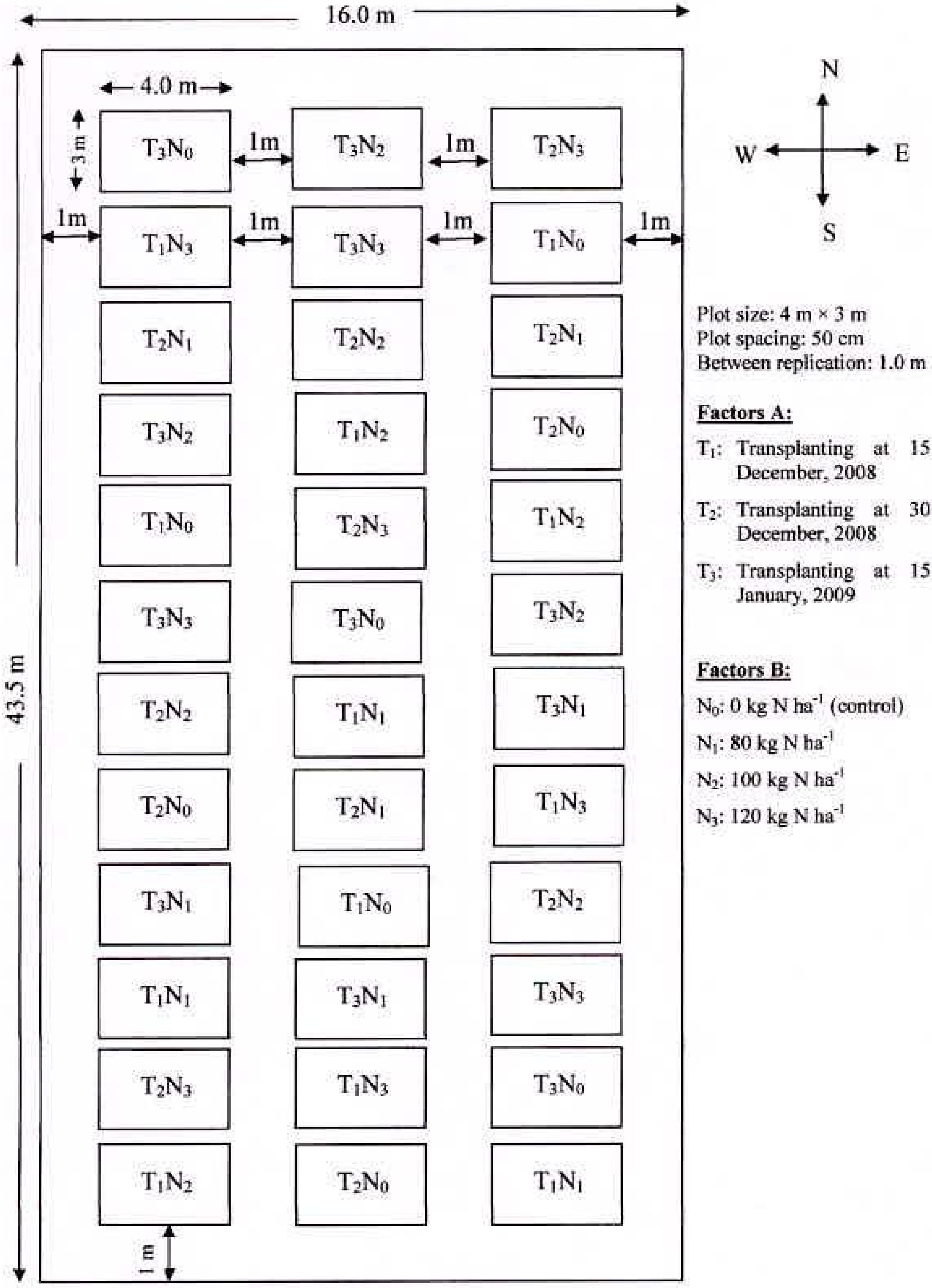


Figure 1. Layout of the experimental plot

3.4.1.3 Preparation of seedling nursery bed and seed sowing

As per BRRI recommendation seedbed was prepared with 1 m wide adding nutrients as per the requirements of soil. Seeds were sown in the seed bed on November 10, 2008, November 25, 2008 and December 10, 2008 in order to transplant the seedlings in the main field.

3.4.2 Preparation of the main field

The plot selected for the experiment was opened in the first week of December 2008 with a power tiller, and was exposed to the sun for a week, after which the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain a good tilth. Weeds and stubble were removed, and finally obtained a desirable tilth of soil for transplanting of seedlings.

3.4.3 Fertilizers and manure application

The fertilizers N, P, K, S and B in the form of urea, TSP, MP, Gypsum and borax, respectively were applied. The entire amount of TSP, MP, Gypsum, Zinc sulphate and borax were applied during the final preparation of land. Urea was top dressed in two equal installments at tillering and panicle initiation stage. The dose and method of application of fertilizers are shown in Table 1.

Table 1. Dose and method of application of fertilizers in rice field

Fertilizers	Dose (kg/ha)	Application (%)		
		Basal	1st installment	2nd installment
Urea	As per treatment	--	50	50
TSP	100	100	--	--
MP	100	100	--	--
Gypsum	60	100	--	--
Borax	10	100	--	--

Source: Adunik Dhaner Chash, 2010, BRRI, Joydevpur, Gazipur

3.4.4 Uprooting of seedlings

The nursery bed was made wet by application of water one day before uprooting of the seedlings. The seedlings were uprooted on December 14, 2008, December, 29, 2008 and January 14, 2009 for transplant on the date of 15 December, 2008, 30 December, 2008 and 15 January, 2009 without causing much mechanical injury to the roots.

3.4.5 Transplanting of seedlings in the field

On the scheduled dates as per experiment the rice seedlings were transplanted in lines each having a line to line distance of 30 cm and plant to plant distance 25 cm in the well prepared plots.

3.4.6 After care

After establishment of seedlings, various intercultural operations were accomplished for better growth and development of the rice seedlings.

3.4.6.1 Irrigation and drainage

Flood irrigation was provided to maintain a constant level of standing water upto 6 cm in the early stages to enhance tillering and 10-12 cm in the later stage to discourage late tillering and weed growth. The field was finally dried out at 15 days before harvesting.

3.4.6.2 Gap filling

First gap filling was done for all of the plots at 10 days after transplanting (DAT) by planting same aged seedlings.

3.4.6.3 Weeding

Weedings were done to keep the plots free from weeds, which ultimately ensured better growth and development. The newly emerged weeds were uprooted carefully at tillering stage and at panicle initiation stage by mechanical means.

3.4.6.4 Top dressing

After basal dose, the remaining doses of urea were top-dressed in 2 equal installments and were applied on both sides of seedlings rows in the soil.

3.4.6.5 Plant protection

Furadan 57 EC was applied at the time of final land preparation and later on other insecticides were applied as and when necessary.

3.5 Harvesting, threshing and cleaning

The rice was harvested depending upon the maturity of plant and harvesting was done manually from each plot. The harvested plants of each plot was bundled separately, properly tagged and brought to threshing floor. Enough care was taken during harvesting, threshing and cleaning of rice seed. Fresh weight of grain and straw were recorded plot wise. The grains were cleaned and finally the weight was adjusted to a moisture content of 14%. The straw was sun dried and the yields of grain and straw $plot^{-1}$ were recorded and converted to t ha^{-1}.

3.6 Data recording

3.6.1 Plant height

The height of plant was recorded in centimeter (cm) at the time of 30, 50, 70, 90 DAT (Days after transplanting) and at harvest. Data were recorded as the average of 5 plants selected at random from the inner rows of each plot. The height was measured from the ground level to the tip of the tiller.

3.6.2 Number of tillers hill^{-1}

The number of tillers hill^{-1} was estimated at 30, 50, 70 and 90 DAT by counting total tillers per hill. Data were recorded as the average of 5 hills selected at random from the inner rows of each plot.

3.6.3 Dry matter plant^{-1}

Total dry matter plant^{-1} was estimated at of 30, 50, 70, 90 DAT and at harvest after oven drying of sample plants. Data were recorded as the average of 3 sample hill^{-1} selected at random from the inner rows of each plot and expressed in gram.

3.6.4 Effective tillers hill^{-1}

The total number of effective tiller hill^{-1} was counted as the number of panicle bearing tiller hill^{-1}. Data on effective tiller hill^{-1} were counted from 5 selected hills at harvest and average value was recorded.

3.6.5 Non-effective tillers hill^{-1}

The total number of non effective tillers hill^{-1} was counted as the number of non panicle bearing tillers plant^{-1}. Data on non effective tiller hill^{-1} were counted from 5 selected hills at harvest and average value was recorded.

3.6.6 Total tillers hill^{-1}

The total tillers hill^{-1} was calculated by adding effective and non-effective tillers hill^{-1} and average value was recorded.

3.6.7 Length of panicle

The length of panicle was measured with a meter scale from 10 selected panicles and the average value was recorded.

3.6.8 Filled grain panicle^{-1}

The total number of filled grains was collected randomly from selected 5 plants of a plot on the basis of grain in the spikelet and then average number of filled grains panicle^{-1} was recorded.

3.6.9 Unfilled grains panicle^{-1}

The total number of unfilled grains was collected randomly from selected 5 plants of a plot on the basis of no grain in the spikelet and then average number of unfilled grains panicle^{-1} was recorded.

3.6.10 Total grains panicle^{-1}

The total number of grains was calculated by adding filled and unfilled grains and then average number of grains panicle^{-1} was recorded.

3.6.11 Weight of 1000 seeds

One thousand seeds were counted randomly from the total cleaned harvested seeds of each individual plot and then weighed in grams and recorded.

3.6.12 Grain yield

Grains obtained from each unit plot were sun-dried and weighed carefully. The dry weight of grains of central 1 m^2 area and five sample plants were added to the respective grain yield m^{-2} and converted to t ha^{-1}.

3.6.13 Straw yield

Straw obtained from each unit plot were sun-dried and weighed carefully. The dry weight of straw of central 1 m^2 area and five sample plants were added to the respective straw yield m^{-2} and finally converted to t ha^{-1}.

3.6.14 Biological yield

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

Biological yield = Grain yield + Straw yield.

3.6.15 Harvest index

Harvest index was calculated from the grain and straw yield of rice for each plot and expressed in percentage.

$$HI = \frac{\text{Economic yield (grain weight)}}{\text{Biological yield (Total dry weight)}} \times 100$$

3.7 Statistical Analysis

The data obtained for different characters were statistically analyzed to observe the significant difference among the treatment means. The mean values of all the characters were calculated and analysis of variance was performed. The significant difference among the treatments means was estimated by the Duncan's Multiple Range Difference (DMRT) test at 5% level of probability (Gomez and Gomez, 1984).

Chapter IV
Results and Discussion

CHAPTER IV

RESULTS AND DISCUSSION

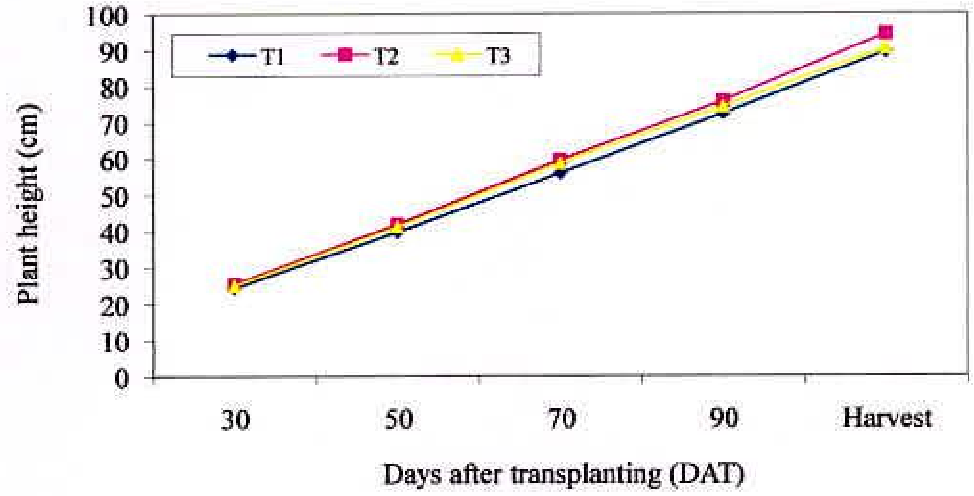
The experiment was conducted to evaluate the effect of planting dates and nitrogen doses on the growth and yield of *Boro* rice CV. BRRI dhan45. Data on different growth parameters, yield attributes and yield were recorded. The analyses of variance (ANOVA) of the data on different parameters are presented in Appendix IV-IX. The results have been presented in the Tables 2-11 and Figures 2-14 and possible interpretations have been given under the following headings:

4.1 Plant height

Plant height of BRRI dhan45 showed statistically significant differences at 30, 50, 70 and 90 DAT and at harvest due to the different planting dates (Appendix IV). At 30 DAT, the tallest plant was recorded from T_2 (25.59 cm) treatment (transplanting at 30 December, 2008) which was statistically identical with T_3 (25.04 cm) (transplanting at 15 January, 2009), while the shortest plant was observed from T_1 (24.42 cm) (transplanting at 15 December, 2008). The tallest plant was found from T_2 (41.88 cm) which was statistically identical with T_3 (41.20 cm) and the shortest plant from the treatment T_1 (39.75 cm) at 50 DAT. At 70 DAT, the tallest plant was observed from T_2 (59.58 cm) which was statistically identical with T_3 (58.69 cm), again the shortest plant was observed from T_1 (55.94 cm). The tallest plant was recorded from T_2 (75.75 cm) which was statistically identical with T_3 (74.29 cm) and the shortest plant was observed from T_1 (72.35

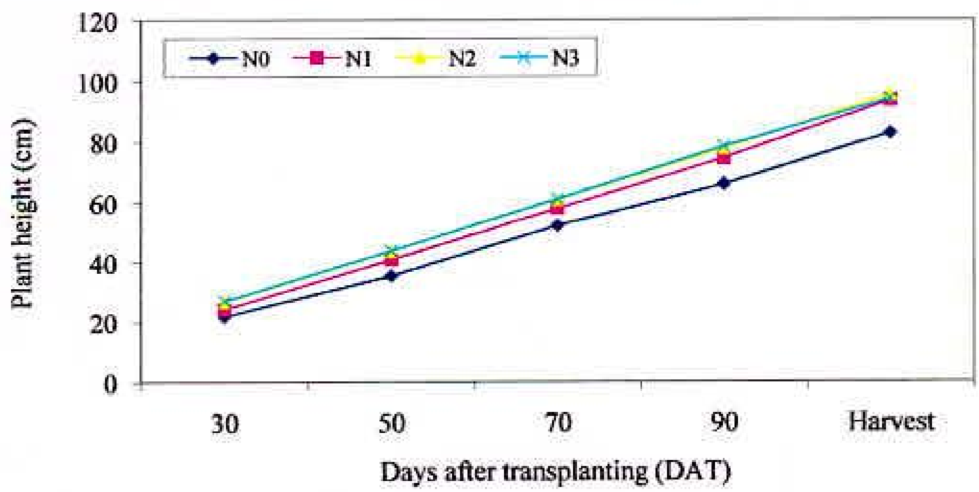
which was closely followed by T_3 (90.44 cm), while the shortest plant was found from T_1 (89.48 cm) (Figure 2). Probably delayed planted crop prevailed lesser time in favourable growing environment which might have shorten the plant height of the variety. This result is in agreement with that of Mejos and Pava (1980) who reported that plant height reduced with delayed transplanting of rice.

Different nitrogen levels showed significant differences on plant height of BRRI dhan45 at 30, 50, 70 and 90 DAT and at harvest (Appendix IV). At 30 DAT, the tallest plant was observed from N_3 (27.09 cm) (120 kg N ha^{-1}) which was statistically identical with N_2 (26.73 cm) (100 kg N ha^{-1}) and followed by N_1 (24.27 cm) (80 kg N ha^{-1}), again the shortest plant was recorded from N_0 (21.98 cm) (0 kg N ha^{-1}). The tallest plant was found from N_3 (43.84 cm) which was statistically identical with N_2 (43.63 cm) and followed by N_1 (40.80 cm), while the shortest plant was obtained from N_0 (35.49 cm) at 50 DAT. At 70 DAT, the tallest plant was found from N_3 (61.21 cm) which was statistically identical with N_2 (60.94 cm) and followed by N_1 (57.90 cm), whereas the shortest plant was recorded from N_0 (52.23 cm). The tallest plant was observed from N_3 (78.38 cm) which was statistically identical with N_2 (77.67 cm) and followed by N_1 (74.48 cm), again the shortest plant from N_0 (66.00 cm) at 90 DAT. At harvest, the tallest plant was recorded from N_2 (95.36 cm) which was closely followed by N_3 (94.10 cm) and N_1 (93.46 cm) and the shortest plant from N_0 (82.72 cm) (Figure 3). Reddy *et al.* (1990) reported a significant effect of nitrogen on plant height in rice with 120 kg N ha^{-1} and 120 kg N ha^{-1} applied gave taller plant.



T_1: Transplanting at 15 December, 2008
T_2: Transplanting at 30 December, 2008
T_3: Transplanting at 15 January, 2009

Figure 2. Effect of planting dates on plant height of BRRI dhan45



N_0: 0 kg N ha^{-1} N_1: 80 kg N ha^{-1}
N_2: 100 kg N ha^{-1} N_3: 120 kg N ha^{-1}

Figure 3.Effect of levels of nitrogen on plant height of BRRI dhan45

Plate 1. Photograph showing experimental *Boro* rice

Interaction effect of planting dates and nitrogen showed significant differences for plant height of BRRI dhan45 at 30, 50, 70 and 90 DAT and at harvest (Appendix IV). At 30 DAT, the tallest plant was found from the treatment combination of T_2N_3 (28.17 cm) (transplanting at 30 December, 2008 × 120 kg N ha^{-1}), again the shortest was observed from the treatment combination of T_1N_0 (21.00 cm) (transplanting at 15 December, 2008 × 0 kg N ha^{-1}). The tallest plant was recorded from the treatment combination of T_2N_3 (45.47 cm), while the shortest was found from the treatment combination of T_1N_0 (33.80 cm) at 50 DAT. At 70 DAT, the tallest plant was obtained from the treatment combination of T_2N_3 (63.77 cm) and the shortest plant was recorded from the treatment combination of T_1N_0 (49.97 cm). The tallest plant was found from the treatment combination of T_2N_3 (82.33 cm), while the shortest was observed from the treatment combination of T_1N_0 (64.60 cm) at 90 DAT. At harvest, the tallest plant was obtained from the treatment combination of T_2N_2 (98.87 cm) whereas the shortest was recorded from the treatment combination of T_1N_0 (80.87 cm) (Table 2).

4.2 Number of tillers hill^{-1}

Statistically significant variation was recorded for number of tillers hill^{-1} of BRRI dhan45 at 30, 50, 70 and 90 DAT due to the different planting dates (Appendix V). At 30 DAT, the maximum number of tillers hill^{-1} was obtained from T_2 (5.19) (transplanting at 30 December, 2008) which was closely followed by T_3 (4.71) (transplanting at 15 January, 2009), while the minimum number was recorded from T_1 (4.39) (transplanting at 15 December, 2008). The maximum number of tillers hill^{-1} was obtained from T_2 (9.09) which was closely followed by T_3 (8.03)

Table 2. Interaction effect of planting dates and nitrogen doses on plant height of *Boro* rice CV. BRRI dhan45

Treatment	Plant height (cm) at				
	30 DAT	50 DAT	70 DAT	90 DAT	Harvest
T_1N_0	21.00 e	33.80 g	49.97 f	64.60 f	80.87 g
T_1N_1	23.73 c	39.70 e	55.53 e	72.83 e	91.13 e
T_1N_2	26.87 ab	43.13 bc	59.03 cd	77.43 bc	92.87 d
T_1N_3	26.07 b	42.37 bcd	59.23 cd	74.53 cde	93.07 cd
T_2N_0	21.80 de	35.73 f	52.20 f	67.27 f	85.80 f
T_2N_1	25.53 b	42.07 cd	59.80 cd	76.50 bcd	96.00 b
T_2N_2	26.87 ab	44.23 ab	62.57 ab	76.90 bcd	98.87 a
T_2N_3	28.17 a	45.47 a	63.77 a	82.33 a	96.53 b
T_3N_0	23.13 cd	36.93 f	54.53 e	66.13 f	81.50 g
T_3N_1	23.53 c	40.63 de	58.37 d	74.10 de	93.23 cd
T_3N_2	26.47 b	43.53 abc	61.23 bc	78.67 b	94.33 c
T_3N_3	27.03 ab	43.70 abc	60.63 bcd	78.27 b	92.70 d
$LSD_{(0.05)}$	1.511	1.794	2.252	3.013	1.312
Level of significance	*	*	*	*	*
CV(%)	7.57	9.59	12.29	10.40	6.85

*: Significant at 0.05 level of probability

In a column mean values having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly at 0.05 level of significance

T_1: Transplanting at 15 December, 2008

T_2: Transplanting at 30 December, 2008

T_3: Transplanting at 15 January, 2009

N_0: 0 kg ha^{-1} (control)

N_1: 80 kg ha^{-1}

N_2: 100 kg ha^{-1}

N_3: 120 kg ha^{-1}

and the minimum number was found from T_1 (7.65) at 50 DAT. At 70 DAT, the maximum number of tillers hill^{-1} was recorded from T_2 (15.88) which was closely followed by T_3 (14.08), again the minimum number was found from T_1 (13.18). The maximum number of tillers hill^{-1} was recorded from T_2 (17.83) which was closely followed by T_3 (16.13) and the minimum number was recorded from T_1 (15.32) at 90 DAT (Table 3). The number of tiller per hill decreased rationally irrespective of all transplanting times after peak as tiller survival was negatively correlated to the maximum tiller number (Schnier *et al.*, 1990) and mutual shading of the crop (Tanaka *et al.*, 1966). Vergara and Chang (1985) reported that in November planting of BR3 when the temperature was cool, the vegetative phase was extended by 50 days and the relative tillering rate reached its peak at 40 to 50 days after transplanting. In contrast with planting in July when the temperature was high, the relative tillering rate reached the highest value within 15 to 25 days after transplanting.

Number of tillers hill^{-1} of BRRI dhan45 showed significant differences on at 30, 50, 70 and 90 DAT due to different nitrogen levels (Appendix V). At 30 DAT, the maximum number of tillers hill^{-1} was found from N_3 (5.63) (120 kg N ha^{-1}) which was statistically identical with N_2 (5.42) (100 kg N ha^{-1}) and followed by N_1 (4.60) (80 kg N ha^{-1}), while the minimum number was obtained from N_0 (3.40) (0 kg N ha^{-1}). The maximum number of tillers hill^{-1} was found from N_3 (9.94) which was closely followed by N_2 (9.29), again the minimum number was found from N_0 (5.83) which was closely followed by N_1 (7.97) at 50 DAT. At 70 DAT, maximum number of tillers hill^{-1} was recorded from N_3 (17.69) which was closely followed by N_2 (16.79), whereas the minimum number was found from N_0 (9.60) which was followed by N_1 (13.46). At 90 DAT, the maximum number of tillers hill^{-1} was recorded from N_3 (19.02) which was closely followed by N_2 (18.04) and again the minimum number was observed from N_0 (12.48) which was closely followed by N_1 (16.18) (Table 3). Islam *et al.* (1996) reported that number of effective tillers hill^{-1} increased with increasing nitrogen level upto 150 kg Nha^{-1}.

Significant variation was recorded for number of tillers hill^{-1}of BRRI dhan45 at 30, 50, 70 and 90 DAT due to interaction effect of planting date and nitrogen (Appendix V). At 30 DAT, the maximum number of tillers hill^{-1} was recorded from the treatment combination of T_2N_3 (6.37) (transplanting at 30 December, 2008 × 120 kg N ha^{-1}), again the minimum number was obtained from the treatment combination of T_1N_0 (3.17) (transplanting at 15 December, 2008 × 0 kg N ha^{-1}). The maximum number of tillers hill^{-1} was found from the treatment combination of T_2N_3 (11.00) and the minimum number was found from the treatment combination of T_1N_0 (5.20) at 50 DAT. At 70 DAT, the maximum number of tillers hill^{-1} was observed from the treatment combination of T_2N_3 (19.57) and the minimum number was found from the treatment combination of T_1N_0 (8.67). The maximum number of tillers hill^{-1} was obtained from the treatment combination of T_2N_3 (20.97), whereas the minimum number was recorded from the treatment combination of T_1N_0 (11.93) at 90 DAT (Table 4).

Table 3. Effect of planting dates and nitrogen doses on number of tiller hill^{-1} of *Boro* rice CV. BRRI dhan45

Treatment	Number of tiller hill^{-1} at			
	30 DAT	50 DAT	70 DAT	90 DAT
Planting date				
T_1	4.39 c	7.65 c	13.18 c	15.32 c
T_2	5.19 a	9.09 a	15.88 a	17.83 a
T_3	4.71 b	8.03 b	14.08 b	16.13 b
$LSD_{(0.05)}$	0.199	0.229	0.517	0.709
Level of significance	**	**	**	**
Levels of nitrogen				
N_0	3.40 c	5.83 d	9.60 d	12.48 d
N_1	4.60 b	7.97 c	13.46 c	16.18 c
N_2	5.42 a	9.29 b	16.79 b	18.04 b
N_3	5.63 a	9.94 a	17.69 a	19.02 a
$LSD_{(0.05)}$	0.229	0.264	0.597	0.819
Level of significance	**	**	**	**
CV(%)	14.94	13.28	8.24	5.10

**: Significant at 0.01 level of probability;

In a column mean values having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly at 0.05 level of significance

T_1: Transplanting at 15 December, 2008

T_2: Transplanting at 30 December, 2008

T_3: Transplanting at 15 January, 2009

N_0: 0 kg ha^{-1} (control)

N_1: 80 kg ha^{-1}

N_2: 100 kg ha^{-1}

N_3: 120 kg ha^{-1}

Table 4. Interaction effect of planting dates and nitrogen doses on number of tiller hill^{-1} of *Boro* rice CV. BRRI dhan45

Treatment	Number of tiller hill^{-1} at			
	30 DAT	50 DAT	70 DAT	90 DAT
T_1N_0	3.17 g	5.20 h	8.67 h	11.93 f
T_1N_1	4.13 e	7.13 f	11.57 f	14.53 e
T_1N_2	5.17 c	8.80 d	16.30 cd	17.13 cd
T_1N_3	5.10 c	9.47 c	16.20 cd	17.70 c
T_2N_0	3.43 fg	6.30 g	10.47 g	12.57 f
T_2N_1	5.10 c	8.87 d	15.67 d	18.13 c
T_2N_2	5.87 b	10.20 b	17.83 b	19.67 ab
T_2N_3	6.37 a	11.00 a	19.57 a	20.97 a
T_3N_0	3.60 f	6.00 g	9.67 gh	12.93 f
T_3N_1	4.57 d	7.90 e	13.13 e	15.87 de
T_3N_2	5.23 c	8.87 d	16.23 cd	17.33 cd
T_3N_3	5.43 c	9.37 c	17.30 bc	18.40 bc
$LSD_{(0.05)}$	0.397	0.458	1.034	1.419
Level of significance	**	**	**	*
CV(%)	14.94	13.28	8.24	5.10

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

In a column mean values having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly at 0.05 level of significance

T_1: Transplanting at 15 December, 2008

T_2: Transplanting at 30 December, 2008

T_3: Transplanting at 15 January, 2009

N_0: 0 kg ha^{-1} (control)

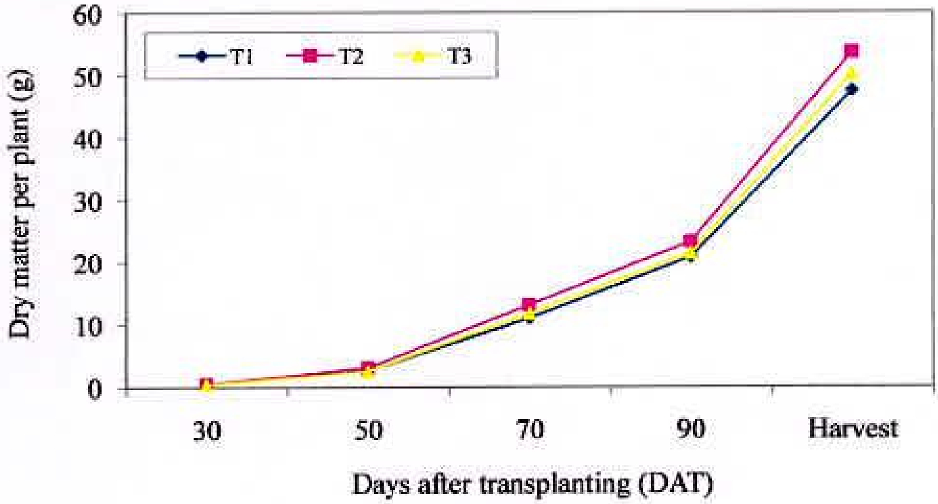
N_1: 80 kg ha^{-1}

N_2: 100 kg ha^{-1}

N_3: 120 kg ha^{-1}

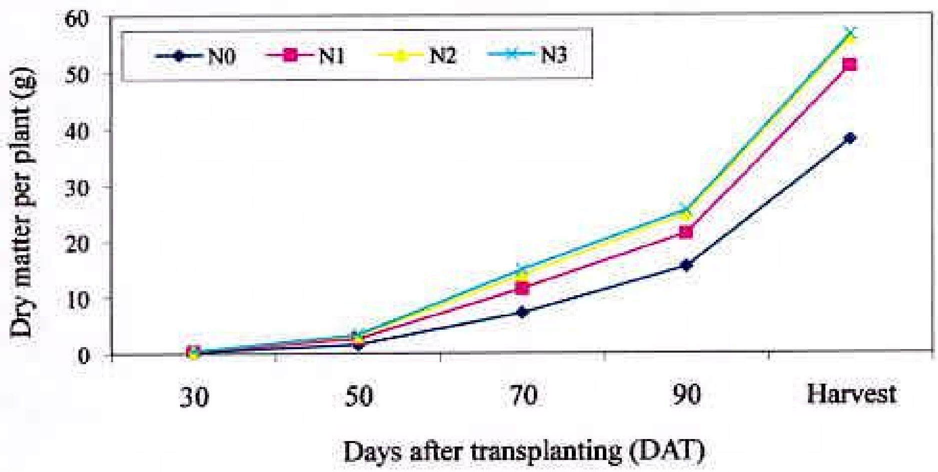
4.3 Dry matter plant^{-1}

Different planting dates showed statistically significant differences for dry matter plant^{-1} of BRRI dhan45 at 30, 50, 70 and 90 DAT and at harvest (Appendix VI). At 30 DAT, the highest dry matter plant^{-1} was recorded from T_2 (0.498 g) (transplanting at 30 December, 2008) which was closely followed by T_3 (0.424 g) (transplanting at 15 January, 2009), whereas the lowest was observed from T_1 (0.410 g) (transplanting at 15 December, 2008). The highest dry matter plant^{-1} was found from T_2 (3.08 g) which was closely followed by T_1 (2.55 g), while the lowest was recorded from T_3 (2.50 g) at 50 DAT. At 70 DAT, the highest dry matter plant^{-1} was found from T_2 (13.07 g) which was closely followed by T_3 (11.69 g), again the lowest was observed from T_1 (10.99 g). The highest dry matter plant^{-1} was obtained from T_2 (23.18 g) which was closely followed by T_3 (21.36 g), whereas the lowest was recorded from T_1 (20.74 g) at 90 DAT. At harvest, the highest dry matter plant^{-1} was found from T_2 (53.58 g) which was closely followed by T_3 (50.03 g), while the lowest was obtained from T_1 (47.46 g) (Figure 4). Late planting might have exposed the crop to relatively more adverse growing environment including low temperature at reproductive phase which might pulled down the dry matter accumulation compared to those of earlier plantings (Gohain and Saikia, 1996). Hundal *et al.* (2005) observed the significant linear and exponential relationships between aboveground biomass and yield of rice and planting time had direct influence on above attributes.



T_1: Transplanting at 15 December, 2008
T_2: Transplanting at 30 December, 2008
T_3: Transplanting at 15 January, 2009

Figure 4. Effect of planting dates on dry matter per plant of BRRI dhan45



N_0: 0 kg N ha^{-1}
N_1: 80 kg N ha^{-1}
N_2: 100 kg N ha^{-1}
N_3: 120 kg N ha^{-1}

Figure 5. Effect of levels of nitrogen on dry matter per plant of BRRI dhan45

Different nitrogen levels showed significant differences on dry matter plant^{-1} of BRRI dhan45 at 30, 50, 70 and 90 DAT and at harvest (Appendix VI). At 30 DAT, the highest dry matter plant^{-1} was observed from N_3 (0.517 g) (120 kg N ha^{-1}) which was statistically identical with N_2 (0.497 g) (100 kg N ha^{-1}) and followed by N_1 (0.437 g) (80 kg N ha^{-1}), again the lowest was obtained from N_0 (0.326 g) (0 kg N ha^{-1}). The highest dry matter plant^{-1} was found from N_3 (3.36 g) which was closely followed by N_2 (3.17 g), while the lowest was recorded from N_0 (1.65 g) which was followed by N_1 (2.66 g) at 50 DAT. At 70 DAT, the highest dry matter plant^{-1} was found from N_3 (14.91 g) which was closely followed by N_2 (13.97 g), whereas the lowest was recorded from N_0 (7.27 g) which was followed by N_1 (11.52 g). The highest dry matter plant^{-1} was obtained from N_3 (25.45 g) which was closely followed by N_2 (24.79 g) and the lowest was observed from N_0 (15.47 g) which was and followed by N_1 (21.33 g) at 90 DAT. At harvest, the highest dry matter plant^{-1} was observed from N_2 (56.57 g) which was statistically similar with N_3 (55.85 g) and closely followed by N_1 (50.95 g), whereas the lowest was recorded from N_0 (38.05 g) (Figure 5). Xie *et al.* (2007) reported that increased split application of nitrogen from control to 140 kg ha^{-1} increased dry matter accumulation (DMA).

Planting date and nitrogen showed significant differences due to interaction in terms of dry matter plant^{-1} of BRRI dhan45 at 30, 50, 70 and 90 DAT and at harvest (Appendix VI). At 30 DAT, the highest dry matter plant^{-1} was obtained from the treatment combination of T_2N_3 (0.585 g) (transplanting at 30 December, 2008 × 120 kg N ha^{-1}), while the lowest was found from the treatment combination of T_1N_0 (0.286 g) (transplanting at 15 December, 2008 × 0 kg N ha^{-1}). The highest dry matter $plant^{-1}$ was recorded from the treatment combination of T_2N_3 (3.92 g), whereas the lowest was observed from the treatment combination of T_1N_0 (1.43 g) at 50 DAT. At 70 DAT, the highest dry matter $plant^{-1}$ was obtained from the treatment combination of T_2N_3 (16.65 g) and the lowest was found from the treatment combination of T_1N_0 (6.33 g). The highest dry matter $plant^{-1}$ was found from the treatment combination of T_2N_3 (26.78 g), while the lowest was observed from the treatment combination of T_2N_0 (14.04 g) at 90 DAT. At harvest, the highest dry matter $plant^{-1}$ was recorded from the treatment combination of T_2N_2 (58.78 g), again the lowest was observed from the treatment combination of T_1N_0 (34.81 g) (Table 5).

4.4 Number of effective tillers $hill^{-1}$

Number of effective tillers $hill^{-1}$ of BRRI dhan45 varied significantly due to the different planting dates (Appendix VII). The maximum number of effective tillers $hill^{-1}$ was observed from T_2 (12.13) (transplanting at 30 December, 2008) which was closely followed by T_3 (11.40) (transplanting at 15 January, 2009). On the other hand, the minimum number was recorded from T_1 (11.07) (transplanting at 15 December, 2008) treatment (Table 6).

Table 5. Interaction effect of planting dates and nitrogen doses on dry matter per plant *Boro* rice CV. BRRI dhan45

Treatment	Dry matter plant^{-1} at				
	30 DAT	50 DAT	70 DAT	90 DAT	Harvest
T_1N_0	0.286 g	1.43 g	6.33 i	14.04 h	34.81 h
T_1N_1	0.395 e	2.61 d	10.39 g	20.35 e	46.55 e
T_1N_2	0.475 c	3.04 c	13.55 d	24.22 c	52.95 cd
T_1N_3	0.485 c	3.10 c	13.70 cd	24.35 c	55.54 b
T_2N_0	0.333 fg	1.93 f	7.63 h	17.41 f	42.16 f
T_2N_1	0.512 bc	2.99 c	12.75 e	22.62 d	54.75 bc
T_2N_2	0.562 ab	3.48 b	15.26 b	25.91 b	58.78 a
T_2N_3	0.585 a	3.92 a	16.65 a	26.78 a	58.63 a
T_3N_0	0.360 ef	1.59 g	7.85 h	14.97 g	37.17 g
T_3N_1	0.403 de	2.36 e	11.41 f	21.01 e	51.54 d
T_3N_2	0.453 cd	2.98 c	13.11 de	24.25 c	55.83 b
T_3N_3	0.480 c	3.06 c	14.37 c	25.23 b	55.56 b
$LSD_{(0.05)}$	0.054	0.233	0.740	0.774	2.270
Level of significance	*	*	**	*	*
CV(%)	8.08	5.11	8.67	9.10	12.66

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

In a column mean values having similar letter(s) are statistically doses and those having dissimilar letter(s) differ significantly at 0.05 level of significance

T_1: Transplanting at 15 December, 2008

T_2: Transplanting at 30 December, 2008

T_3: Transplanting at 15 January, 2009

N_0: 0 kg ha^{-1} (control)

N_1: 80 kg ha^{-1}

N_2: 100 kg ha^{-1}

N_3: 120 kg ha^{-1}

Number of effective tillers hill^{-1} of BRRI dhan45 showed significant differences for the application of different nitrogen levels (Appendix VII). The maximum number of effective tillers hill^{-1} was found from N_3 (13.27) (120 kg N ha^{-1}) which was closely followed by N_2 (12.76) (100 kg N ha^{-1}), whereas the minimum number was obtained from N_0 (9.07) (0 kg N ha^{-1}) which was followed (4.60) by N_1 (80 kg N ha^{-1}) treatment (Table 6). 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 effective tillers m^{-2}.

Planting date and nitrogen showed significant differences for number of effective tillers hill^{-1} of BRRI dhan45 due to their interaction effect (Appendix VII). The maximum number of effective tillers hill^{-1} was recorded from the treatment combination of T_2N_3 (13.93) (transplanting at 30 December, 2008 × 120 kg N ha^{-1}), again the minimum number was found from T_1N_0 (8.40) (transplanting at 15 December, 2008 × 0 kg N ha^{-1}) treatment combination (Table 7).

4.5 Number of non-effective tillers hill^{-1}

Statistically significant variation was recorded for number of non-effective tillers hill^{-1} of BRRI dhan45 showed due to the different planting dates (Appendix VII). The minimum number of non-effective tillers hill^{-1} was recorded from T_3 (3.18) (transplanting at 15 January, 2009), again the maximum number was found from T_1 (4.05) (transplanting at 15 December, 2008) which was statistically similar to T_2 (3.78) (transplanting at 30 December, 2008) treatment (Table 6).

Table 6. Effect of planting dates and nitrogen doses on number of effective, non-effective and total tillers hill^{-1} of *Boro* rice CV. BRRI dhan45

Treatment	Number of effective tillers hill^{-1}	Number of non-effective tillers hill^{-1}	Number of total tillers hill^{-1}
Planting date			
T_1	11.07 c	4.05 a	15.12 b
T_2	12.13 a	3.78 a	15.90 a
T_3	11.40 b	3.18 b	14.58 c
$LSD_{(0.05)}$	0.292	0.290	0.462
Level of significance	**	**	**
Levels of nitrogen			
N_0	9.07 d	2.59 c	11.66 d
N_1	11.03 c	3.58 b	14.61 c
N_2	12.76 b	3.88 b	16.63 b
N_3	13.27 a	4.63 a	17.90 a
$LSD_{(0.05)}$	0.337	0.334	0.534
Level of significance	**	**	**
CV(%)	7.99	9.32	6.59

**: Significant at 0.01 level of probability;

In a column mean values having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly at 0.05 level of significance

T_1: Transplanting at 15 December, 2008

T_2: Transplanting at 30 December, 2008

T_3: Transplanting at 15 January, 2009

N_0: 0 kg ha^{-1} (control)

N_1: 80 kg ha^{-1}

N_2: 100 kg ha^{-1}

N_3: 120 kg ha^{-1}

Table 7. Interaction effect of planting dates and nitrogen doses on number of effective, non-effective and total tillers hill^{-1} of *Boro* rice CV. BRRI dhan45

Treatment	Number of effective tillers hill^{-1}	Number of non-effective tillers hill^{-1}	Number of total tillers hill^{-1}
T_1N_0	8.40 h	3.20 f	11.60 e
T_1N_1	10.53 f	3.87 cde	14.40 d
T_1N_2	12.47 cde	4.40 bc	16.87 b
T_1N_3	12.87 bcd	4.73 ab	17.60 b
T_2N_0	9.23 g	2.20 g	11.43 e
T_2N_1	11.90 e	3.70 def	15.60 c
T_2N_2	13.43 ab	3.97 cd	17.40 b
T_2N_3	13.93 a	5.23 a	19.17 a
T_3N_0	9.57 g	2.37 g	11.93 e
T_3N_1	10.67 f	3.17 f	13.83 d
T_3N_2	12.37 de	3.27 ef	15.63 c
T_3N_3	13.00 bc	3.93 cd	16.93 b
$LSD_{(0.05)}$	0.584	0.579	0.924
Level of significance	**	*	**
CV(%)	7.99	9.32	6.59

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

In a column mean values having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly at 0.05 level of significance

T_1: Transplanting at 15 December, 2008
T_2: Transplanting at 30 December, 2008
T_3: Transplanting at 15 January, 2009

N_0: 0 kg ha^{-1} (control)
N_1: 80 kg ha^{-1}
N_2: 100 kg ha^{-1}
N_3: 120 kg ha^{-1}

Different nitrogen levels showed significant variation on number of non-effective tillers hill^{-1} of BRRI dhan45 (Appendix VII). The minimum number of non-effective tillers hill^{-1} was obtained from N_0 (2.59) (0 kg N ha^{-1}) which was closely followed by N_2 (3.88) (100 kg N ha^{-1}) and N_1 (3.58) (80 kg N ha^{-1}), whereas the maximum number was found from N_3 (4.63) (120 kg N ha^{-1}) treatment (Table 6).

Statistically significant variation was recorded for the interaction effect of planting date and nitrogen on number of non-effective tillers hill^{-1} of BRRI dhan45 (Appendix VII). The minimum number of non-effective tillers hill^{-1} was recorded from the treatment combination of T_2N_0 (2.20) (transplanting at 30 December, 2008 × 0 kg N ha^{-1}), while the maximum number was recorded from T_2N_3 (5.23) (transplanting at 30 December, 2008 × 120 kg N ha^{-1}) treatment combination (Table 7).

4.6 Number of total tillers hill^{-1}

Different planting dates showed significant differences for number of total tillers hill^{-1} of BRRI dhan45 (Appendix VII). The maximum number of tillers hill^{-1} was found from T_2 (15.90) (transplanting at 30 December, 2008) which was closely followed by T_1 (15.12) (transplanting at 15 December, 2008), whereas the minimum number was attained from T_3 (14.58) (transplanting at 15 January, 2009) treatment (Table 6).

Statistically significant variation was observed for different nitrogen levels on number of total tillers hill^{-1} of BRRI dhan45 (Appendix VII). The maximum number of tillers hill^{-1} was found from N_3 (17.90) (120 kg N ha^{-1}) which was closely followed by N_2 (16.63) (100 kg N ha^{-1}), again the minimum number was recorded from N_0 (11.66) (0 kg N ha^{-1}) which was followed by N_1 (14.61) (80 kg N ha^{-1}) treatment (Table 6).

Interaction effect of planting date and nitrogen showed significant variation for number of total tillers $hill^{-1}$ of BRRI dhan45 (Appendix VII). The maximum number of tillers $hill^{-1}$ was observed from the treatment combination of T_2N_3 (19.17) (transplanting at 30 December, 2008 × 120 kg N ha^{-1}). On the other hand the minimum number was recorded from T_2N_0 (11.43) (transplanting at 30 December, 2008 × 0 kg N ha^{-1}) treatment combination (Table 7).

4.7 Length of panicle

Length of panicle of BRRI dhan45 showed statistically significant differences due to the different planting dates (Appendix VII). The longest panicle was recorded from T_2 (23.73 cm) (transplanting at 30 December, 2008) which was closely followed by T_1 (22.47 cm) (transplanting at 15 December, 2008) and the shortest panicle was observed from T_3 (21.17 cm) (transplanting at 15 January, 2009) treatment (Figure 6).

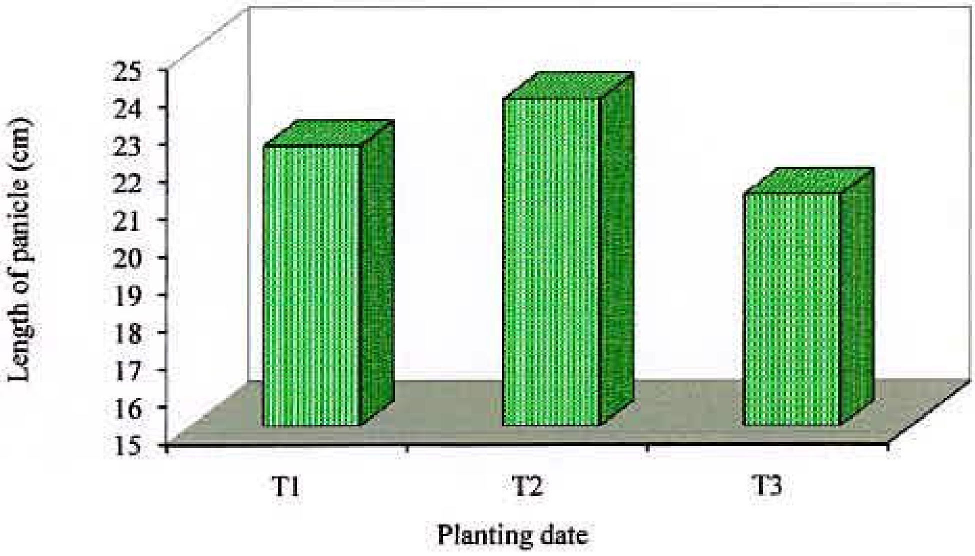
Different nitrogen levels showed significant difference for length of panicle of BRRI dhan45 (Appendix VII). The longest panicle was observed from N_2 (23.73 cm) (100 kg N ha^{-1}) which was statistically identical with N_3 (23.26 cm) (120 kg N ha^{-1}) and was followed by N_1 (22.36 cm) (80 kg N ha^{-1}), whereas the shortest panicle was found from N_0 (20.47 cm) (0 kg N ha^{-1}) treatment (Figure 7). Rao *et* *al.* (1997) showed that nitrogen application at 50 kg ha^{-1} at tillering, 25 kg ha^{-1} at panicle initiation and 25 kg ha^{-1} at booting stage produced the longest panicle.

Interaction effect of planting date and nitrogen showed significant differences for panicle length of BRRI dhan45 (Appendix VII). The longest panicle was found from the treatment combination of T_2N_2 (25.50 cm) (transplanting at 30 December, 2008 × 100 kg N ha^{-1}), while the shortest length was observed from T_3N_0 (20.05 cm) (transplanting at 15 January, 2009 × 0 kg N ha^{-1}) treatment combination (Figure 8).

4.8 Number of filled grains plant^{-1}

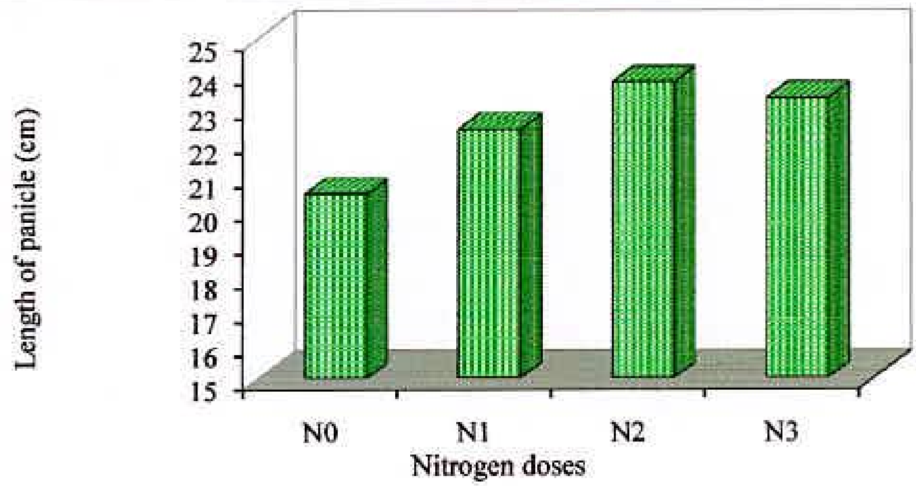
Statistically significant variation was recorded for number of filled grains plant^{-1} of BRRI dhan45 showed differences due to the different planting dates (Appendix VIII). The maximum number of filled grains plant^{-1} was obtained from T_2 (88.66) (transplanting at 30 December, 2008) which was closely followed by T_3 (85.24) (transplanting at 15 January, 2009), again the minimum number was attained from T_1 (83.61) (transplanting at 15 December, 2008) treatment (Table 8).

Number of filled grains plant^{-1} of BRRI dhan45 varied significantly for different nitrogen levels (Appendix VIII). The maximum number of filled grains plant^{-1} was recorded from N_2 (95.43) (100 kg N ha^{-1}) which was closely followed by N_3 (92.41) (120 kg N ha^{-1}), while the minimum number was observed from N_0 (67.89) (0 kg N ha^{-1}) which was followed by N_1 (87.61) (80 kg N ha^{-1}) treatment (Table 8). Reddy *et al.* (1987) reported that total number of spikelets panicle^{-1} increased with 120 kg with N ha^{-1}.



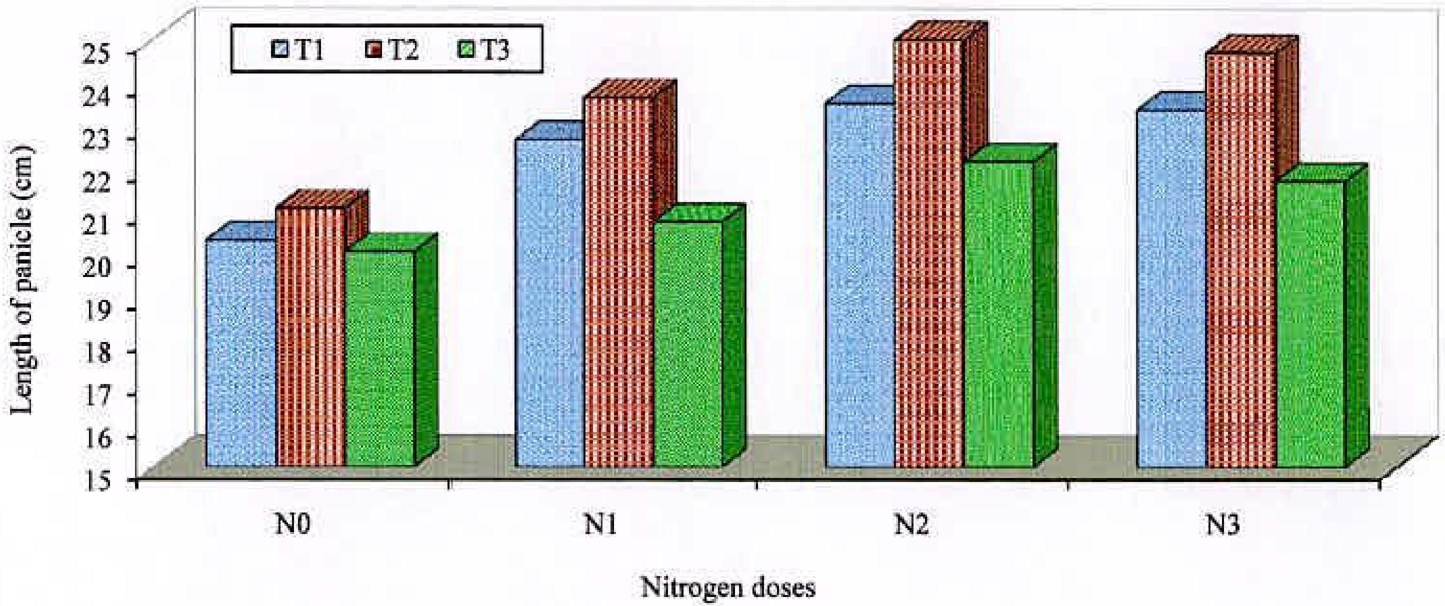
T_1: Transplanting at 15 December, 2008
T_2: Transplanting at 30 December, 2008
T_3: Transplanting at 15 January, 2009

Figure 6. Effect of planting dates on length of panicle of BRRI dhan45



N_0: 0 kg N ha^{-1} N_1: 80 kg N ha^{-1}
N_2: 100 kg N ha^{-1} N_3: 120 kg N ha^{-1}

Figure 7. Effect of nitrogen doses on length of panicle of BRRI dhan45



T_1: Transplanting at 15 December, 2008
T_2: Transplanting at 30 December, 2008
T_3: Transplanting at 15 January, 2009

N_0: 0 kg N ha^{-1}
N_2: 100 kg N ha^{-1}

N_1: 80 kg N ha^{-1}
N_3: 120 kg N ha^{-1}

Figure 8. Interaction effect of planting dates and nitrogen doses on length of panicle of BRRI dhan45

Interaction effect of planting date and nitrogen showed significant differences for number of filled grains plant^{-1} of BRRI dhan45 (Appendix VIII). The maximum number of filled grains plant^{-1} was found from the treatment combination of T_2N_2 (97.40) (transplanting at 30 December, 2008 × 100 kg N ha^{-1}), whereas the minimum number was recorded from T_1N_0 (64.00) (transplanting at 15 December, 2008 × 0 kg N ha^{-1}) treatment combination (Table 9).

4.9 Number of unfilled grains plant^{-1}

Number of unfilled grains plant^{-1} of BRRI dhan45 varied significantly for different planting dates (Appendix VIII). The minimum number of unfilled grains plant^{-1} was found from T_2 (7.32) (transplanting at 30 December, 2008) which was closely followed by T_3 (8.23) (transplanting at 15 January, 2009) and the maximum number was recorded from T_1 (9.34) (transplanting at 15 December, 2008) treatment (Table 8).

Nitrogen levels showed significant variations on number of unfilled grains plant^{-1} of BRRI dhan45 (Appendix VIII). The minimum number of unfilled grains plant^{-1} was obtained from N_2 (6.59) (100 kg N ha^{-1}) which was closely followed by N_3 (7.26) (120 kg N ha^{-1}). On the other hand, the maximum number was found from N_0 (11.32) (0 kg N ha^{-1}) which was followed by N_1 (8.02) (80 kg N ha^{-1}) treatment (Table 8).

Planting date and nitrogen showed significant differences due to interaction effect in terms of number of unfilled grains plant^{-1} of BRRI dhan45 (Appendix VIII). The minimum number of unfilled grains plant^{-1} was found from the treatment

Table 8. Effect of planting dates and nitrogen doses on number of filled, unfilled and total grains plant^{-1} *Boro* rice CV. BRRI dhan45

Treatment	Number of filled grains plant^{-1}	Number of unfilled grains plant^{-1}	Number of total grains plant^{-1}
Planting date			
T_1	83.61 c	9.34 a	92.95 b
T_2	88.66 a	7.32 c	95.97 a
T_3	85.24 b	8.23 b	93.47 b
$LSD_{(0.05)}$	1.412	0.471	1.440
Level of significance	**	**	**
Levels of nitrogen			
N_0	67.89 d	11.32 a	79.21 d
N_1	87.61 c	8.02 b	95.63 c
N_2	95.43 a	6.59 d	102.02 a
N_3	92.41 b	7.26 c	99.67 b
$LSD_{(0.05)}$	1.630	0.544	1.663
Level of significance	**	**	**
CV(%)	11.94	6.71	11.81

**: Significant at 0.01 level of probability;

In a column mean values having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly at 0.05 level of significance

T_1: Transplanting at 15 December, 2008
T_2: Transplanting at 30 December, 2008
T_3: Transplanting at 15 January, 2009

N_0: 0 kg ha^{-1} (control)
N_1: 80 kg ha^{-1}
N_2: 100 kg ha^{-1}
N_3: 120 kg ha^{-1}

Table 9. Interaction effect of planting dates and nitrogen doses on number of filled, unfilled and total grains plant^{-1} *Boro* rice CV. BRRI dhan45

Treatment	Number of filled grains plant^{-1}	Number of unfilled grains plant^{-1}	Number of total grains plant^{-1}
T_1N_0	64.00 h	13.80 a	77.80 g
T_1N_1	84.77 f	8.53 cd	93.30 e
T_1N_2	94.33 bc	7.20 ef	101.53 ab
T_1N_3	91.33 cd	7.83 de	99.17 bc
T_2N_0	73.70 g	9.43 c	83.13 f
T_2N_1	90.17 de	7.33 ef	97.50 cd
T_2N_2	97.40 a	6.10 g	103.50 a
T_2N_3	93.37 bc	6.40 fg	99.77 bc
T_3N_0	65.97 h	10.73 b	76.70 g
T_3N_1	87.90 e	8.20 de	96.10 de
T_3N_2	94.57 b	6.47 fg	101.03 ab
T_3N_3	92.53 bcd	7.53 de	100.07 bc
$LSD_{(0.05)}$	2.823	0.943	2.881
Level of significance	**	**	*
CV(%)	11.94	6.71	11.81

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

In a column mean values having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly at 0.05 level of significance

T_1: Transplanting at 15 December, 2008
T_2: Transplanting at 30 December, 2008
T_3: Transplanting at 15 January, 2009

N_0: 0 kg ha^{-1} (control)
N_1: 80 kg ha^{-1}
N_2: 100 kg ha^{-1}
N_3: 120 kg ha^{-1}

combination of T_2N_2 (6.10) (transplanting at 30 December, 2008 × 100 kg N ha^{-1}), while the maximum number was observed from T_1N_0 (13.80) (transplanting at 15 December, 2008 × 0 kg N ha^{-1}) treatment combination (Table 9).

4.10 Number of total grains $plant^{-1}$

Number of total grains $plant^{-1}$ of BRRI dhan45 showed significant variations due to the different planting dates (Appendix VIII). The maximum number of total grains $plant^{-1}$ was recorded from T_2 (95.97) (transplanting at 30 December, 2008), whereas the minimum number was observed from T_1 (92.95) (transplanting at 15 December, 2008) which was statistically similar with T_3 (93.47) (transplanting at 15 January, 2009) treatment (Table 8). Islam *et al.* (2008) reported that direct wet-seeded rice produced 10% higher grain yield than transplanted rice and 31 December seeded rice produced the highest grain yield. Rice planted on 1 December significantly reduced the grains per panicle and January planted rice significantly reduced the panicle per unit area.

Number of total grains $plant^{-1}$ of BRRI dhan45 showed significant difference due to different nitrogen levels (Appendix VIII). The maximum number of total grains $plant^{-1}$ was recorded from N_2 (102.02) (100 kg N ha^{-1}) which was closely followed by N_3 (99.67) (120 kg N ha^{-1}), again the minimum number was obtained from N_0 (79.21) (0 kg N ha^{-1}) which was followed by N_1 (95.63) (80 kg N ha^{-1}) treatment (Table 8).

Interaction effect of planting date and nitrogen showed significant differences for number of total grains plant^{-1} of BRRI dhan45 (Appendix VIII). The maximum number of total grains plant^{-1} was recorded from the treatment combination of T_2N_2 (103.50) (transplanting at 30 December, 2008 × 100 kg N ha^{-1}), while the minimum number was attained from T_1N_0 (77.80) (transplanting at 15 December, 2008 × 0 kg N ha^{-1}) treatment combination (Table 9).

4.11 Weight of 1000 grains

Statistically significant difference was recorded for weight of 1000 grains of BRRI dhan45 for different planting dates (Appendix IX). The highest weight of 1000 grains was observed from T_2 (22.47 g) (transplanting at 30 December, 2008), while the lowest weight was recorded from T_1 (21.11 g) (transplanting at 15 December, 2008) which was statistically identical with T_3 (21.40 g) (transplanting at 15 January, 2009) treatment (Figure 9). Alim *et al.*, 1993 reported that better results are obtained from early transplanting than late transplanting.

Different nitrogen levels showed significant differences on weight of 1000 grains of BRRI dhan45 (Appendix VIII). The highest weight of 1000 grains was found from N_2 (22.83 g) (100 kg N ha^{-1}) which was statistically similar with N_3 (22.52 g) (120 kg N ha^{-1}) and followed by N_1 (21.37 g) (80 kg N ha^{-1}), again the lowest weight was observed from N_0 (19.91 g) (0 kg N ha^{-1}) treatment (Figure 10). Subhendu *et al.* (2003) conducted a field experiment during *kharif* season at Hyderabad, India. They found that the application of nitrogen (120 kg N ha^{-1}) as urea in equal splits resulted in the highest 1000 grain weight (22.57 g).

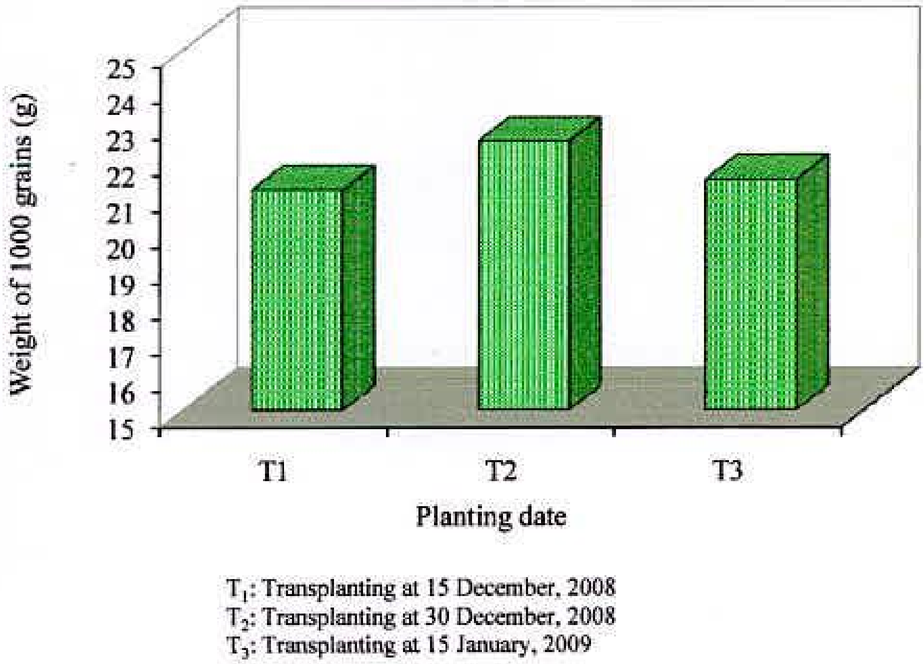


Figure 9. Effect of planting dates on weight of 1000 grains of BRRI dhan45

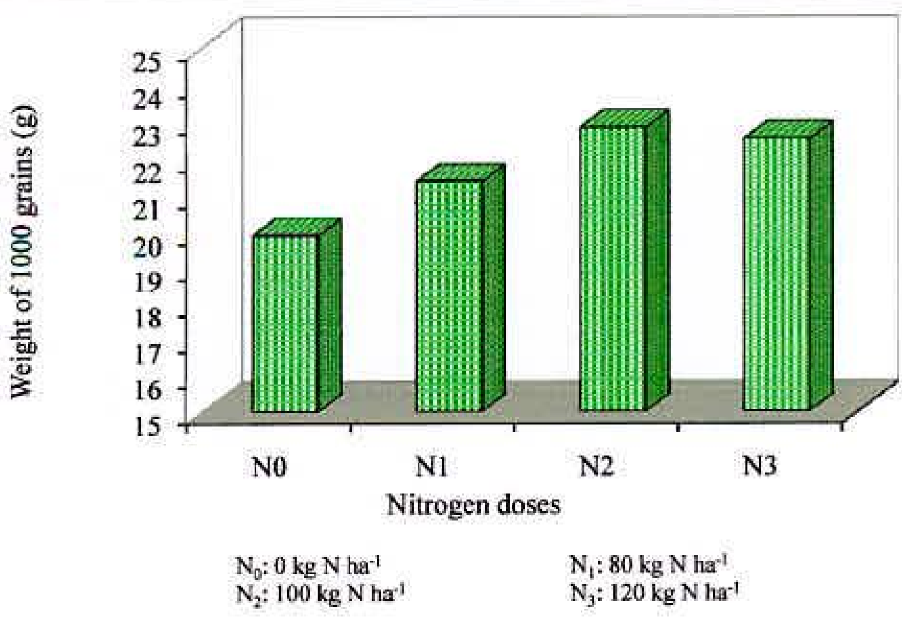


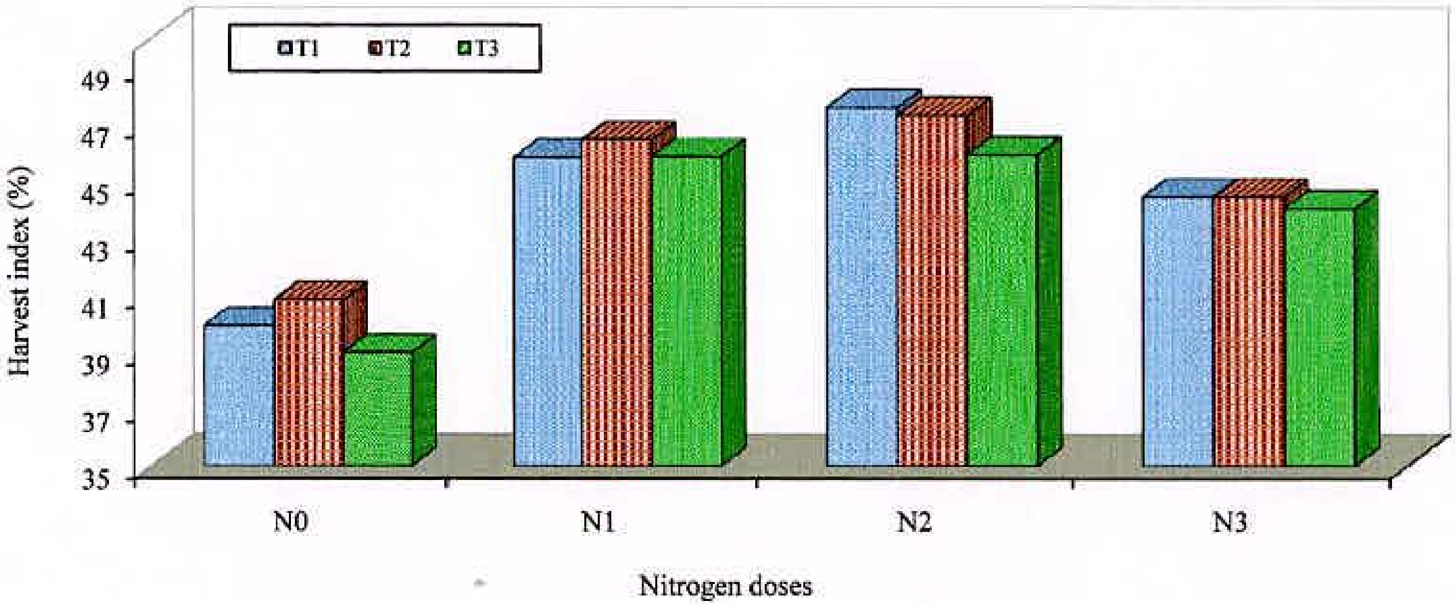
Figure 10. Effect of nitrogen doses on weight of 1000 grains of BRRI dhan45

Weight of 1000 grains of BRRI dhan45 showed significant differences due to interaction effect of planting date and nitrogen (Appendix VIII). The highest weight of 1000 grains was recorded from the treatment combination of T_2N_3 (23.44 g) (transplanting at 30 December, 2008 × 120 kg N ha^{-1}). On the other hand, the lowest weight was recorded from T_1N_0 (19.40 g) (transplanting at 15 December, 2008 × 0 kg N ha^{-1}) treatment combination (Figure 11).

4.12 Grain yield per hectare

Grain yield per hectare of BRRI dhan45 varied significantly for different planting dates (Appendix VIII). The highest grain yield was found from T_2 (5.91 t/ha) (transplanting at 30 December, 2008) which was closely followed by T_1 (5.32 t/ha) (transplanting at 15 December, 2008), whereas the lowest yield was recorded from T_3 (5.12 t/ha) (transplanting at 15 January, 2009) treatment (Table 10). These results agrees with the results of Nafziger (1994), in that an optimum planting date exists and the planting before or after that optimum results in yield reduction of crops. Singh *et al.*, 1995; Patel *et al.*, 1987 reported that grain yield of rice markedly declined with delayed planting.

Statistically significant variation was recorded for different nitrogen levels on grain yield per hectare of BRRI dhan45 (Appendix IX). The highest grain yield was obtained from N_2 (6.44 t/ha) (100 kg N ha^{-1}) which was closely followed by N_1 (5.97 t/ha) (80 kg N ha^{-1}) and N_3 (5.89 t/ha) (120 kg N ha^{-1}), while the lowest yield from N_0 (3.50 t/ha) (0 kg N ha^{-1}) treatment (Table 10). Geethadevi *et al.* (2000) showed that four split applications of 150 kg Nha^{-1} nitrogen in KRH-1



T_1: Transplanting at 15 December, 2008
T_2: Transplanting at 30 December, 2008
T_3: Transplanting at 15 January, 2009

N_0: 0 kg N ha^{-1}
N_1: 80 kg N ha^{-1}
N_2: 100 kg N ha^{-1}
N_3: 120 kg N ha^{-1}

Figure 14. Interaction effect of planting dates and nitrogen doses on harvest index of BRRI dhan45

recorded the maximum yield, as well as increased growth and yield components. Vaiyapuri *et al.* (1995) stated that application of 100 kg N ha^{-1} in three splits 25% basal + 50% tillering stage +25% panicle initiation gave the highest yield (5.88 t ha^{-1}).

Interaction effect of planting date and nitrogen showed significant differences for grain yield per hectare of BRRI dhan45 (Appendix IX). The highest grain yield was recorded from the treatment combination of T_2N_2 (6.83 t/ha) (transplanting at 30 December, 2008 × 100 kg N ha^{-1}) and the lowest yield was observed from T_1N_0 (3.26 t/ha) (transplanting at 15 December, 2008 × 0 kg N ha^{-1}) treatment combination (Table 11).

4.13 Straw yield per hectare

Different planting dates showed statistically significant differences on straw yield per hectare of BRRI dhan45 (Appendix IX). The highest straw yield was recorded from T_2 (7.19 t/ha) (transplanting at 30 December, 2008). On the other hand, the lowest yield was obtained from T_3 (6.48 t/ha) (transplanting at 15 January, 2009) which was statistically identical with T_1 (6.52 t/ha) (transplanting at 15 December, 2008) treatment (Table 10).

Different nitrogen levels varied significantly on straw yield per hectare of BRRI dhan45 (Appendix IX). The highest straw yield was observed from N_3 (7.40 t/ha) (120 kg N ha^{-1}) which was statistically similar with N_2 (7.27 t/ha) (100 kg N ha^{-1}) and closely followed by N_1 (6.99 t/ha) (80 kg N ha^{-1}) and the lowest yield was recorded from N_0 (5.26 t/ha) (0 kg N ha^{-1}) treatment (Table 10).

Table 10. Effect of planting dates and nitrogen doses on grain, straw and biological yield of *Boro* rice CV. BRRI dhan45

Treatment	Grain yield (t/ha)	Straw yield (t/ha)	Biological yield (t/ha)
Planting date			
T_1	5.32 b	6.52 b	11.84 b
T_2	5.91 a	7.19 a	13.10 a
T_3	5.12 c	6.48 b	11.60 c
$LSD_{(0.05)}$	0.174	0.134	0.230
Level of significance	**	**	**
Levels of nitrogen			
N_0	3.50 c	5.26 c	8.76 d
N_1	5.97 b	6.99 b	12.96 c
N_2	6.44 a	7.27 a	13.70 a
N_3	5.89 b	7.40 a	13.29 b
$LSD_{(0.05)}$	0.200	0.155	0.266
Level of significance	**	**	**
CV(%)	6.78	8.35	7.23

**: Significant at 0.01 level of probability;

In a column mean values having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly at 0.05 level of significance

T_1: Transplanting at 15 December, 2008

T_2: Transplanting at 30 December, 2008

T_3: Transplanting at 15 January, 2009

N_0: 0 kg ha^{-1} (control)

N_1: 80 kg ha^{-1}

N_2: 100 kg ha^{-1}

N_3: 120 kg ha^{-1}

Table 11. Interaction effect of planting dates and nitrogen doses on grain, straw and biological yield of *Boro* rice CV. BRRI dhan45

Treatment	Grain yield (t/ha)	Straw yield (t/ha)	Biological yield (t/ha)
T_1N_0	3.26 g	4.90 h	8.16 h
T_1N_1	5.60 de	6.61 f	12.21 f
T_1N_2	6.53 ab	7.19 cd	13.72 bc
T_1N_3	5.90 cde	7.37 bc	13.27 cd
T_2N_0	4.03 f	5.84 g	9.87 g
T_2N_1	6.56 ab	7.55 ab	14.12 ab
T_2N_2	6.83 a	7.60 ab	14.43 a
T_2N_3	6.21 bc	7.76 a	13.97 ab
T_3N_0	3.21 g	5.03 h	8.24 h
T_3N_1	5.76 de	6.80 ef	12.56 ef
T_3N_2	5.96 cd	7.01 de	12.96 de
T_3N_3	5.57 e	7.07 de	12.64 ef
$LSD_{(0.05)}$	0.347	0.268	0.461
Level of significance	*	*	**
CV(%)	6.78	8.35	7.23

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

In a column mean values having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly at 0.05 level of significance

T_1: Transplanting at 15 December, 2008
T_2: Transplanting at 30 December, 2008
T_3: Transplanting at 15 January, 2009

N_0: 0 kg ha^{-1} (control)
N_1: 80 kg ha^{-1}
N_2: 100 kg ha^{-1}
N_3: 120 kg ha^{-1}

Interaction effect of planting date and nitrogen varied significantly on straw yield per hectare of BRRI dhan45 (Appendix IX). The highest straw yield was found from the treatment combination of T_2N_3 (7.76 t/ha) (transplanting at 30 December, 2008 × 120 kg N ha^{-1}), whereas the lowest yield was recorded from T_1N_0 (4.90 t/ha) (transplanting at 15 December, 2008 × 0 kg N ha^{-1}) treatment combination (Table 11).

4.14 Biological yield per hectare

Statistically significant difference was observed in biological yield per hectare of BRRI dhan45 due to the different planting dates (Appendix IX). The highest biological yield was observed from T_2 (13.10 t/ha) (transplanting at 30 December, 2008) which was closely followed by T_1 (11.84 t/ha) (transplanting at 15 December, 2008) and the lowest yield was found from T_3 (11.60 t/ha) (transplanting at 15 January, 2009) treatment (Table 10). Kainth and Mehra, 1985 reported that when transplanting is delayed beyond normal period, the grain development is very poor which results in more quantity of under developed grains and ultimately severe reduction in yield.

Biological yield per hectare of BRRI dhan45 showed significant differences for different nitrogen levels (Appendix IX). The highest biological yield was observed from N_2 (13.70 t/ha) (100 kg N ha^{-1}) which was closely followed by N_3 (13.29 t/ha) (120 kg N ha^{-1}). On the other hand, the lowest yield was recorded from N_0 (8.76 t/ha) (0 kg N ha^{-1}) which was followed by N_1 (12.96 t/ha) (80 kg N ha^{-1}) and treatment (Table 10).

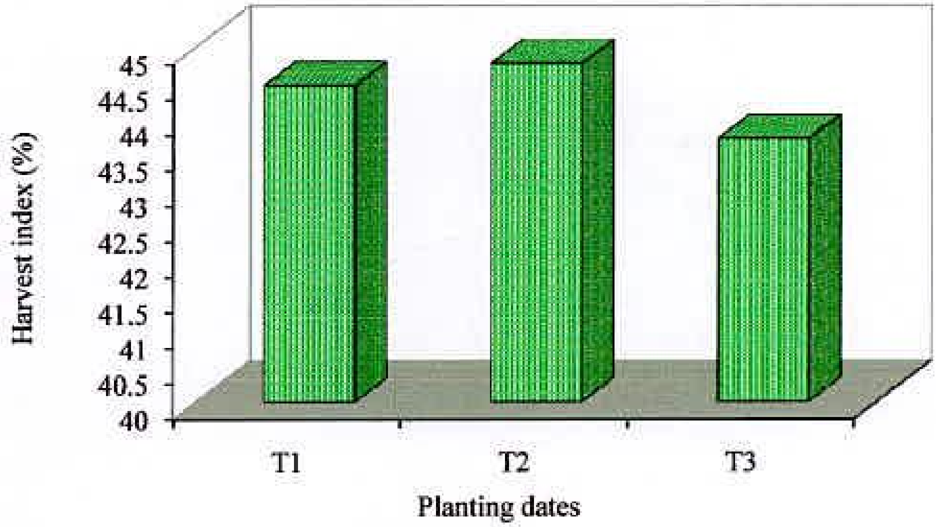
Variation was recorded due to interaction effect of planting date and nitrogen for biological yield per hectare of BRRI dhan45 (Appendix IX). The highest biological yield was recorded from the treatment combination of T_2N_2 (14.43 t/ha) (transplanting at 30 December, 2008 × 100 kg N ha^{-1}), again the lowest yield was observed from T_1N_0 (8.16 t/ha) (transplanting at 15 December, 2008 × 0 kg N ha^{-1}) treatment combination (Table 11).

4.15 Harvest index

Statistically significant difference was recorded in terms of harvest index of BRRI dhan45 for different planting dates (Appendix IX). The highest harvest index was found from T_2 (44.77%) (transplanting at 30 December, 2008) which was followed by T_1 (44.46%) (transplanting at 15 December, 2008), while the lowest from T_3 (43.71%) (transplanting at 15 January, 2009) treatment (Figure 12).

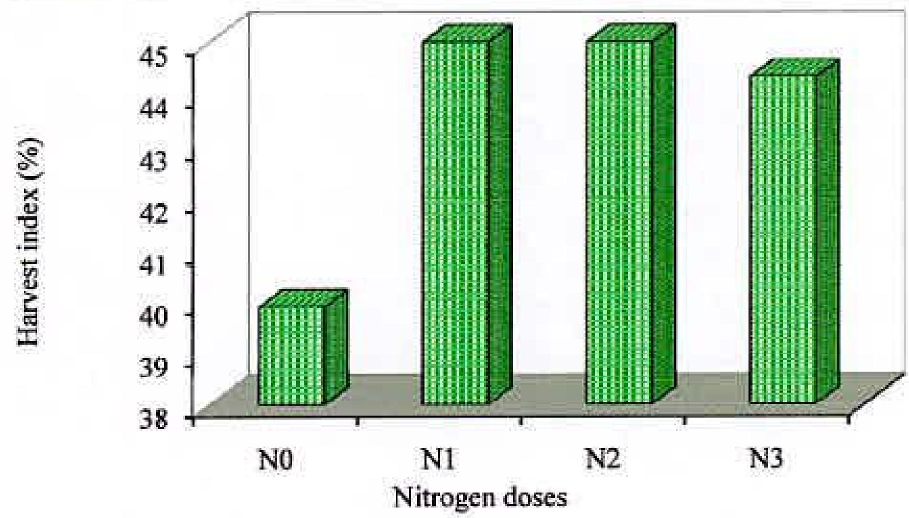
Different nitrogen levels showed significant differences on harvest index of BRRI dhan45 (Appendix IX). The highest harvest index was recorded from N_2 (46.95%) (100 kg N ha^{-1}) which was statistically similar with N_1 (46.06%) (80 kg N ha^{-1}) and closely followed by N_3 (44.33%) (120 kg N ha^{-1}), whereas the lowest was obtained from (39.91%) N_0 (0 kg N ha^{-1}) treatment (Figure 13).

Planting date and nitrogen showed significant differences for harvest index of BRRI dhan45 due to interaction effect (Appendix IX). The highest harvest index was recorded from T_1N_2 (47.58%) (transplanting at 15 December, 2008 × 100 kg N ha^{-1}), again the lowest was found from T_3N_0 (38.98%) (transplanting at 15 January, 2009 × 0 kg N ha^{-1}) treatment combination (Figure 14).



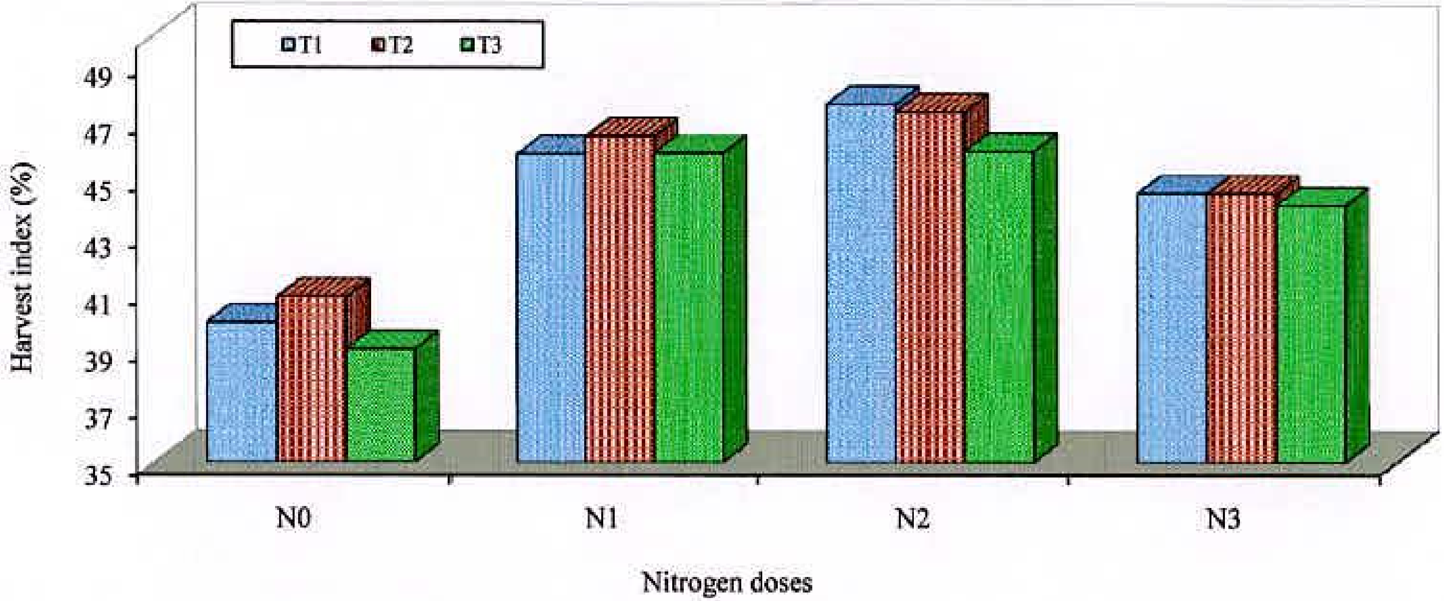
T_1: Transplanting at 15 December, 2008
T_2: Transplanting at 30 December, 2008
T_3: Transplanting at 15 January, 2009

Figure 12. Effect of planting dates on harvest index of BRRI dhan45



N_0: 0 kg N ha^{-1}
N_1: 80 kg N ha^{-1}
N_2: 100 kg N ha^{-1}
N_3: 120 kg N ha^{-1}

Figure 13. Effect of nitrogen doses on harvest index of BRRI dhan45



T_1: Transplanting at 15 December, 2008
T_2: Transplanting at 30 December, 2008
T_3: Transplanting at 15 January, 2009

N_0: 0 kg N ha^{-1}
N_2: 100 kg N ha^{-1}

N_1: 80 kg N ha^{-1}
N_3: 120 kg N ha^{-1}

Figure 14. Interaction effect of planting dates and nitrogen doses on harvest index of BRRI dhan45

Chapter V

Summary and Conclusion

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted at the experimental field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from November 2008 to May 2009 to study the effect of planting dates and nitrogen management on the growth and yield of *Boro* rice CV. BRRI dhan45. BRRI dhan45 was used as the test crop in this experiment. The experiment comprised of two factors. Factor A: transplanting date: 3 dates; transplanting at 15 December 2008 – T_1; transplanting at 30 December 2008 – T_2 and Transplanting at 15 January 2009 – T_3. Factor B: Nitrogen level: 4 levels; 0 kg N ha^{-1} (control) – N_0; 80 kg N ha^{-1} – N_1; 100 kg N ha^{-1} – N_2 and 120 kg N ha^{-1} – N_3. The experiment was laid out in two factors Randomized Complete Block Design with three replications. Data on different yield contributing characters and yield were recorded.

At 30, 50, 70 and 90 DAT and at harvest, the longest plant was recorded from T_2(25.59 cm, 41.88 cm, 59.58 cm, 75.75 cm and 94.44 cm), while the shortest plant was observed from T_1(24.42 cm, 39.75 cm, 55.94 cm, 72.35 cm and 89.48 cm). At 30, 50, 70 and 90 DAT, the maximum number of tillers $hill^{-1}$ was obtained from T_2 (5.19, 9.09, 15.88 and 17.83), while the minimum number from T_1 (4.39, 7.65, 13.18 and 15.32). At 30, 50, 70 and 90 DAT and at harvest, the highest dry matter $plant^{-1}$ was recorded from T_2 (0.498 g, 3.08 g, 13.07 g, 23.18 g and 53.58 g), whereas the lowest from T_1 (0.410 g, 2.50 g, 10.99 g, 20.74 g and 47.46 g). The maximum number of effective tillers $hill^{-1}$ was observed from T_2 (12.13) and the minimum number from T_1 (11.07). The minimum number of non-effective tillers $hill^{-1}$ was recorded from T_3 (3.18), again the maximum number from T_1 (4.05). The maximum number of tillers $hill^{-1}$ was found from T_2 (15.90), whereas the minimum number from T_3 (14.58). The longest panicle was recorded from T_2 (23.73 cm) and the shortest panicle from T_3 (21.17 cm). The maximum number of filled grains $plant^{-1}$ was obtained from T_2 (88.66), again the minimum number from T_1 (83.61). The minimum number of unfilled grains $plant^{-1}$ was found from T_2 (7.32) and the maximum number from T_1 (9.34). The maximum number of total grains $plant^{-1}$ was recorded from T_2 (95.97), whereas the minimum number from T_1 (92.95). The highest weight of 1000 grains was observed from T_2 (22.47 g), while the lowest weight from T_1 (21.11 g). The highest grain yield was found from T_2 (5.91 t/ha), whereas the lowest yield from T_3 (5.12 t/ha). The highest straw yield was recorded from T_2 (7.19 t/ha) and the lowest yield from T_3 (6.48 t/ha). The highest biological yield was observed from T_2 (13.10 t/ha) and the lowest yield from T_3 (11.60 t/ha). The highest harvest index was found from T_2 (44.77%), while the lowest from T_3 (43.71%).

At 30, 50, 70 and 90 DAT and at harvest, the longest plant was observed from N_3 (27.09 cm, 43.84 cm, 61.21 cm, 78.38 cm and 95.36 cm)again the shortest plant was recorded from N_0 (21.98 cm, 35.49 cm, 52.23 cm, 66.00 cm and 82.72 cm). At 30, 50, 70 and 90 DAT, the maximum number of tillers $hill^{-1}$ was found from N_3 (5.63, 9.94, 17.69 and 19.02) (120 kg N ha^{-1}), while the minimum number from N_0 (3.40, 5.83, 9.60 and 12.48). At 30, 50, 70 and 90 DAT and at harvest, the highest dry matter $plant^{-1}$ was observed from N_3 (0.517 g, 3.36 g, 14.91 g, 25.45 g and 56.57 g), again the lowest from N_0 (0.326 g, 1.65 g, 7.27 g, 15.47 g and 38.05

g). The maximum number of effective tillers hill^{-1} was found from N_3 (13.27), whereas the minimum number from N_0 (9.07). The minimum number of non-effective tillers hill^{-1} was obtained from N_0 (2.59), whereas the maximum number from N_3 (4.63). The maximum number of tillers hill^{-1} was found from N_3 (17.90), again the minimum number from N_0 (11.66). The longest panicle was observed from N_2 (23.73 cm), whereas the shortest panicle from N_0 (20.47 cm). The maximum number of filled grains plant^{-1} was recorded from N_2 (95.43), while the minimum number from N_0 (67.89). The minimum number of unfilled grains plant^{-1} was obtained from N_2 (6.59) and the maximum number from N_0 (11.32). The maximum number of total grains plant^{-1} was recorded from N_2 (102.02), again the minimum number from N_0 (79.21). The highest weight of 1000 grains was found from N_2 (22.83 g), again the lowest weight from N_0 (19.91 g). The highest grain yield was obtained from N_2 (6.44 t/ha), while the lowest yield from N_0 (3.50 t/ha). The highest straw yield was observed from N_3 (7.40 t/ha) and the lowest yield from N_0 (5.26 t/ha). The highest biological yield was observed from N_2 (13.70 t/ha) and the lowest yield from N_0 (8.76 t/ha). The highest harvest index was recorded from N_2 (46.95%), whereas the lowest was obtained from N_0 (39.91%).

At 30, 50, 70 and 90 DAT and at harvest, the longest plant was found from the treatment combination of T_2N_3(28.17 cm, 45.47 cm, 63.77 cm, 86.26 cm and 98.87 cm), whereas the shortest from the treatment combination of T_1N_0(21.00 cm, 33.80 cm, 49.97 cm, 82.33 cm and 80.87 cm). At 30, 50, 70 and 90 DAT, the maximum number of tillers hill^{-1} was recorded from the treatment combination of T_2N_3 (6.37, 11.00, 19.57 and 20.97), again the minimum number from the treatment combination of T_1N_0 (3.17, 5.20, 8.67 and 11.93). At 30, 50, 70 and 90 DAT and at harvest, the highest dry matter plant^{-1} was obtained from the treatment combination of T_2N_3 (0.585 g, 3.92 g, 16.65 g, 26.78 g and 58.78 g), while the lowest from the treatment combination of T_1N_0 (0.286 g, 1.43 g, 6.33 g, 14.04 g and 34.81 g). The maximum number of effective tillers hill^{-1} was recorded from the treatment combination of T_2N_3 (13.93), again the minimum number from T_1N_0 (8.40). The minimum number of non-effective tillers hill^{-1} was recorded from the treatment combination of T_3N_0 (2.37), while the maximum number from T_2N_3 (5.23). The maximum number of tillers hill^{-1} was observed from the treatment combination of T_2N_3 (19.17) and the minimum number from T_1N_0 (11.60). The longest panicle was found from the treatment combination of T_2N_2 (25.50 cm), while the shortest length from T_3N_0 (20.05 cm). The maximum number of filled grains plant^{-1} was found from the treatment combination of T_2N_2 (97.40), whereas the minimum number from T_1N_0 (64.00). The minimum number of unfilled grains plant^{-1} was found from the treatment combination of T_2N_2 (6.10), while the maximum number from T_1N_0 (13.80). The maximum number of total grains plant^{-1} was recorded from the treatment combination of T_2N_2 (103.50), while the minimum number from T_1N_0 (77.80). The highest weight of 1000 grains was recorded from the treatment combination of T_2N_3 (23.44 g) and the lowest weight from T_1N_0 (19.40 g). The highest grain yield was recorded from the treatment combination of T_2N_2 (6.83 t/ha) and the lowest yield from T_1N_0 (3.26 t/ha). The highest straw yield was found from the treatment combination of T_2N_3 (7.76 t/ha), whereas the lowest yield from T_1N_0 (4.90 t/ha). The highest biological yield was recorded from the treatment combination of T_2N_2 (14.43 t/ha), again the lowest yield from T_1N_0 (8.16 t/ha). The highest harvest index was recorded from the treatment combination of T_1N_2(47.58%), again the lowest from T_3N_0 (38.98%).

It may be concluded that growth, yield and yield contributing characters of BRRI dhan45 were greatly influenced by planting date and nitrogen management. The planting at 30 December and application of 100 kg N ha^{-1} provided the maximum yield of BRRI dhan45.

Considering the situation of the present experiment, further studies in the following areas may be suggested:

1. BRRI dhan45 is to be transplanted before 15 January for getting better yield.
2. 100kg Nha^{-1} should be applied in two equal installments at tiller & panicle initiation stage for getting maximum yield.
3. Such study is needed in different agro-ecological zones (AEZ) of Bangladesh for regional compliance and other performances.

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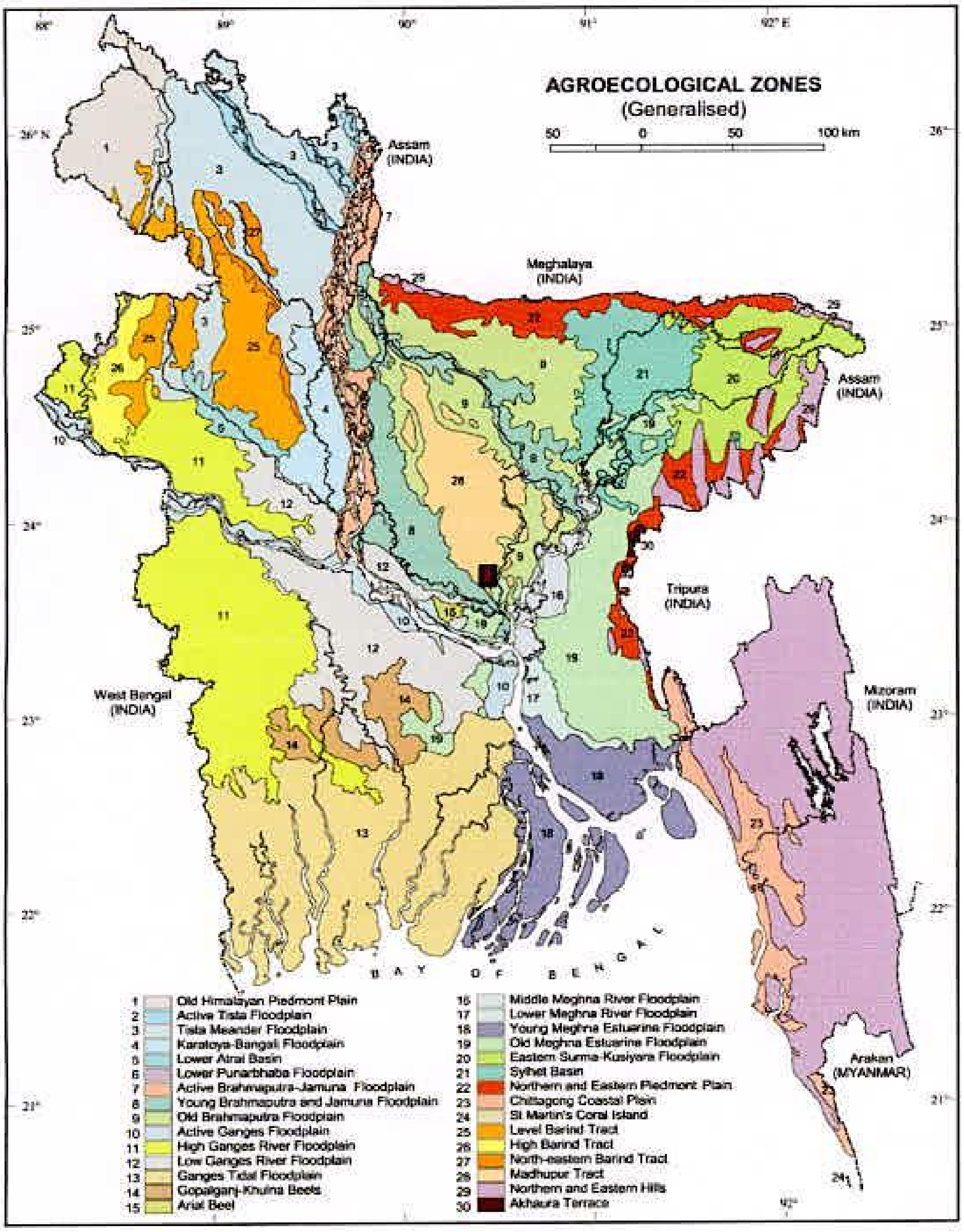
APPENDICES

Appendix I. Map showing the experimental sites under study



■ **The experimental site under study**

Appendix II. Characteristics of experimental field soil as analyzed by Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Exprimental field , SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained

B. Physical and chemical properties of the initial soil

Characteristics	Value
% Sand	27
% Silt	43
% clay	30
Textural class	silty-clay
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	45

Source: SRDI

Appendix III. Monthly record of air temperature, relative humidity, rainfall, and Sunshine of the experimental site during the period from November 2008 to May 2009

Month	*Air temperature (°c)		*Relative humidity (%)	*Rain fall (mm) (total)	*Sunshine (hr)
	Maximum	Minimum			
November, 2008	19.4	15.3	78	00	6.2
December, 2008	22.4	13.5	74	00	6.3
January, 2009	24.5	12.4	68	00	5.7
February, 2009	27.1	16.7	67	30	6.7
March, 2009	31.4	19.6	54	11	8.2
April, 2009	33.6	23.6	69	163	6.4
May, 2009	32.4	27.2	71	134	7.1

* Monthly average,

Source: Bangladesh Meteorological Department (Climate & weather division) Agargoan, Dhaka - 1212

Appendix IV. Analysis of variance of the data on plant height of *Boro* rice CV. BRRI dhan45 as influenced by planting date and nitrogen doses

Source of variation	Degrees of freedom	Mean square				
		Plant height (cm) at				
		30 DAT	50 DAT	70 DAT	90 DAT	Harvest
Replication	2	0.347	0.528	0.397	1.295	0.303
Planting date (A)	2	4.148**	14.147**	43.239**	34.914**	78.011**
Nitrogen management (B)	3	51.115**	136.27**	156.67**	290.31**	307.40**
Interaction (A×B)	6	2.150*	4.933*	4.088*	9.662*	1.417*
Error	22	0.796	1.123	1.768	3.167	0.600

**: Significant at 0.01 level of probability: *: Significant at 0.05 level of probability

Appendix V. Analysis of variance of the data on number of tillers hill^{-1} of *Boro* rice CV. BRRI dhan45 as influenced by planting date and nitrogen doses

Source of variation	Degrees of freedom	Mean square			
		Number of tillers hill^{-1} at			
		30 DAT	50 DAT	70 DAT	90 DAT
Replication	2	0.050	0.041	0.271	0.014
Planting date (A)	2	1.948**	6.691**	22.680**	19.670**
Nitrogen management (B)	3	9.229**	29.612**	121.363**	75.029**
Interaction (A×B)	6	0.213**	0.309**	1.300**	1.954*
Error	22	0.055	0.073	0.373	0.702

**: Significant at 0.01 level of probability: *: Significant at 0.05 level of probability

Appendix VI. Analysis of variance of the data on dry matter plant^{-1} of *Boro* rice CV. BRRI dhan45 as influenced by planting date and nitrogen doses

Source of variation	Degrees of freedom	Mean square				
		Dry matter plant^{-1} at				
		30 DAT	50 DAT	70 DAT	90 DAT	Harvest
Replication	2	0.000	0.000	0.008	0.047	1.752
Planting date (A)	2	0.027**	1.256**	13.441**	19.301**	113.29**
Nitrogen management (B)	3	0.066**	5.280**	104.79**	187.62**	662.24**
Interaction (A×B)	6	0.004*	0.057*	1.263**	1.416*	5.063*
Error	22	0.001	0.019	0.191	0.209	1.797

**: Significant at 0.01 level of probability: *: Significant at 0.05 level of probability

Appendix VII. Analysis of variance of the data on effective, non-effective & total tillers plant^{-1} and length of panicle of *Boro* rice CV. BRRI dhan45 as influenced by planting date and nitrogen doses

Source of variation	Degrees of freedom	Mean square			
		Effective tiller hill^{-1}	Non-effective tiller hill^{-1}	Total tiller hill^{-1}	Length of panicle (cm)
Replication	2	0.112	0.020	0.101	0.155
Planting date (A)	2	3.514**	2.354**	5.263**	19.790**
Nitrogen management (B)	3	32.498**	6.445**	66.763**	18.662**
Interaction (A×B)	6	0.442**	0.393*	1.260**	0.968**
Error	22	0.119	0.117	0.298	0.280

**: Significant at 0.01 level of probability: *: Significant at 0.05 level of probability

Appendix VIII. Analysis of variance of the data on filled, unfilled & total grains and weight of 1000 seeds of *Boro* rice CV. BRRI dhan45 as influenced by planting date and nitrogen doses

Source of variation	Degrees of freedom	Mean square			
		Number of filled grains plant^{-1}	Number of unfilled grains plant^{-1}	Number of total grains plant^{-1}	Weight of 1000 Seed (g)
Replication	2	1.252	0.577	1.231	0.010
Planting date (A)	2	79.688**	12.339**	31.352**	6.152**
Nitrogen management (B)	3	1381.772**	39.689**	953.325**	15.806**
Interaction (A×B)	6	11.043**	2.183**	7.873*	1.344*
Error	22	2.780	0.310	2.894	0.178

**: Significant at 0.01 level of probability: *: Significant at 0.05 level of probability

Appendix IX. Analysis of variance of the data on grain, straw & biological yield and harvest index of *Boro* rice CV. BRRI dhan45 as influenced by planting date and nitrogen doses

Source of variation	Degrees of freedom	Mean square			
		Grain yield (t/ha)	Straw yield (t/ha)	Biological yield (t/ha)	Harvest index (%)
Replication	2	0.025	0.011	0.056	0.153
Planting date (A)	2	2.005**	1.919**	7.778**	3.532**
Nitrogen management (B)	3	15.742**	8.899**	47.617**	88.150**
Interaction (A×B)	6	0.112*	0.081*	0.357**	6.629*
Error	22	0.042	0.025	0.074	1.144

**: Significant at 0.01 level of probability: *: Significant at 0.05 level of probability