EFFECT OF DIFFERENT LEVELS OF NITROGEN AND TRANSPLANTING DEPTH ON GROWTH AND YIELD OF BRRI dhan50

A Thesis
By
MD. APPEL MAHMUD
Reg No: 09-03716

DEPARTMENT OF AGRONOMY
SHER-E-BANGLA AGRICULTURAL UNIVERSITY
DHAKA 1207

DECEMBER, 2010

EFFECT OF DIFFERENT LEVELS OF NITROGEN AND TRANSPLANTING DEPTH ON GROWTH AND YIELD OF BRRI dhan50

BY

MD. APPEL MAHMUD

REG. NO. : 09-03716

A Thesis
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 (MS)
IN
AGRONOMY

SEMESTER: JULY-DECEMBER, 2010

APPROVED BY:

Prof. Dr. Tuhin Suvra Roy Supervisor	**Prof. Dr. Parimal Kanti Biswas** Co-Supervisor

Prof. Dr. A. K. M. Ruhul Amin
Chairman
Examination Committee

DEDICATED
TO
MY BELOVED PARENTS

DEPARTMENT OF AGRONOMY
Sher-e-Bangla Agricultural University
Sher-e-Bangla Nagar, Dhaka-1207

CERTIFICATE

This is to certify that the thesis entitled **“Effect of Different Levels of Nitrogen and Transplanting Depth on Growth and Yield of BRRI dhan50”** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **Master of Science** in **Agronomy**, embodies the result of a piece of bonafide research work carried out by **Md. Appel Mahmud**, Registration number: **09-03716** 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.

Dated:
Dhaka, Bangladesh

Prof. Dr. Tuhin Suvra Roy
Department of Agronomy
Sher-e-Bangla Agricultural University
Dhaka-1207

ACKNOWLEDGEMENTS

All praises to Almightly and Kindfull trust on to "Omnipotent Creator" for His never-ending blessing, the author deems it a great pleasure to express his profound thankfulness to his respected parents, who entiled much hardship inspiring for prosecuting his studies, receiving proper education.

The author likes to express his deepest sense of gratitude to his respected Supervisor, Dr. Tuhin Suvra Roy, Professor, Department of Agronomy, Sher-e-Bangla Agricultural University (SAU), Dhaka for his scholastic guidance, support, encouragement and invaluable suggestions and constructive criticism throughout the study period, gratuitous labor in conducting and successfully completing the research work, and in the preparation of the manuscript.

The author also grateful to his respected Co-Supervisor, Dr. Parimal Kanti Biswas, Professor, Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka for his scholastic guidance, helpful comments and constant inspiration, inestimatable help, valuable suggestions throughout the research work and in preparation of the thesis.

The author expresses his sincere gratitude towards the sincerity of the Chairman, Dr. A. K. M. Ruhul Amin, Professor, Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka for his valuable suggestions and cooperation during the study period. The author also expresses heartfelt thanks to all the teachers of the Department of Agronomy, SAU, for their valuable suggestions, instructions, cordial help and encouragement during the period of the study.

The author expresses his sincere appreciation to his brother, sisters, relatives, well wishers and friends for their inspiration, help and encouragement throughout the study period.

The Author

EFFECT OF DIFFERENT LEVELS OF NITROGEN AND TRANSPLANTING DEPTH ON GROWTH AND YIELD OF BRRI dhan50

ABSTRACT

A field experiment was conducted at the experimental field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during November 2010 to April 2011 to study the effect of different levels of nitrogen and transplanting depth on the growth and yield of BRRI dhan50. The experiment consists of 4 different levels of N (0, 92, 115 and 136 kg ha^{-1}) and 3 levels of transplanting depth (1.5, 3.0 and 4.5 cm). The experiment was laid out in split-plot design with three replications. Both nitrogen levels and transplanting depth had significant effects on most of the growth and yield contributing characters of BRRI dhan50. At 30, 50, 70 and 90 DAT (days after transplanting) and at harvest, the longest plant (27.07 cm, 43.85 cm, 61.22 cm, 78.37 cm and 95.35 cm) was observed from 136 kg N ha^{-1}, while the shortest plant (21.92 cm, 35.51 cm, 52.22 cm, 66.02 cm and 82.71 cm) was recorded from the application of 0 kg N ha^{-1}. The highest grain yield (6.17 t ha^{-1}) was obtained from 115 kg N ha^{-1}, while the lowest yield (3.53 t ha^{-1}) was found from 0 kg N ha^{-1}. At 30, 50, 70 and 90 DAT and at harvest, the longest plant (25.57 cm, 41.89 cm, 59.56 cm, 75.72 cm and 94.42 cm) was recorded from transplanting at 3.0 cm depth, while the shortest plant (24.44 cm, 39.73 cm, 55.92 cm, 72.34 cm and 88.49 cm) was observed from transplanting at 1.5 cm depth. The maximum number of effective tillers hill^{-1} (12.12) was observed from transplanting at 3.0 cm depth and the minimum number (11.09) was recorded from transplanting at 1.5 cm depth. The highest grain yield (5.63 t ha^{-1}) was found from transplanting at 3.0 cm depth, whereas the lowest yield (5.16 t ha^{-1}) was recorded at 1.5 cm depth. At 30, 50, 70 and 90 DAT and at harvest, the longest plant (28.17 cm, 45.45 cm, 63.76 cm, 82.33 cm and 98.89 cm) was found from the combination of 136 kg N ha^{-1} and transplanting at 3.0 cm depth, 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 0 kg N ha^{-1} and transplanting at 1.5 cm depth. The maximum number of effective tillers hill^{-1} (14.00) was recorded from the treatment combination of 136 kg N ha^{-1} and transplanting at 4.5 cm depth, again the minimum number (8.50) was found from 0 kg N ha^{-1} and transplanting at 1.5 cm depth. The highest grain yield (6.41 t ha^{-1}) was recorded from the treatment combination of 115 kg N ha^{-1} and transplanting at 3.0 cm depth and the lowest yield (3.24 t ha^{-1}) from 0 kg N ha^{-1} and transplanting at 1.5 cm depth. It may be concluded that growth, yield and yield contributing characters of BRRI dhan50 were greatly influenced by nitrogen level and transplanting depth. Applications of 115 kg N ha^{-1} at transplanting depth 3.0 cm provided the maximum yields of BRRI dhan50.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

CHAPTER I

INTRODUCTION

Rice is the most important food for majority of people around the world. It is the staple food for more than two 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 in Bangladesh (4.2 t ha^{-1}) is very low compared to those of other rice growing countries, like China is (8.75 t ha^{-1}), Japan (8.22 t ha^{-1}) and Korea (8.04 t ha^{-1}) also (FAO, 2009). 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.

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 to success of production systems of Bangladesh agriculture being responsible for about 50% of the total crop production (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, optimum nitrogen (N) is essential for vegetative growth but excess N may cause excessive vegetative growth, prolong the growth duration and delay crop maturity with reduction in grain yield. Among the different elements N is universally needed for all crops. Many workers have reported a significant response of rice to N fertilizer in different soils (Bhuiya *et al.*, 1989; Hussain *et al.*, 1989). The efficient N management can increase crop yield and reduce production cost. An increase in the yield of rice by 70 to 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 N fertilizer plays vital role for the growth and development of rice plant and its growth is seriously hampered when lower dose of N is applied, which drastically reduced yield; further, excessive N 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 rate of N application for efficient utilization of these elements by the plants for better yield.

Appropriate transplanting depth is one of the most important cultural practices for *Boro* rice, may have a positive effect on the number of tillers hill^{-1}, grains panicle^{-1} and ultimately this can increase the yield of rice (Grist, 1965). Ahmed and Faiz (1972) reported that transplanting depth can play an important role for achieving higher yield of rice because chemical and mineralogical composition, biotic activities, organic matter content and plant nutrients such as N, P, K, S etc., differ significantly with the depths of soil (Miller *et al.*, 1965). Therefore, proper transplanting depth provides adequate root zone area and sufficient moisture level for having proper growth and development of the crop. As for example, greater transplanting depth of rice seedlings hampers normal root development and a new root system develops from the upper nodes. This phenomenon retards plant growth which ultimately affects the yield (Grist, 1965). However, there are reports that increasing transplanting depth results in the decrease in grain yield and its components (BRRI, 1979; Karim, 1985 and Sarker *et al*., 1986). A suitable depth of transplanting for a cultivar of rice under question may play a remarkable role for the improvement in yield of *Boro* rice. Very recently various new rice varieties were developed and available as BRRI dhan**.** The BRRI dhan50 (Banglamoti) is exceptionally high yielding, slender and has mild aroma of cooked rice. It was recommended for cultivation in *Boro* season. Under this circumstance the present research work has been taken with the following objectives:

a. To find out the effects of different levels of N on growth and yield of BRRI dhan50.

b. To find out the effects of transplanting depths on growth and yield of BRRI dhan50

c. To find out the interaction effects of different levels of N and transplanting depths on growth and yield of BRRI dhan50.

CHAPTER II

REVIEW OF LITERATURE

Yield and yield contributing characters of rice are considerably depends on manipulation of basic ingredients of agriculture. The basic ingredients include variety, environment and agronomic practices (transplanting depth, density & time, fertilizer, irrigation, weeding etc.). Among the above factors nitrogen and transplanting depth are more responsible for the growth and yield of rice. High yielding varieties (HYV) are generally more adaptive to appropriate nitrogen application and transplanting depth and they produce higher yield with increasing nitrogen levels up to a certain end with optimum transplanting depth. The available relevant reviews of related to nitrogen management and transplanting depth in the recent past have been presented and discussed under the following headings:

2.1 Effect of nitrogen management on rice

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 of *Boro* rice. 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 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). They also 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. They also reported 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 length, 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}. Naseem *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. He also observed that yield 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. 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. He also mentioned from 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.

2.1.2 Yield parameters

Grain yield

A field experiment was conducted by Hossain *et al.* (2008) to evaluate the effect of different nitrogen levels on the performance of four rice varieties in transplanted aman (monsoon) season. Aromatic rice varieties included BRRI dhan38, Kalizira, Badshabhog and Tulsimala, while nitrogen was applied at 30, 60, 90 and 120 kg ha^{-1}. Performance of different varieties was different. All the yield components were significantly increased up to 90 kg N ha^{-1}. Nonetheless, maximum grain yield (3.62 t ha^{-1}) was observed from 60 kg N ha^{-1}.

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.

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 $hills^{-1}$ 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 as 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.

Surekha *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}).

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 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.

2.2 Effect of transplanting depth on rice

2.2.1 Growth parameters

Plant height

Plant height is significantly influenced by the interaction effect between cultivar and depth of transplanting. BAU-63 produced taller plants when planted at 8 cm depth than BR3 cultivar with similar depth of transplanting (Sarker *et al.*, 1986). But in another study Karim (1985) observed that plant height was not significantly affected by various planting depth though the tallest plants (112.23 cm) were produced from 2.5 cm planting depth and the shortest plants (110.18 cm) from 7.5 cm planting depth.

Enyi (1963) found that seedlings transplanted to a depth of 9.0 cm produced plants significantly taller than those of transplanted to 3.0 cm and 6.0 depths, respectively at 30 days after transplanting.

Total tillers hill^{-1}

Rao *et al*. (1986) found that planting depth did not influence the poorly or moderately tillering varieties Visaya and Kanagi but shallow planting resulted in a better response than deeper planting in pro functional tillering Kalinga-11. Karim (1985) reported that there was a reduction in tiller number with increase in depth of transplanting beyond 5.0 cm.

BRRI (1979) carried out a research on the depth of planting with BR7 rice variety using different depths of transplanting and found a progressive deterioration of tillering rate with an increase in transplanting depth. When the seedlings were shallowly planted 1.0-5.0 cm they reported that the total number of tillers/hill did not differ significantly.

Matsushima (1976) got the similar result that shallow transplanting of 1 cm depth promoted the emergence of tillers in the early growth period in comparison to deep transplanting of 5 cm depth. Rice seedlings planted deeper than 2-4 cm delayed and reduced tiller formation.

Generally, no standard depth of transplanting of rice is followed in Bangladesh. But the depth of transplanting influences total tillers hill^{-1} which ultimately affect the grain yield of rice plant. Kawasima and Tanabe (1970) observed that shallow planting of 20 days old seedlings produced higher number of tillers hill^{-1}. In terms of tillering nature, the majority of available research findings indicated that shallow planting was better than deep planting. But Enyi (1963) stated that deep transplanting increased the tiller number and reduced the tiller mortality.

Effective tillers hill^{-1}

Karim (1985) reported that 5.0 cm planting depth produced higher number of effective tillers hill^{-1} which was significantly superior to 1.0 cm and 7.5 cm planting depths, respectively. In a depth of planting study with BR7 rice BRRI (1979) indicated that the effective tillers differed between planting depth except in 3.0 cm where higher numbers of panicles were attained. Matsushima (1976) stated that shallow depth of transplanting promotes the emergence of tillers in the early growth period resulting in increase effective tillers.

There are contradictory reports regarding the production of effective tillers hill^{-1} due to different planting depths. Padalia and Mahpatra (1965) carried out an experiment with depths of 1.0, 3.0, 7.0 and 15.0 cm and in presence of NPK alone or in combination at different rates and they found that shallow planting increase slightly the number of effective tillers hill^{-1}.

Panicle length

Duraisamy *et al*. (2011) carried out a field experiment during March-June 2008 at wetland in Tamil Nadu Agricultural University to optimize the spacing and depth of transplanting in rice cultivation using a self propelled rice transplanter (Yanmar 6 row). The treatment consisted of 4 levels of hill spacing in the main plot and depth of planting (manual: 2 cm and 4 cm depth) in the sub plot. Among the depth of planting, panicle length (22 cm) were produced in 4 cm depth.

Panicle of *Boro* rice is influenced by the depth of the planting density. From a study of Mahapatra and Padalia (1971) regarding the various depths of transplanting of rice seedlings it was revealed that the panicle length in plants increased with the increase of planting depth.

Total spikelets panicle^{-1}

Karim (1985) reported that an increase in depth of planting beyond 2.5 cm increased the total number of spikelets per panicle. Depth of planting and age of seedlings interacted to cause a marked variation in the number of total spikelets panicle^{-1}. Kawashima and Tanabe (1970) found that shallow planting of 20 day old seedlings produced higher number of spikelets per panicle than 40 day old seedlings.

Filled grains panicle^{-1}

Duraisamy *et al*. (2011) conducted a field experiment during March-June 2008 at wetland in Tamil Nadu Agricultural University to optimize the spacing and depth of transplanting in rice cultivation using a self propelled rice transplanter (Yanmar 6 row). The treatment consisted of 4 levels of hill spacing in the main plot and depth of planting (manual, 2 cm and 4 cm depth) in the sub plot. Among the depth of planting, filled grains panicle^{-1} (113) were produced in 4 cm depth.

The number of filled grains per panicle is influenced significantly by the depth of planting. In a field experiment Karim (1985) observed that 5.0 cm planting depth produced the maximum number of grains per panicle which was identical to 2.5 cm planting depth whereas transplanting at 1.0 cm depth produced the minimum number of grains per panicle which was identical to 7.5 cm planting depth.

2.2.2 Yield parameters

Grain yield

A field experiment was conducted by Duraisamy *et al*. (2011) during March-June 2008 at wetland in Tamil Nadu Agricultural University to optimize the spacing and depth of transplanting in rice cultivation using a self propelled rice transplanter (Yanmar 6 row). The treatment consisted of 4 levels of hill spacing in the main plot and depth of planting (manual: 2 cm and 4 cm depth) in the sub plot. Among the depth of planting, grain yield (7,667 kg ha^{-1}) were produced in 4 cm depth.

Sarker *et al.* (1986) repotted that by sing variety BAU-63 and BR3 in Boro rice reported that the depth of transplanting below 6 cm produced significantly lower grain yield. Karim (1985) found similar results that shallow planting produced lower gain yield than deeper planting.

Patel *et al. (*1983) showed that the grain yield increased by transplanting 24 day old seedling to a depth 3.0 to 4.0cm than transplanting of 36 or 45 day old seedlings at a depth of 3.0 to 4.0 cm or 5.0 to 7.0 cm.

In an experiment BRRI (1979) used 2 age group of seedlings (20 and 30 day) of BR4 transplanted at various depths ranging from 0 to 8 cm and concluded that overall planting depths and grain yields were higher with 20 day old seedlings than that of 30 day of old seedlings. Grain yield did not differ widely between planting depths except in a few cases which could not be explained.

Though 3.0 and 4.5 cm depth produced higher yield than 1.5, 6.0 or 7.5 cm depths of transplanting, they did not differ significantly (Nair *et al*., 1978).

Similarly Ahmed *et al*. (1972) got the higher yield for 4 seedlings hill^{-1} than 1, 2 or 6 seedlings at a depth of 5.08 than 2.5 and 7.62 cm, respectively.

There is a seasonal variation in depth of transplanting like the number of seedlings hill^{-1}. Mahapatra and Padalia (1971) conducted separate experiments in two seasons and found that in Rabi season, 1.0 and 3.0 cm depth of transplanting produced higher grain yield than transplanting at 5.0 cm and 7.0 cm depth. But in *Kharif* season, 5.0 cm depth gave the highest yield compared to 1.0, 3.0 and 7.0 cm depths, respectively.

Kawasima and Tanabe (1970) observed shallow planting of 20 day old seedlings produced higher yield per hectare of rice than that of 40 day old seedlings with increasing the depth of transplanting.

In case of various depth of transplanting there is a significant difference in grain yield per hectare. Shallow transplanting permits greater advantages over deep transplanting in respect of grain yield. With the increase in depth of transplanting the root formation is delayed and at the same time plant growth is retarded and finally the gain yield is decreased when compared to shallow transplanting (Padalia and Mahapatra, 1965).

From the literature cited above it may be concluded that the yield and yield Components of rice vary with various depths of transplanting. Responses of rice to different depths of transplanting vary in different seasons of the year and rice cultivars response differently to different depths of transplanting. Variation in rice yield has also been found in different countries of the world due to different depths of transplanting. Therefore, the present research work has been planned and conducted to determine the influence of depth of transplanting on the growth and yield of rice under Bangladesh condition.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted at the Agronomy experimental field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from November 2010 to April 2011 to study the effect of different levels of nitrogen and transplanting depths on growth and yield of BRRI dhan50. The details of the materials and methods have been presented below:

3.1 Description of the experimental site

3.1.1 Location

The present piece of research work was conducted in the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka. The location of the site is $23^0 74^/$N latitude and $90^0 35^/$E longitude with an elevation of 8.2 m from sea level. Location of the experimental site presented in Appendix I.

3.1.2 Soil

The soil belongs to “The Modhupur Tract”, AEZ – 28 (FAO, 1988). Top soil was silty clay in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. Soil pH was 5.6 and has organic carbon 0.45%. The experimental area was flat having available irrigation and drainage system and above flood level. The selected plot was medium high land. The details were presented in Appendix II.

3.1.3 Climate

The geographical location of the experimental site was under the subtropical climate, characterized by 3 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 metrological 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, presented in Appendix III.

3.2 Test crop and its characteristics

BRRI dhan50 was used as the test crop in this experiment. This variety was developed at the Bangladesh Rice Research Institute (BRRI). It is recommended for *Boro* season. Average plant height of the variety is 80 to 85 cm at the ripening stage. The grains are medium fine and white. It requires about average 152 to 155 days completing its life cycle with an average grain yield of 6.0 to 6.5 t ha^{-1} (BRRI, 2011).

3.3 Experimental details

3.3.1 Treatments

The experiment comprised as two factors.

Factor A: Nitrogen level: 4 levels

i. 0 kg N ha^{-1} (control) – N_0
ii. 92 kg N ha^{-1} – N_1
iii. 115 kg N ha^{-1} – N_2
iv. 136 kg N ha^{-1} – N_3

Factor A: Transplanting depth: 3 levels

i. Transplanting at 1.5 cm depth from soil level – D_1
ii. Transplanting at 3.0 cm depth from soil level – D_2
iii. Transplanting at 4.5 cm depth from soil level – D_3

There were 12 (4 × 3) treatment combinations viz., N_0D_1, N_0D_2, N_0D_3, N_1D_1, N_1D_2, N_1D_3, N_2D_1, N_2D_2, N_2D_3, N_3D_1, N_3D_2, and N_3D_3.

3.3.2 Experimental design and layout

The experiment was laid out in split-plot design with 3 replications. Nitrogen was assigned to main plots and transplanting depth to sub-plots. The layout of the experiment was prepared for distributing the combination of level of N and transplanting depth. The 12 treatment combinations of the experiment were assigned at random into 12 plots of each replication.

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 dhan50 were collected from Bangladesh Rice Research Institute (BRRI), Joydevpur, Gazipur.

3.4.1.2 Seed sprouting

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

3.4.1.3 Preparation of seedling nursery bed and seed sowing

Two pieces of high land were selected in the Agronomy Field of Sher-e-Bangla Agricultural University for raising seedlings. The land was puddled well with country plough followed by cleaning and leveled with ladder. Pre-germinated seeds were sown in the wet nursery bed on 09 November 2010, respectively to get 32 days old seedlings. Proper care was taken to raise the seedlings in the nursery bed. Weeds were removed and irrigation was given in the nursery bed as and when necessary.

3.4.2 Preparation of the main field

The plot selected for the experiment was opened in the last week of December 2010 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 one third amount of urea and entire amount of TSP, MP, Gypsum, Zinc sulphate and borax were applied during the final preparation of land. Rest urea was applied in two equal installments at tillering and panicle initiation stage. The dose and method of application of fertilizer are shown in Table 1.

Table 1. Levels and methods of application of fertilizers in rice field

Fertilizers	Dose (kg/ha)	Application (%)		
		Basal	1st installment	2nd installment
Urea	As per treatment	33.33	33.33	33.33
TSP	120	100	--	--
MP	120	100	--	--
Gypsum	100	100	--	--
Borax	10	100	--	--

Source: BRRI, 2011 (Adunik Dhaner Chash)

3.4.4 Uprooting seedlings

The nursery beds were made wet by application of water both in the morning and evening on the previous day before uprooting the seedlings avoiding mechanical injury to the roots. The seedlings were uprooted and kept on soft mud in shade before transplanting.

3.4.5 Transplanting of seedlings in the field

Seedlings of 32 days old were transplanted on the well puddled experimental plots on 10 January 2011 in the main field at the rate of 2-3 seedlings hill^{-1} with 20 × 15 cm spacing. Planting depth was maintained by measuring scale as per treatments.

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

Experimental field was given flood irrigation to maintain a constant level of standing water up to 6 cm in early stage to enhance tillering and 10 to12 cm in later stage to discourage late tillering. A total of 7 to 8 irrigations was needed throughout the growing season. The field was finally drained out before 15 days of harvest to enhance maturity.

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 and same sources seedlings.

3.4.6.3 Weeding

Weedings were done to keep the plots free from weeds, which ultimately ensured better growth and development. First weeding was done at 20 days after transplanting, 2^{nd} and 3^{rd} weeding was done at 35 and 50 DAT.

3.4.6.4 Top dressing

After basal dose, the remaining doses of urea (as per treatment) were top-dressed in 2 equal installments and were applied at (30 DAT) and 50 (DAT) with the soil.

3.4.6.5 Plant protection

The plots were infested by rice stem borer (*Sesamia inferens*) which was successfully controlled by applying Basudin 10 G at the rate of 16.8 $kgha^{-1}$. There was no disease infestation on the crop.

3.5 Harvesting, threshing and cleaning

The crop was harvested at full maturity on 28 April 2011and harvesting was done manually from each plot. The harvested crop of each plot was bundled separately, properly tagged and brought to threshing floor. Enough care was taken for harvesting, threshing and also 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 recorded at the time of 30, 50, 70 and 90 DAT by counting total tillers. Data were recorded as the average of 5 hills selected at random from the inner rows of each plot.

3.6.3 Dry matter hill^{-1}

Total dry matter hill^{-1} was recorded at the time of 30, 50, 70, 90 DAT and at harvest by drying plant sample. Data were recorded as the average of 3 samples hill^{-1} selected at random from the inner rows of each plot (leaving harvest area) and expressed in gram.

3.6.4 Effective tillers hill^{-1}

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

3.6.5 Ineffective tillers hill^{-1}

The total number of ineffective tillers hill^{-1} was counted as the number of non panicle bearing tillers hill^{-1}. Data on ineffective tillers 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 ineffective 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 grains panicle^{-1}

The total number of filled grains was collected randomly from selected 5 panicles of a plot 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 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 grains

One thousand grains 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 was recorded 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 was recorded 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:

$$\text{Biological yield} = \text{Grain yield} + \text{Straw yield}.$$

3.6.15 Harvest index

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

$$\text{HI} = \frac{\text{Economic yield (Grain yield)}}{\text{Biological yield (Grain yield + Straw yield)}} \times 100$$

3.7 Statistical Analysis

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

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to determine the effects of different levels of N and transplanting depth on the growth and yield of BRRI dhan50. Data on different growth parameter, 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 and possible interpretations given under the following headings:

4.1 Plant height

A significant variation was observed for N rate on plant height of BRRI dhan50 at 30, 50, 70, 90 DAT and at harvest (Appendix IV and Fig.1). At 30 DAT, the longest plant (27.07 cm) was observed in N_3 (136 kg N ha^{-1}) which was statistically similar (26.73 cm) with N_2 (115 kg N ha^{-1}) and followed (24.27 cm) by N_1 (92 kg N ha^{-1}), again the shortest plant (21.92 cm) was recorded in N_0 (0 kg N ha^{-1}). The longest plant (43.85 cm) was found in N_3 which was statistically similar (43.63 cm) with N_2 and followed (40.80 cm) by N_1, while the shortest plant was obtained in N_0 (35.51 cm) at 50 DAT. At 70 DAT, the longest plant was found in N_3 (61.22 cm) which was statistically similar with N_2 (60.94 cm) and followed by N_1 (57.90 cm), whereas the shortest plant was recorded in N_0 (52.22 cm). The longest plant was observed in N_3 (78.37 cm) which was statistically similar with N_2 (77.67 cm) and followed by N_1 (74.48 cm), again the shortest plant was found in N_0 (66.02 cm) at 90 DAT. At harvest, the longest plant was recorded in N_2 (95.35 cm) which was closely followed by N_3 (94.10 cm) and N_1 (93.46 cm). On the other hand, the shortest plant was obtained in N_0 (82.71 cm). Reddy *et al.* (1990) reported a significant effect of N on plant height in rice with 120 kg N ha^{-1}.

Plant height of BRRI dhan50 showed statistically significant differences at 30, 50, 70 and 90 DAT and at harvest due to the different transplanting depth (Appendix IV and Fig.2). At 30 DAT, the longest plant (25.57 cm) was recorded in D_2 (transplanting at 3.0 cm depth) which was statistically similar (25.04 cm) with D_3 (transplanting at 4.5 cm depth), while the shortest plant (24.44 cm) was observed in D_1 (transplanting at 1.5 cm depth). The longest plant was found in D_2 (41.89 cm) which was statistically similar with D_3 (41.20 cm) and the shortest plant was observed in D_1 (39.73 cm) at 50 DAT. At 70 DAT, the longest plant was observed in D_2 (59.56 cm) which was statistically similar with D_3 (58.69 cm), while the shortest plant was observed in D_1 (55.92 cm). The longest plant was recorded in D_2 (75.72 cm) which was statistically similar with D_3 (74.29 cm) and the shortest plant was observed in D_1 (72.34 cm) at 90 DAT. At harvest, the longest plant was recorded in D_2 (94.42 cm) which was closely followed by D_3 (90.44 cm), while the shortest plant was found in D_1 (88.49 cm).

Interaction effect of N and transplanting depth showed significant differences for plant height of BRRI dhan50 at 30, 50, 70 and 90 DAT and at harvest (Appendix IV and Table 2). At 30 DAT, the longest plant (28.17 cm) was found in the treatment combination of N_3D_2 (136 kg N ha^{-1} × transplanting at 3.0 cm depth) and the shortest plant height (20.94 cm) was observed in the treatment combination of N_0D_1 (0 kg N ha^{-1} × transplanting at 1.5 cm depth). The longest plant (45.45 cm) was recorded in the treatment combination of N_3D_2, while the shortest (33.80 cm) was found in the treatment combination of N_0D_1 at 50 DAT. At 70 DAT, the longest plant (63.76 cm) was obtained in the treatment combination of N_3D_2 and the shortest plant (49.97 cm) was recorded in the treatment combination of N_0D_1. The longest plant (82.33 cm) was found in the treatment combination of N_3D_2, while the shortest (64.60 cm) was observed in the treatment combination of N_0D_1 at 90 DAT. At harvest, the longest plant (98.89 cm) was obtained in the treatment combination of N_3D_2 whereas the shortest (80.87 cm) was recorded in the treatment combination of N_0D_1 .

Table 2. Interaction effect of N levels and transplanting depths on plant height of BRRI dhan50

Treatments	Plant height (cm) at				
	30 DAT	50 DAT	70 DAT	90 DAT	Harvest
N_0D_1	20.94 e	33.80 g	49.97 f	64.60 f	80.87 g
N_0D_2	21.81 de	35.71 f	52.20 f	67.27 f	85.80 f
N_0D_3	23.13 cd	36.93 f	54.53 e	66.13 f	81.50 g
N_1D_1	23.75 c	39.70 e	55.50 e	72.83 e	91.13 e
N_1D_2	25.53 b	42.07 cd	59.80 cd	76.50 bcd	96.00 b
N_1D_3	23.53 c	40.63 de	58.37 d	74.10 de	93.23 cd
N_2D_1	26.89 ab	43.13 bc	59.03 cd	77.43 bc	92.87 d
N_2D_2	26.87 ab	44.23 ab	62.55 ab	76.95 bcd	96.53 b
N_2D_3	26.47 b	43.53 abc	61.23 bc	78.67 b	94.33 c
N_3D_1	26.07 b	42.37 b-d	59.23 cd	74.53 cde	93.04 cd
N_3D_2	28.17 a	45.45 a	63.76 a	82.33 a	98.89 a
N_3D_3	27.03 ab	43.70 abc	60.63 bcd	78.27 b	92.70 d
SE	0.578	0.645	0.809	1.09	0.455
CV(%)	6.00	5.73	7.41	9.54	7.86

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

N_0: 0 kg N ha^{-1} (control)	D_1: Transplanting at 1.5 cm depth
N_1: 92 kg N ha^{-1}	D_2: Transplanting at 3.0 cm depth
N_2: 115 kg N ha^{-1}	D_3: Transplanting at 4.5 cm depth
N_3: 136 kg N ha^{-1}	

4.2 Number of tillers hill^{-1}

Number of tillers hill^{-1} of BRRI dhan50 showed significant effects at 30, 50, 70 and 90 DAT due to different N level (Appendix V and Table 3). At 30 DAT, the highest number of tillers hill^{-1} (5.97) was found in N_3 (136 kg N ha^{-1}) which was closely followed (5.42) with N_2 (115 kg N ha^{-1}), while the lowest number (3.73) was obtained in N_0 (0 kg N ha^{-1}) and followed (4.60) by N_1 (92 kg N ha^{-1}). The highest number of tillers hill^{-1} (18.36) was found in N_3 which was closely followed by N_2 (16.04), whereas the lowest number (12.81) found in N_0 which was closely followed (15.51) by N_1 at 50 DAT. At 70 DAT, the highest number of tillers hill^{-1} (18.20) was recorded in N_3 which was closely followed (16.53) by N_2 and the lowest number (15.91) was observed in N_1 which was closely followed (16.65) by N_0 . At 90 DAT, highest number of tillers hill^{-1} (17.91) was recorded in $N_{3,}$ whereas the lowest number (15.63) was found in N_0. Islam *et al.* (1996) reported that number of effective tillers hill^{-1} increased with increasing N level up to 150 kg Nha^{-1}.

Statistically significant variation was also found for number of tillers hill^{-1} of BRRI dhan50 at 30, 50, 70 and 90 DAT due to the different transplanting depth (Appendix V and Table3). At 30 DAT, the highest number of tillers hill^{-1} (5.19) was obtained in D_2 (transplanting at 3.0 cm depth) which was closely followed (4.89) by D_1 (transplanting at 1.5 cm depth), while the lowest number (4.71) was recorded in D_3 (transplanting at 4.5 cm depth). The highest number of tillers hill^{-1} (15.88) was

Table 3. Effect of N levels and transplanting depths on number of tillers hill^{-1} of BRRI dhan50

Treatments	Number of tillers hill^{-1} at			
	30 DAT	50 DAT	70 DAT	90 DAT
Levels of N				
N_0	3.73 d	12.81 d	14.65 b	15.63 c
N_1	4.60 c	15.51 c	15.91 c	16.13 b
N_2	5.42 b	16.04 b	16.53 b	16.63 b
N_3	5.97 a	18.36 a	18.20 a	17.91 a
SE	0.136	0.048	0.166	0.276
Transplanting depth				
D_1	4.89 b	15.57 b	17.08 a	17.37 a
D_2	5.19 a	15.59 b	17.07 a	17.58 a
D_3	4.71 b	15.88 a	16.32 b	16.29 b
SE	0.082	0.076	0.180	0.108
CV(%)	5.79	7.67	6.70	5.19

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

N_0: 0 kg N ha^{-1} (control)
N_1: 92 kg N ha^{-1}
N_2: 115 kg N ha^{-1}
N_3: 136 kg N ha^{-1}

D_1: Transplanting at 1.5 cm depth
D_2: Transplanting at 3.0 cm depth
D_3: Transplanting at 4.5 cm depth

obtained in D_3 and the lowest number (15.57) was found in D_1 at 50 DAT which was statistically similar (15.59) with D_2. The highest number of tillers hill^{-1} (17.08) was recorded in D_1 which was statistically similar (17.07) by D_2 and the lowest number (16.32) was recorded in D_3 at 70 DAT (Table 3). At 90 DAT, the highest number of tillers hill^{-1} (17.58) was recorded in D_2 which was statistically identical (17.37) with D_1, again the lowest number (16.29) was found in D_3.

Significant variation was observed for number of tillers hill^{-1}of BRRI dhan50 at 30, 50, 70 and 90 DAT due to interaction effect of N and transplanting depth (Appendix V and Table 4). At 30 DAT, the highest number of tillers hill^{-1} (6.37) was recorded in the treatment combination of N_3D_2 (136 kg N ha^{-1} × transplanting at 3.0 cm depth), while the lowest number (3.43) was obtained in the treatment combination of N_0D_2 (0 kg N ha^{-1} × transplanting at 3.0 cm depth). The highest number of tillers hill^{-1} (18.97) was found in the treatment combination of N_3D_2 and the lowest number (12.57) was found in the treatment combination of N_0D_2 at 50 DAT. The highest number of tillers hill^{-1} (19.55) was obtained in the treatment combination of N_3D_2, whereas the lowest number (15.65) was recorded in the treatment combination of N_0D_3 at 70 DAT. At 90 DAT, the highest number of tillers hill^{-1} (19.20) was observed in the treatment combination of N_3D_2 whereas the lowest number (15.80) was found in the treatment combination of N_1D_3 .

Table 4. Interaction effect of N levels and transplanting depths on number of tillers hill^{-1} of BRRI dhan50

Treatments	Number of tillers hill^{-1} at			
	30 DAT	50 DAT	70 DAT	90 DAT
N_0D_1	4.17 d	12.93 h	17.80 b	18.50 b
N_0D_2	3.43 e	12.57 h	16.50 cde	17.60 c
N_0D_3	3.60 e	12.93 h	15.65 e	16.80 de
N_1D_1	4.13 d	15.53 fg	15.83 de	16.50 ef
N_1D_2	5.10 c	15.13 g	16.01 de	16.10 fg
N_1D_3	4.57 d	15.87 def	15.88 de	15.80 g
N_2D_1	5.17 c	16.13 de	16.90 bcd	16.87 de
N_2D_2	5.87 ab	15.67 ef	16.20 cde	17.40 cd
N_2D_3	5.23 c	16.33 d	16.50 cde	15.63 g
N_3D_1	6.10 a	17.70 c	17.80 b	17.60 c
N_3D_2	6.37 a	18.97 a	19.55 a	19.20 a
N_3D_3	5.43 bc	18.40 b	17.26 bc	16.93 cde
SE	0.165	0.151	0.360	0.216
CV(%)	5.79	7.67	6.70	5.19

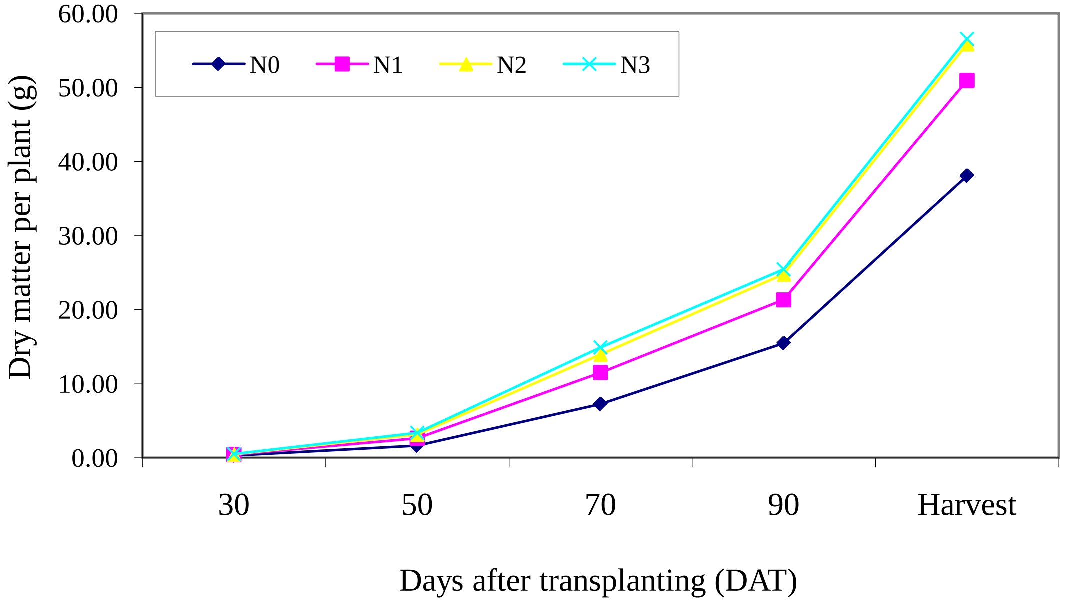
In a column mean values having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of significance

N_0: 0 kg N ha^{-1} (control)	D_1: Transplanting at 1.5 cm depth
N_1: 92 kg N ha^{-1}	D_2: Transplanting at 3.0 cm depth
N_2: 115 kg N ha^{-1}	D_3: Transplanting at 4.5 cm depth
N_3: 136 kg N ha^{-1}	

4.3 Dry matter hill^{-1}

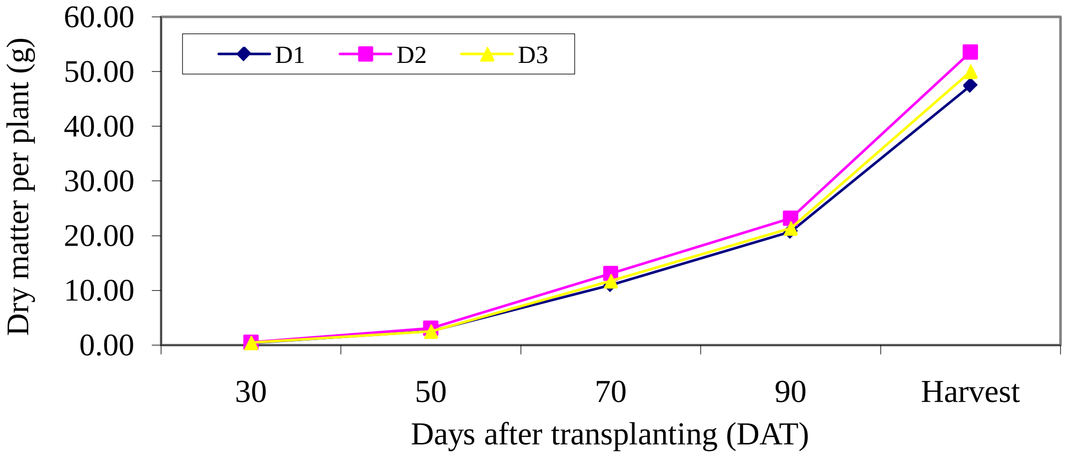
Different N level showed significant differences on dry matter hill^{-1} of BRRI dhan50 at 30, 50, 70, 90 DAT and at harvest (Appendix VI and Fig. 3). At 30 DAT, the highest dry matter hill^{-1} (0.517 g) was produced in N_3 (136 kg N ha^{-1}) which was statistically similar (0.497 g) with N_2 (115 kg N ha^{-1}) and followed (0.437 g) by N_1 (92 kg N ha^{-1}), again the lowest (0.326 g) was obtained in N_0 (0 kg N ha^{-1}). The highest dry matter hill^{-1} (3.36 g) was found in N_3 which was closely followed (3.17 g) by N_2, while the lowest (1.65 g) was recorded in N_0 which was followed (2.66 g) by N_1 at 50 DAT. At 70 DAT, the highest dry matter hill^{-1} (14.91 g) was found in N_3 which was closely followed (13.97 g) by N_2, whereas the lowest (7.27 g) was recorded in N_0 which was followed (11.52 g) by N_1. The highest dry matter hill^{-1} (25.45 g) was obtained in N_3 which was closely followed (24.79 g) by N_2 and the lowest (15.47 g) was observed in N_0 which was and followed (21.33 g) by N_1 at 90 DAT. At harvest, the highest dry matter hill^{-1} (56.57 g) was observed in N_2 which was statistically similar (55.85 g) with N_3 and closely followed (50.95 g) by N_1, whereas the lowest (38.05 g) was recorded in N_0. Xie *et al.* (2007) reported that increased split application of N in control to 140 kg ha^{-1} increased dry matter accumulation (DMA).

Different transplanting depth showed statistically significant differences for dry matter hill^{-1} of BRRI dhan50 at 30, 50, 70 and 90 DAT and at harvest (Appendix VI and Fig. 4). At 30 DAT, the highest dry matter hill^{-1} (0.498 g) was recorded in D_2 (transplanting at 3.0 cm depth) which was closely followed (0.424 g) by D_3



N_0: 0 kg N ha^{-1} N_1: 92 kg N ha^{-1}
N_2: 115 kg N ha^{-1} N_3: 136 kg N ha^{-1}

Figure 3. Effect of N levels on dry matter per plant of BRRI dhan50 [SE= 0.010, 0.050, 0.056, 0.188 and 0.415 for 30, 50, 70, 90 DAT and Harvest]



D_1: Transplanting at 1.5 cm depth
D_2: Transplanting at 3.0 cm depth
D_3: Transplanting at 4.5 cm depth

(transplanting at 4.5 cm depth), whereas the lowest dry matter (0.410 g) was observed in D_1 (transplanting at 1.5 cm depth). The highest dry matter hill^{-1} (3.08 g) was found in D_2 which was closely followed (2.55 g) with D_1, while the lowest (2.50 g) was recorded in D_3 at 50 DAT. At 70 DAT, the highest dry matter hill^{-1} (13.07 g) was found in D_2 which was closely followed (11.69 g) with D_3, again the lowest (10.99 g) was observed in D_1. The highest dry matter hill^{-1} (23.18 g) was obtained in D_2 which was closely followed (21.36 g) with D_3, whereas the lowest (20.74 g) was recorded in D_1 at 90 DAT. At harvest, the highest dry matter hill^{-1} (53.58 g) was found in D_2 which was closely followed (50.03 g) by D_3, while the lowest (47.46 g) was obtained in D_1 .

Transplanting depth and N level showed significant differences due to interaction in terms of dry matter hill^{-1} of BRRI dhan50 at 30, 50, 70 and 90 DAT and at harvest (Appendix VI and Table 5). At 30 DAT, the highest dry matter hill^{-1} (0.583 g) was obtained in the treatment combination of N_3D_2 (136 kg N ha^{-1} × transplanting at 3.0 cm depth), while the lowest (0.285 g) was found in the treatment combination of N_0D_1 (0 kg N ha^{-1} × transplanting at 1.5 cm depth). The highest dry matter hill^{-1} (3.90 g) was recorded in the treatment combination of N_3D_2, whereas the lowest (1.40 g) was observed in the treatment combination of N_0D_1 at 50 DAT. At 70 DAT, the highest dry matter hill^{-1} (16.60 g) was obtained in the treatment combination of N_3D_2 and the lowest (6.30 g) was found in the treatment combination of N_0D_1. The highest dry matter hill^{-1} (26.80 g) was found in the treatment combination of N_3D_2, while the lowest (14.00 g) was observed in

Table 5. Interaction effect of N levels and transplanting depths on dry matter hill^{-1} of BRRI dhan50

Treatments	Dry matter hill^{-1} (g) at				
	30 DAT	50 DAT	70 DAT	90 DAT	Harvest
N_0D_1	0.285 g	1.40 g	6.30 i	14.00 h	34.80 h
N_0D_2	0.330 fg	1.90 f	7.63 h	17.40 f	42.15 f
N_0D_3	0.360 ef	1.59 g	7.85 h	14.97 g	37.17 g
N_1D_1	0.395 e	2.61 d	10.39 g	20.35 e	46.55 e
N_1D_2	0.512 bc	2.99 c	12.75 e	22.62 d	54.75 bc
N_1D_3	0.403 de	2.36 e	11.41 f	21.01 e	51.54 d
N_2D_1	0.475 c	3.04 c	13.55 d	24.22 c	52.95 cd
N_2D_2	0.562 ab	3.48 b	15.26 b	25.91 b	58.78 a
N_2D_3	0.453 cd	2.98 c	13.11 de	24.25 c	55.83 b
N_3D_1	0.485 c	3.10 c	13.70 cd	24.35 c	55.54 b
N_3D_2	0.583 a	3.90 a	16.60 a	26.80 a	58.60 a
N_3D_3	0.480 c	3.06 c	14.37 c	25.23 b	55.56 b
SE	0.022	0.078	0.290	0.237	0.794
CV(%)	8.62	6.96	8.21	10.89	7.73

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

N_0: 0 kg N ha^{-1} (control)	D_1: Transplanting at 1.5 cm depth
N_1: 92 kg N ha^{-1}	D_2: Transplanting at 3.0 cm depth
N_2: 115 kg N ha^{-1}	D_3: Transplanting at 4.5 cm depth
N_3: 136 kg N ha^{-1}	

The treatment combination of N_3D_2 at 90 DAT. At harvest, the highest dry matter hill^{-1} (58.60 g) was recorded in the treatment combination of N_2D_2, again the lowest (34.80 g) was observed in the treatment combination of N_0D_1.

4.4 Number of effective tillers hill^{-1}

Number of effective tillers hill^{-1} of BRRI dhan50 showed significant differences for the application of different N level (Appendix VII and Table 6). The maximum number of effective tillers hill^{-1} (13.59) was found in N_3 (136 kg N ha^{-1}) which was closely followed (13.09) with N_2 (115 kg N ha^{-1}), whereas the minimum number (9.11) was obtained in N_0 (0 kg N ha^{-1}) which was followed (11.03) by N_1 (92 kg N ha^{-1}) treatment.

Number of effective tillers hill^{-1} of BRRI dhan50 varied significantly due to the different transplanting depth (Appendix VII and Table 6). The maximum number of effective tillers hill^{-1} (12.12) was observed in D_2 (transplanting at 3.0 cm depth) which was similar (11.90) by D_3 (transplanting at 4.5 cm depth). On the other hand, the minimum number (11.09) in D_1 (transplanting at 1.5 cm depth).

Transplanting depth and N showed significant differences for number of effective tillers hill^{-1} of BRRI dhan50 due to their interaction effect (Appendix VII and Table 7). The maximum number of effective tillers hill^{-1} (14.00) was recorded in the treatment combination of N_3D_3 (136 kg N ha^{-1} × transplanting at 4.5 cm depth), again the minimum number (8.50) was found in N_0D_1 (0 kg N ha^{-1} × transplanting at 1.5 cm depth) treatment combination.

Table 6. Effect of N levels and transplanting depths on number of effective tillers hill^{-1}, ineffective tillers hill^{-1} and total tillers hill^{-1} of BRRI dhan50

Treatments	Number of effective tillers hill^{-1}	Number of ineffective tillers hill^{-1}	Number of total tillers hill^{-1}
Levels of N			
N_0	9.11 d	6.53 a	15.63 c
N_1	11.03 c	5.11 b	16.14 b
N_2	13.09 b	3.54 d	16.63 b
N_3	13.59 a	4.29 c	17.88 a
SE	0.080	0.141	0.155
Transplanting depth			
D_1	11.09 b	6.28 a	17.38 a
D_2	12.12 a	5.43 b	17.55 a
D_3	11.90 a	4.39 c	16.29 b
SE	0.078	0.085	0.065
CV(%)	7.32	5.50	6.31

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

N_0: 0 kg N ha^{-1} (control)	D_1: Transplanting at 1.5 cm depth
N_1: 92 kg N ha^{-1}	D_2: Transplanting at 3.0 cm depth
N_2: 115 kg N ha^{-1}	D_3: Transplanting at 4.5 cm depth
N_3: 136 kg N ha^{-1}	

4.5 Number of ineffective tillers hill^{-1}

Different N level showed significant variation on number of ineffective tillers hill^{-1} of BRRI dhan50 (Appendix VII and Table 6). The maximum number of ineffective tillers hill^{-1} (6.53) was obtained in N_0 (0 kg N ha^{-1}) which was closely followed (5.11 and 4.29) by N_1 (92 kg N ha^{-1}) and N_3 (136 kg N ha^{-1}), whereas the minimum number (3.54) was found in N_2 (115 kg N ha^{-1}) treatment.

Statistically significant variation was recorded for number of ineffective tillers hill^{-1} of BRRI dhan50 showed due to the different transplanting depth (Appendix VII and Table 6). The minimum number of ineffective tillers hill^{-1} (4.39) was recorded in D_3 (transplanting at 4.5 cm depth), while the maximum number (6.28) was found in D_1 (transplanting at 1.5 cm depth) which was statistically similar (5.43) with D_2 (transplanting at 3.0 cm depth) treatment.

Statistically significant variation was recorded for the interaction effect of N and transplanting depth on number of ineffective tillers hill^{-1} of BRRI dhan50 (Appendix VII and Table 7). The minimum number of ineffective tillers hill^{-1} (2.26) was recorded in the treatment combination of N_2D_3 (115 kg N ha^{-1} × transplanting at 4.5 cm depth), while the maximum number (10.00) was recorded in N_0D_1 (0 kg N ha^{-1} × transplanting at 1.5 cm depth) treatment combination.

Table 7. Interaction effect of N levels and transplanting depths on number of effective tillers hill^{-1}, ineffective tillers hill^{-1} and total tillers hill^{-1} of BRRI dhan50

Treatments	Number of effective tillers hill^{-1}	Number of ineffective tillers hill^{-1}	Number of total tillers hill^{-1}
N_0D_1	8.50 h	10.00 a	18.50 b
N_0D_2	9.25 g	8.35 b	17.60 c
N_0D_3	9.57 g	7.23 c	16.80 d
N_1D_1	10.53 f	6.00 d	16.53 d
N_1D_2	11.90 e	4.20 fg	16.10 e
N_1D_3	10.67 f	5.13 e	15.80 ef
N_2D_1	12.47 d	4.40 fg	16.87 d
N_2D_2	13.43 bc	3.97 g	17.40 c
N_2D_3	13.37 c	2.26 i	15.63 f
N_3D_1	12.87 d	4.73 ef	17.60 c
N_3D_2	13.90 ab	5.20 e	19.10 a
N_3D_3	14.00 a	2.93 h	16.93 d
SE	0.157	0.170	0.130
CV(%)	7.32	5.50	6.31

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

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

N_1: 92 kg N ha^{-1}

N_2: 115 kg N ha^{-1}

N_3: 136 kg N ha^{-1}

D_1: Transplanting at 1.5 cm depth

D_2: Transplanting at 3.0 cm depth

D_3: Transplanting at 4.5 cm depth

4.6 Number of total tillers hill^{-1}

Statistically significant variation was observed for different N level on number of total tillers hill^{-1} of BRRI dhan50 (Appendix VII and Table 6). The maximum number of tillers hill^{-1} (17.88) was found in N_3 (136 kg N ha^{-1}) which was similar with (17.63) by N_0 (0 kg N ha^{-1}), again the minimum number (16.14) was recorded in N_1 (92 kg N ha^{-1}) which was similar (16.63) by N_2 (115 kg N ha^{-1}) treatment.

Different transplanting depth showed significant differences for number of total tillers hill^{-1} of BRRI dhan50 (Appendix VII and Table 6). The maximum number of tillers hill^{-1} (17.55) was found in D_2 (transplanting at 3.0 cm depth) which was similar (17.38) with D_1 (transplanting at 1.5 cm depth), whereas the minimum number (16.29) was attained in D_3 (transplanting at 4.5 cm depth) treatment .

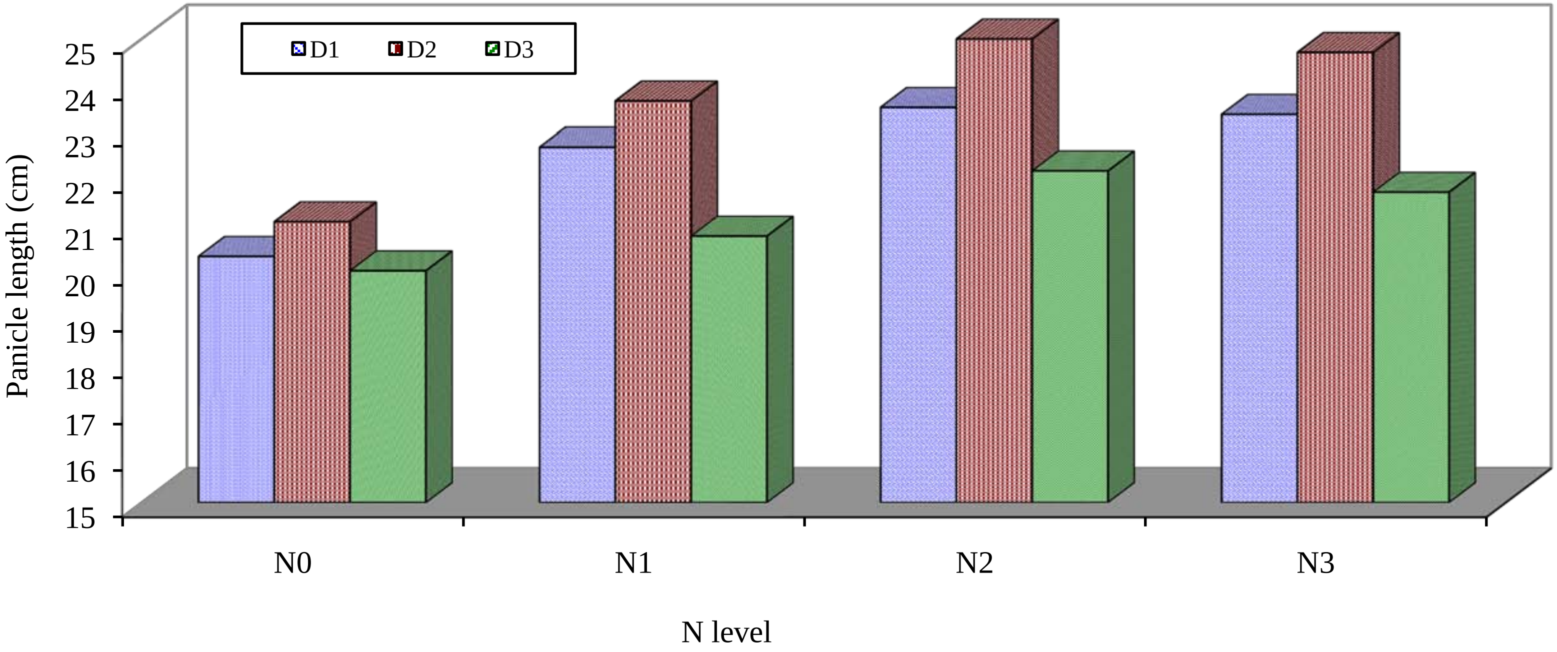
Interaction effect of N and transplanting depth showed significant variation for number of total tillers hill^{-1} of BRRI dhan50 (Appendix VII and Table 7). The maximum number of tillers hill^{-1} (19.10) was observed in the treatment combination of N_3D_2 (115 kg N ha^{-1} × transplanting at 3.0 cm depth). On the other hand the minimum number (15.63) was recorded in N_2D_3 (115 kg N ha^{-1} × transplanting at 4.5 cm depth) treatment combination.

4.7 Length of panicle

Different N level showed significant difference for length of panicle of BRRI dhan50 (Appendix VII and Fig. 5). The longest panicle (23.75 cm) was observed in N_2 (115 kg N ha^{-1}) which was statistically similar (23.25 cm) with N_3 (136 kg N ha^{-1}) and was followed (22.36 cm) by N_1 (92 kg N ha^{-1}), whereas the shortest panicle (20.50 cm) was found in N_0 (0 kg N ha^{-1}) treatment (Figure 5). Rao *et al*. (1997) showed that N 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.

Length of panicle of BRRI dhan50 showed statistically significant differences due to the different transplanting depths (Appendix VII and Fig. 6). The longest panicle (23.70 cm) was recorded in D_2 (transplanting at 3.0 cm depth) which was closely followed (22.47 cm) by D_1 (transplanting at 1.5 cm depth) and the shortest panicle (20.50 cm) was observed in D_3 (transplanting at 4.5 cm depth) treatment.

Interaction effect of N and transplanting depth showed significant differences for panicle length of BRRI dhan50 (Appendix VII and Fig. 7). The longest panicle (25.55 cm) was found in the treatment combination of N_2D_2 (115 kg N ha^{-1} × transplanting at 3.0 cm depth), while the shortest length (20.00 cm) was observed in N_0D_3 (0 kg N ha^{-1} × transplanting at 4.5 cm depth) treatment combination .



N_0: 0 kg N ha^{-1}
N_2: 115 kg N ha^{-1}

N_1: 92 kg N ha^{-1}
N_3: 136 kg N ha^{-1}

D_1: Transplanting at 1.5 cm depth
D_2: Transplanting at 3.0 cm depth
D_3: Transplanting at 4.5 cm depth

Figure 7. Interaction effect of N levels and transplanting depths on panicle length of BRRI dhan50 [SE=0.347]

4.8 Number of filled grains panicle^{-1}

Number of filled grains panicle^{-1} of BRRI dhan50 varied significantly for different N level (Appendix VIII and Table 8). The maximum number of filled grains panicle^{-1} (95.40) was recorded in N_2 (115 kg N ha^{-1}) which was closely followed (92.40) by N_3 (136 kg N ha^{-1}), while the minimum number (67.90) was observed in N_0 (0 kg N ha^{-1}) which was followed (87.60) by N_1 (92 kg N ha^{-1}) treatment. Reddy *et al.* (1987) reported that total number of spikelets panicle^{-1} increased with 120 kg N ha^{-1}.

Statistically significant variation was observed for number of filled grains panicle^{-1} of BRRI dhan50 due to the different transplanting depth (Appendix VIII and Table 8). The maximum number of filled grains panicle^{-1} (88.70) was obtained in D_2 (transplanting at 3.0 cm depth) which was closely followed (85.20) by D_3 (transplanting at 4.5 cm depth), whereas the minimum number (83.60) was attained in D_1 (transplanting at 1.5 cm depth) treatment.

Interaction effect of N and transplanting depth showed significant differences for number of filled grains panicle^{-1} of BRRI dhan50 (Appendix VIII and Table 9). The maximum number of filled grains panicle^{-1} (97.50) was found in the treatment combination of N_2D_2 (115 kg N ha^{-1} × transplanting at 3.0 cm depth), whereas the minimum number (64.10) was recorded in N_0D_1 (0 kg N ha^{-1} × transplanting at 1.5 cm depth) treatment combination.

Table 8. Effect of N levels and transplanting depths on number of filled grains panicle^{-1}, unfilled grains panicle^{-1} and total grains panicle^{-1} of BRRI dhan50

Treatments	Number of filled grains panicle^{-1}	Number of unfilled grains panicle^{-1}	Number of total grains panicle^{-1}
Levels of N			
N_0	67.90 d	11.30 a	79.20 d
N_1	87.60 c	8.00 b	95.60 c
N_2	95.40 a	6.60 d	102.00 a
N_3	92.40 b	7.30 c	99.70 b
SE	0.548	0.107	0.624
Transplanting depth			
D_1	83.60 c	9.30 a	92.90 b
D_2	88.70 a	7.30 c	96.00 a
D_3	85.20 b	8.20 b	93.40 b
SE	0.484	0.180	0.471
CV(%)	5.95	7.50	10.73

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

N_0: 0 kg N ha^{-1} (control)	D_1: Transplanting at 1.5 cm depth
N_1: 92 kg N ha^{-1}	D_2: Transplanting at 3.0 cm depth
N_2: 115 kg N ha^{-1}	D_3: Transplanting at 4.5 cm depth
N_3: 136 kg N ha^{-1}	

Table 9. Interaction effect of N levels and transplanting depths on number of filled grains panicle^{-1} , unfilled grains panicle^{-1} and total grains panicle^{-1} of BRRI dhan50

Treatments	Number of filled grains panicle^{-1}	Number of unfilled grains panicle^{-1}	Number of total grains panicle^{-1}
N_0D_1	64.10 h	13.90 a	78.00 g
N_0D_2	73.70 g	9.43 c	83.13 f
N_0D_3	65.97 h	10.73 b	76.70 g
N_1D_1	84.77 f	8.53 cd	93.30 e
N_1D_2	90.17 de	7.33 ef	97.50 cd
N_1D_3	87.90 e	8.20 de	96.10 de
N_2D_1	94.33 bc	7.20 ef	101.53 ab
N_2D_2	97.50 a	6.00 g	103.50 a
N_2D_3	94.57 b	6.47 fg	101.03 ab
N_3D_1	91.33 cd	7.83 de	99.17 bc
N_3D_2	93.37 bc	6.40 fg	99.77 bc
N_3D_3	92.53 b-d	7.53 de	100.07 bc
SE	0.968	0.359	0.943
CV(%)	5.95	7.50	10.73

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

N_0: 0 kg N ha^{-1} (control)
N_1: 92 kg N ha^{-1}
N_2: 115 kg N ha^{-1}
N_3: 136 kg N ha^{-1}

D_1: Transplanting at 1.5 cm depth
D_2: Transplanting at 3.0 cm depth
D_3: Transplanting at 4.5 cm depth

4.9 Number of unfilled grains panicle^{-1}

Nitrogen levels showed significant variations on number of unfilled grains panicle^{-1} of BRRI dhan50 (Appendix VIII and Table 8). The minimum number of unfilled grains panicle^{-1} (6.60) was obtained in N_2 (115 kg N ha^{-1}) which was closely followed (7.30) by N_3 (136 kg N ha^{-1}). On the other hand, the maximum number (11.30) was found in N_0 (0 kg N ha^{-1}) which was followed (8.00) by N_1 (92 kg N ha^{-1}) treatment.

Number of unfilled grains panicle^{-1} of BRRI dhan50 varied significantly for different transplanting depth (Appendix VIII and Table 8). The minimum number of unfilled grains panicle^{-1} (7.30) was found in D_2 (transplanting at 3.0 cm depth) which was closely followed (8.20) by D_3 (transplanting at 4.5 cm depth) and the maximum number (9.30) was recorded in D_1 (transplanting at 1.5 cm depth) treatment.

Different levels of N and transplanting depth showed significant differences due to interaction effect in terms of number of unfilled grains panicle^{-1} of BRRI dhan50 (Appendix VIII and Table 9). The minimum number of unfilled grains panicle^{-1} (6.00) was found in the treatment combination of N_2D_2 (115 kg N ha^{-1} × transplanting at 3.0 cm depth), while the maximum number (13.90) was observed in N_0D_1 (0 kg N ha^{-1} × transplanting at 1.5 cm depth) treatment combination.

4.10 Number of total grains panicle^{-1}

Number of total grains panicle^{-1} of BRRI dhan50 showed significant difference due to different N level (Appendix VIII and Table 8). The maximum number of total grains panicle^{-1} (102.00) was recorded in N_2 (115 kg N ha^{-1}) which was closely followed (99.70) by N_3 (136 kg N ha^{-1}), again the minimum number (79.20) was obtained in N_0 (0 kg N ha^{-1}) which was followed (95.60) by N_1 (92 kg N ha^{-1}) treatment.

Number of total grains panicle^{-1} of BRRI dhan50 showed significant variations due to the different transplanting depth (Appendix VIII and Table 8). The maximum number of total grains panicle^{-1} (96.00) was recorded in D_2 (transplanting at 3.0 cm depth), whereas the minimum number (92.90) was observed in D_1 (transplanting at 1.5 cm depth) which was statistically similar (93.40) with D_3 (transplanting at 4.5 cm depth) treatment.

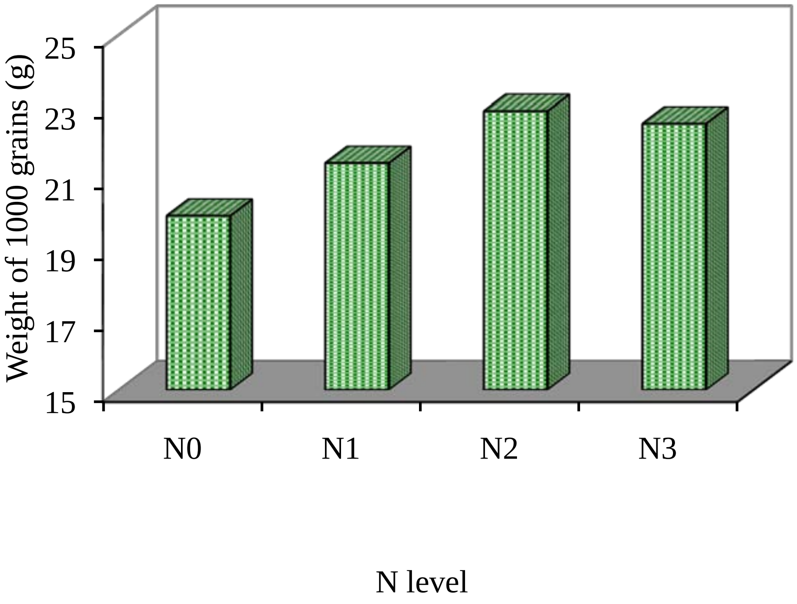
Interaction effect of transplanting depth and N showed significant differences for number of total grains panicle^{-1} of BRRI dhan50 (Appendix VIII and Table 9). The maximum number of total grains panicle^{-1} (103.50) was recorded in the treatment combination of N_2D_2 (115 kg N ha^{-1} × transplanting at 3.0 cm depth), while the minimum number (78.00) was attained in N_0D_1 (0 kg N ha^{-1} × transplanting at 1.5 cm depth) treatment combination.

4.11 Weight of 1000 - grains

There was a significant effect of N rate on weight of 1000 - grains of BRRI dhan50 (Appendix VIII and Fig. 8). The highest weight of 1000 - grains (22.85 g) was found in N_2 (115 kg N ha^{-1}) which was statistically similar (22.50 g) with N_3 (136 kg N ha^{-1}) and followed (21.39 g) by N_1 (92 kg N ha^{-1}), again the lowest weight (19.90 g) was observed in N_0 (0 kg N ha^{-1}) treatment. Subhendu *et al.* (2003) conducted a field experiment during *kharif* season at Hyderabad, India. They found that the application of N (120 kg N ha^{-1}) as urea in equal splits resulted in the highest 1000 grain weight (22.57 g).

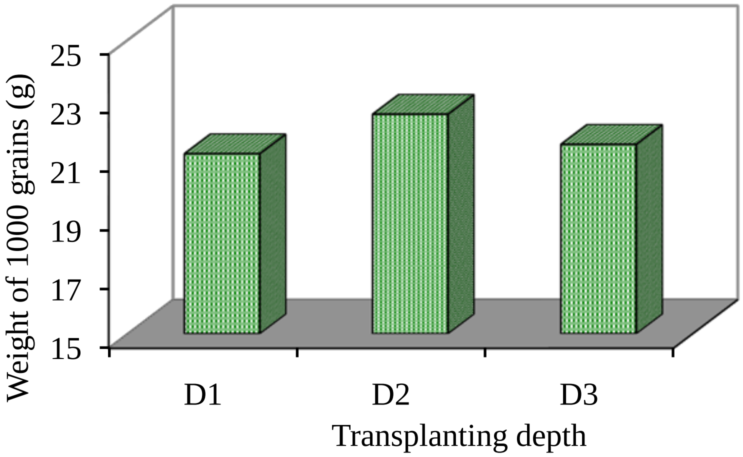
Statistically significant difference was recorded for weight of 1000 grains of BRRI dhan50 for different transplanting depth (Appendix VIII and Fig. 9). The highest weight of 1000 grains (22.48 g) was observed in D_2 (transplanting at 3.0 cm depth), while the lowest weight (21.13 g) was recorded in D_1 (transplanting at 1.5 cm depth) which was statistically similar (21.45 g) with D_3 (transplanting at 4.5 cm depth) treatment.

Weight of 1000 grains of BRRI dhan50 showed significant differences due to interaction effect of transplanting depth and N (Appendix VIII and Fig. 10). The highest weight of 1000 grains (23.46 g) was recorded in the treatment combination of N_3D_2 (136 kg N ha^{-1} × transplanting at 3.0 cm depth). On the other hand, the lowest weight (19.45 g) was recorded in N_0D_1 (0 kg N ha^{-1} × transplanting at 1.5 cm depth) treatment combination.



N_0: 0 kg N ha^{-1} N_1: 92 kg N ha^{-1}
N_2: 115 kg N ha^{-1} N_3: 136 kg N ha^{-1}

Figure 8. Effect of N levels on weight of 1000 grains of BRRI dhan50 [SE=0.177]



D_1: Transplanting at 1.5 cm depth
D_2: Transplanting at 3.0 cm depth
D_3: Transplanting at 4.5 cm depth

Figure 9. Effect of transplanting depths on weight of 1000 grains of BRRI dhan50 [SE=0.107]

4.12 Grain yield

Statistically significant variation was recorded for different N level on grain yield of BRRI dhan50 (Appendix IX and Table 10). The highest grain yield (6.17 t ha^{-1}) was obtained in N_2 (115 kg N ha^{-1}) which was closely followed (6.03 t ha^{-1} and 5.75 t ha^{-1}) by N_3 (136 kg N ha^{-1}) and N_1 (92 kg N ha^{-1}), while the lowest yield (3.53 t ha^{-1}) was found in N_0 (0 kg N ha^{-1}) treatment. Geethadevi *et al.* (2000) showed that four split applications of 150 kg N ha^{-1} N in KRH-1 recorded the maximum yield, as well as increased growth and yield components.

Grain yield ha^{-1} of BRRI dhan50 varied significantly for different transplanting depth (Appendix IX an Table 10). The highest grain yield (5.63 t ha^{-1}) was found in D_2 (transplanting at 3.0 cm depth) which was closely followed (5.32 t ha^{-1}) by D_3 (transplanting at 4.5 cm depth), whereas the lowest yield (5.16 t ha^{-1}) was recorded in D_1 (transplanting at 1.5 cm depth) treatment.

Interaction effect of transplanting depth and N showed significant differences for grain yield ha^{-1} hectare of BRRI dhan50 (Appendix IX and Table 11). The highest grain yield (6.41 t ha^{-1}) was recorded in N_2 D_2 (115 kg N ha^{-1} × transplanting at 3.0 cm depth), the similar grain yield (6.22 t ha^{-1}) was also obtained from the combination of 136 krg. N ha^{-1} and transplanting at 3.0 cm depth while the lowest yield (3.24 t ha^{-1}) was observed in N_0D_1 (0 kg N ha^{-1} × transplanting at 1.5 cm depth) treatment combination.

4.13 Straw yield

Different N levels varied significantly on straw yield of BRRI dhan50 (Appendix IX and Table 10). The highest straw yield (7.40 t ha^{-1}) was observed in N_3 (136 kg N ha^{-1}) which was statistically similar (7.27 t ha^{-1}) with N_2 (115 kg N ha^{-1}) and closely followed (6.99 t ha^{-1}) by N_1 (92 kg N ha^{-1}) and the lowest yield (5.26 t ha^{-1}) was recorded in N_0 (0 kg N ha^{-1}) treatment.

Table 10. Effect of N levels and transplanting depths on grain yield, straw yield and biological yield of BRRI dhan50

Treatments	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})
Levels of N			
N_0	3.53 d	5.26 c	8.80 c
N_1	5.75 c	6.99 b	12.74 b
N_2	6.17 a	7.27 a	13.45 a
N_3	6.03 b	7.40 a	13.42 a
SE	0.021	0.046	0.047
Transplanting depth			
D_1	5.16 c	6.52 b	11.68 c
D_2	5.63 a	7.19 a	12.82 a
D_3	5.32 b	6.48 b	11.80 b
SE	0.039	0.035	0.031
CV(%)	5.52	6.81	5.87

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

N_0: 0 kg N ha^{-1} (control)	D_1: Transplanting at 1.5 cm depth
N_1: 92 kg N ha^{-1}	D_2: Transplanting at 3.0 cm depth
N_2: 115 kg N ha^{-1}	D_3: Transplanting at 4.5 cm depth
N_3: 136 kg N ha^{-1}	

Table 11. Interaction effect of N levels and transplanting depths on grain yield, straw yield and biological yield of BRRI dhan50

Treatments	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})
N_0D_1	3.24 e	4.92 h	8.16 i
N_0D_2	4.02 d	5.84 g	9.86 g
N_0D_3	3.34 e	5.03 h	8.37 h
N_1D_1	5.62 c	6.61 f	12.23 f
N_1D_2	5.87 b	7.55 ab	13.42 b
N_1D_3	5.76 bc	6.80 ef	12.56 e
N_2D_1	5.88 b	7.19 cd	13.07 cd
N_2D_2	6.41 a	7.62 a	14.03 a
N_2D_3	6.23 a	7.01 de	13.24 bc
N_3D_1	5.90 b	7.37 bc	13.27 b
N_3D_2	6.22 a	7.75 a	13.97 a
N_3D_3	5.96 b	7.07 d	13.03 d
SE	0.078	0.070	0.061
CV(%)	5.52	6.81	5.87

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

N_0: 0 kg N ha^{-1} (control)	D_1: Transplanting at 1.5 cm depth
N_1: 92 kg N ha^{-1}	D_2: Transplanting at 3.0 cm depth
N_2: 115 kg N ha^{-1}	D_3: Transplanting at 4.5 cm depth
N_3: 136 kg N ha^{-1}	

Different transplanting depth showed statistically significant differences on straw yield of BRRI dhan50 (Appendix IX and Table 10). The highest straw yield (7.19 t ha^{-1}) was recorded in D_2 (transplanting at 3.0 cm depth) and the lowest yield (6.48 t ha^{-1}) was obtained in D_3 (transplanting at 4.5 cm depth) which was statistically identical (6.52 t ha^{-1}) with D_1 (transplanting at 1.5 cm depth) treatment.

Interaction effect of transplanting depth and N varied significantly on straw yield of BRRI dhan50 (Appendix IX and Table 11). The highest straw yield (7.75 t ha^{-1}) was found in the treatment combination of N_3D_2 (136 kg N ha^{-1} × transplanting at 3.0 cm depth), whereas the lowest yield (4.92 t ha^{-1}) was recorded in N_0D_1 (0 kg N ha^{-1} × transplanting at 1.5 cm depth) treatment combination.

4.14 Biological yield

Biological yield of BRRI dhan50 showed significant differences for different N level (Appendix IX and Table 10). The highest biological yield (13.45 t ha^{-1}) was observed in N_2 (115 kg N ha^{-1}) which was statistically similar (13.42 t ha^{-1}) with N_3 (136 kg N ha^{-1}). On the other hand, the lowest yield (8.80 t ha^{-1}) in N_0 (0 kg N ha^{-1}) which was followed (12.74 t ha^{-1}) by N_1 (92 kg N ha^{-1}) and treatment.

Statistically significant difference was observed in biological yield of BRRI dhan50 for different transplanting depth (Appendix IX and Table 10). The highest biological yield (12.82 t ha^{-1}) was observed in D_2 (transplanting at 3.0 cm depth) which was closely followed (11.80 t ha^{-1}) by D_3 (transplanting at 4.5 cm depth) and the lowest (11.68 t ha^{-1}) in D_1 (transplanting at 1.5 cm depth) treatment.

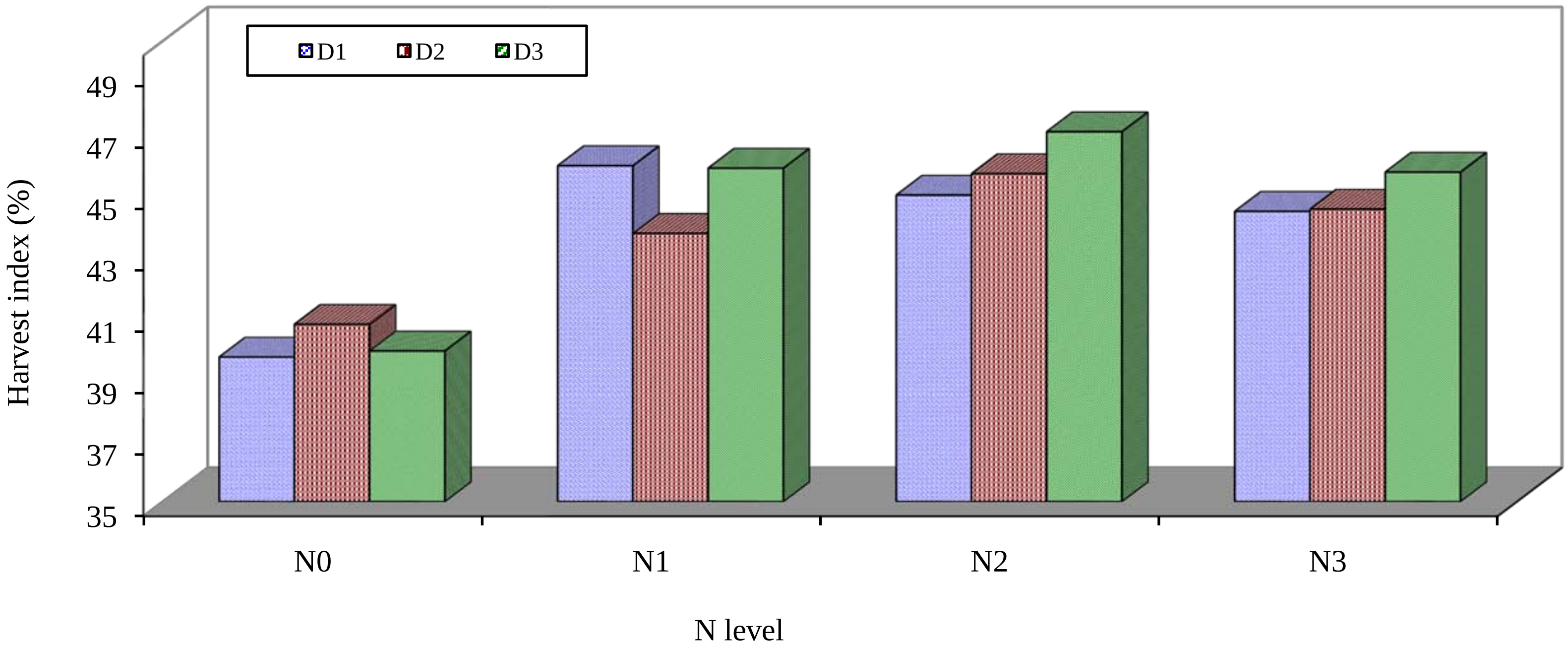
Variation was recorded due to interaction effect of transplanting depth and N for biological yield of BRRI dhan50 (Appendix IX and Table 11). The highest biological yield (14.03 t ha^{-1}) was recorded in the treatment combination of N_2D_2 (115 kg N ha^{-1} × transplanting at 3.0 cm depth), again the lowest yield (8.16 t ha^{-1}) in N_0D_1 (0 kg N ha^{-1} × transplanting at 1.5 cm depth) treatment combination.

4.15 Harvest index

Different N level showed significant differences on harvest index of BRRI dhan50 (Appendix IX and Fig. 11). The highest harvest index (45.91%) was recorded in N_2 (115 kg N ha^{-1}) which was statistically similar (45.19%) with N_1 (92 kg N ha^{-1}) and closely followed (44.91%) by N_3 (136 kg N ha^{-1}), whereas the lowest (40.13%) was obtained in N_0 (0 kg N ha^{-1}) treatment.

Statistically significant difference was recorded in terms of harvest index of BRRI dhan50 for different transplanting depth (Appendix IX and Fig. 12). The highest harvest index (44.64%) was found in D_3 (transplanting at 4.5 cm depth) which was followed (43.78%) by D_1 (transplanting at 1.5 cm depth), while the lowest (43.68%) in D_2 (transplanting at 3.0 cm depth) treatment.

Transplanting depth and N showed significant differences for harvest index of BRRI dhan50 due to interaction effect (Appendix IX and Fig. 13). The highest harvest index (47.04%) was recorded in N_2D_3 (115 kg N ha^{-1} × transplanting at 4.5 cm depth), again the lowest (39.70%) was found in N_0D_1 (0 kg N ha^{-1} × transplanting at 1.5 cm depth) treatment combination.



N_0: 0 kg N ha^{-1}
N_2: 115 kg N ha^{-1}

N_1: 92 kg N ha^{-1}
N_3: 136 kg N ha^{-1}

D_1: Transplanting at 1.5 cm depth
D_2: Transplanting at 3.0 cm depth
D_3: Transplanting at 4.5 cm depth

Figure 13. Interaction effect of N levels and transplanting depths on harvest index of BRRI dhan50 [SE=0.525]

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted at the experimental field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during November 2010 to April 2011 to study the effect of different levels of N and transplanting depth on growth and yield of BRRI dhan50. The experiment consisting of 4 different levels of N (0, 92, 115 and 136 kg ha^{-1}) and 3 levels of transplanting depth (1.5, 3.0 and 4.5 cm). The experiment was laid out in split - plot design with 3 replications. Both N levels and transplanting depths had significant effects on most of the growth and yield contributing characters of BRRI dhan50.

At 30, 50, 70 and 90 DAT and at harvest, most of the growth and yield contributing parameters viz., plant height, number of tillers, dry matter production effective tillers showed maximum values from the application of 136 kg N ha^{-1}, whereas, lower values were recorded in 0 kg N ha^{-1}. The longest panicle, maximum number of filled grains panicle^{-1}, maximum 1000-grains weight, highest grain yield and maximum harvest index were recorded from the application of 115 kg N ha^{-1}, while lower values were recorded in 0 kg N ha^{-1}.

Most of the growth and yield contributing characters showed maximum values from transplanting at 3.0 cm whereas the minimum values were recorded in 1.5 cm transplanting depth.

The combination of N levels and transplanting depth had significant effects on most of the growth and yield contributing parameters. At 30, 50, 70 and 90 DAT and at harvest, the longest plant (28.17 cm, 45.45 cm, 63.76 cm, 82.33 cm and 98.89 cm) was found from the treatment combination of N_3D_2, 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 N_0D_1. At 30, 50, 70 and 90 DAT, the maximum number of tillers hill^{-1} (6.37, 18.97, 19.55 and 19.20) was recorded from the treatment combination of N_3D_2, again the minimum number (4.17, 12.93, 15.65 and 15.63) was obtained from the treatment combination of N_0D_1. At 30, 50, 70 and 90 DAT and at harvest, the highest dry matter plant^{-1} (0.583 g, 3.90 g, 16.60 g, 26.80 g and 58.60 g) was obtained from the treatment combination of N_3D_2, while the lowest (0.285 g, 1.40 g, 6.30 g, 14.00 g and 34.80 g) was found from the treatment combination of N_0D_1. The maximum number of effective tillers hill^{-1} (14.00) was recorded from the treatment combination of N_3D_3, again the minimum number (8.50) was found from N_0D_1. The minimum number of ineffective tillers hill^{-1} (2.26) was recorded from the treatment combination of N_2D_3, while the maximum number (10.00) was recorded from N_0D_1. The maximum number of tillers hill^{-1} (19.10) was observed from the treatment combination of N_3D_2 and the minimum number (15.63) was recorded from N_2D_3. The longest panicle (25.55 cm) was found from the treatment combination of N_2D_2, while the shortest length (20.00 cm) was observed from N_0D_3. The maximum number of filled grains plant^{-1} (97.50) was found from the treatment combination of N_2D_2, whereas the minimum number (64.10) was recorded in N_0D_1. The minimum number of unfilled grains plant^{-1} (6.00) was found from the treatment combination of N_2D_2, while the maximum number (13.90) was observed from N_0D_1. The maximum number of total grains plant^{-1} (103.50) was recorded from the treatment combination of N_2D_2, while the minimum number (78.00) was attained from N_0D_1. The highest weight of 1000 grains (23.46 g) was recorded from the treatment combination of N_3D_2 and the lowest weight (19.45 g) from N_0D_1. The highest grain yield (6.41 t ha^{-1}) was recorded from the treatment combination of N_2D_2 and the Combination of N_3D_2 also produced statistically similar yield (6.22 t ha^{-1}) where as the lowest (3.24 t ha^{-1}) from N_0D_1. The highest straw yield (7.75 t ha^{-1}) was found from the treatment combination of N_3D_2, whereas the lowest yield (4.92 t ha^{-1}) from N_0D_1. The highest biological yield (13.97 t ha^{-1}) was recorded from the treatment combination of N_3D_2, again the lowest yield (8.16 t ha^{-1}) from N_0D_1. The highest harvest index (47.04%) was recorded from the treatment combination of N_2D_3, again the lowest (39.70%) was found from N_0D_1.

It may be concluded that growth, yield and yield contributing characters of BRRI dhan50 were greatly influenced by N levels and transplanting depth. Applications of 115 kg N ha^{-1} at transplanting depth 3.0 cm produced longest panicle, maximum number of filled grains $panicle^{-1}$ and highest 1000 grains weight and ultimately provides maximum yields of BRRI dhan50.

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

1. Such study is needed in different agro-ecological zones (AEZ) of Bangladesh for regional compliance and other performance.
2. Another levels of N may be included in the future study.
3. Another experiment may be carried out with another transplanting depth maximizing highest benefit.

REFERENCES

Ahmed, M. H., Islam, M. A., Kader, M. A. and Anwar, M. P. (2000). Evaluation of USG as a source of nitrogen in T. aman rice. *Pakistan J. Biol. Sci*., **25**(5): 735-737.

Ahmed, U. U. and Faiz, S. M. A. (1972).A study of effect of different levels of nitrogen and water on the growth, yield and quality of 1R8 28 8-3 rice.*Pakistan J. Soil Sci*., **5**(2): 1-15.

Akanda, M. R. U., Eunes, M., Islam, M. A. and Au, M. I. (1986). Nitrogen application timing and performance of BR4 transplant aman rice. *J. of Bangladesh Agril*. Sci. **11**(1): 39-43.

Ali, A. Karim, Hassan, M. A. G., Ali, A. S. S. and Majid, A. (1992).Rice grain quality as influenced by split application of nitrogenous fertilizer.*Intl. Rice. Res. Newsl*., **17**(3): 7.

Angayarkanni, A. and Ravichandran, M. (2001). Judicious fertilizer N split for higher use efficiency in transplanted rice. *Indian J. Agril. Res*., **35**(4): 278-280.

Asif, M., Chaudhary, F. M., and Saeed, M. (1999). Influence of NPK levels and split N application on grain filling and yield of fine rice. *Intl. Rice. Res. Notes*., **24**(1): 30-31.

Avasthe, M. K., Yoshihashi T. and Sarhadi, W.A. (1993).Evaluation of aroma in rice (*Oryza sativa* L.) using KOH method, molecular markers and measurement of 2-acetyl-1-pyrroline concentration.*Jpn. J. Trop. Agr*.**22**: 123-127.

BARC (Bangladesh Agricultural Research Council). (1997). Rice the main staple food. In: Agriculture in Bangladesh. Farm Gase, Dhaka. pp. 8-12.

Bayan, H. C. and Kandasamy, O. S. (2002). Effect of weed control methods and split application of nitrogen on weed and crop in direct seeded puddle rice. *Crop Res. Hisar*. **24**(2): 266-272

Bhuiya, M. S. U., Hossain, S. M. A. and Kabir, S. K. G. (1989).Nitrogen fertilization in rice cv. BR 10 after green manuring.*Bangladesh J. Agril. Sci*., **16**(1): 87-92.

Bowen, W. T., Diamand, R. B., Singh, U. and Thompson, T. P. (2005). Urea deep placement increases yield and saves nitrogen fertilizer in farmers' field in Bangladesh. Rice in life: scientific perspectives for the 21st century proceeding of the World Rice Research Conference held in Tsukuba, Japan, 4-7 November, 2004. pp. 369-372.

BRRI (Bangladesh Rice Research Institute). (2011). Adhunik Dhaner Chash. Joydebpur, Dhaka. p. 10.

BRRI (Bangladesh Rice Research Institute). (1979). Annual Report.Joydebpur, Dhaka. p. 8.

Channabasavanan, A. S. and Setty, R. A. (1994).Response of broadcast rice (*Oryza sativa)* at two levels of nitrogen, phosphorus and potassium and time of N application.*Indian J. Agron*., **39**(3): 457-459.

Chaudhary, N. A., Nair, A. K. and Gautam, R. C. (1994).Effect of rate and schedule of nitrogen on rice yield.*Indian J. Agron*.**21**(1): 349-350.

Das, S. and Singh, T. A. (1994). Nitrogen use efficiency by rice and flood water parameters as affected by fertilizer placement techniques. *J. Indian Soc. Soil Sci*. **42**(l): 46-50.

Duraisamy, V. M., Subbulakhsmi, S., Senthilkumar, T. (2011). Studies on standardisation of spacing and transplanting depth for a self propelled rice transplanter. *Agricultural Mechanization in Asia, Africa and Latin America*. **42**(1): 42-44.

Edris, K. M., Islam, A. T. M. T., Chowdhury, M. S. and Haque, A. K. M. M. (1979). Detailed Soil Survey of Bangladesh Agricultural University Farm, Mymensingh, Dept. Soil Survey, Govt. People's Republic of Bangladesh.118 p.

Ehsanullah, A., Cheema, M. S. and Usman, M. (2001).Rice Basmati-385 response to single and split application of nitrogen at different growth stages.*Pakistan J. Agril. Sci*., **38**(1-2): 84-86.

Enyi, B. A. C. (1963). The effect of seedling age, depth of planting and fertilizer placement on the growth and yield of rice (Oryza sativa L.).*J. Agril. Sci*. **61**(3): 29 1-297.

FAO (Food and Agriculture Organization). (2009). FAO Production Yearbook, Food and Agriculture Organization, Rome, Italy. 56-77.

FAO (Food and Agriculture Organization). (1988). FAO Production Yearbook, Food and Agriculture Organization, Rome, Italy. 56-77.

Faraji, A and Mirlohi, A. (1998).Effect of splitting and rate of nitrogen application on yield and yield components of rice (*Oryza sativa* L).in Isfahan. *J. Agril. Sci*., **2**(3): 25-34.

Geethadevi, T., Gowada, A., Vidyachandra, B. and Babu, B. T. R. (2000).Studied on split application of nitrogen and their timings on growth and yield of rice genotypes.Current Res. *Univ. Agril. Sci*., **29**(3-4): 42-46.

Gomez, K. A. and Gomez, A. A. (1984).Statistical Procedure for Agricultural Research (2ndedn.). Int. Rice Res. Inst., A Willey Int. Sci., pp. 28-192.

Grist, D.H. (1965).Rice.4thEdn. London: Longmans and Green Co, 1td. Pp. 142-1143.

Hien, N.L., Yoshihashi,T.andSarhadi,W.A. (2006). Evaluation of aroma in rice (*Oryza sativa* L.) using KOH method, molecular markers and measurement of 2-acetyl-1-pyrroline concentration.*Jpn. J. Trop. Agr*. **50**: 190-198.

Hossain, M. B., Islam, M. O. and Hasanuzzaman, M. (2008).Influence of Different Nitrogen Levels on the Performance of Four Aromatic Rice Varieties.*Interl J. Agric.& Biol.,* 16(4):1560–8530.

Hussain, M. A., Salahuddin, A. B. M., Roy, S. K., Nasreen, S. and Ali, M. A. (1989).Effect of green manuring on the growth and yield of transplant aman rice.*Bangladesh J. Agril. Sci*. **16**(1): 25-33.

IFC.(1982). Response of rice *(Oryza sativa)* to nitrogen fertilizer in acidic soil of Nagaland.*Indian J. Agril. Sci*. **61**(9): 662-664.

Ikeda, A., Yoshida, T., Shirota, M. and Takei, M. (2003). Method of the non-split application of fertilizer to rice “Koshihikari” on pneumatic direct seeding culture on submerged paddy filed. *Res. Bull. Aichi ken Agril. Res. Cent*. **35**: 23-29.

Islam, N., Inanagta, S., Chishaki, N. and Horiguchi, T. (1996).Effect of nitrogen top-dressing on dry matter and nitrogen distribution in *Indica rice*.*Japanese J. Trop. Agric*. **40**(2): 89-92.

Jaiswal, V. P. and Singh, G. P. (2001). Performance of urea super granules and prilled urea under different planting methods in irrigated rice (*Oryza sativa*). *Indian J. Agril. Sci*., **71**(3): 187-189.

Kamal, J., Tomy P. J. and Rajappan, N. (1991). Effect of sources and levels of nitrogen on the growth of wetland rice. *Indian J. Agron*., **36**(1): 40-43.

Kapre, M. M., Bisen, C. R. and Johar, M. S. (1996). Effect of slow release N fertilizers on rice under low land conditions. *Crop Res, Hisar*.,**11**:1, 17-23.

Karim, M. A. (1985). Effect of number of seedlings per hill and depth of planting on the performance of transplanted aman rice. M. Sc. (Ag.). Thesis.Dept. Agron., Bangladesh Agril. Univ., Mymensingh. pp. 29-32.

Kawasima, S. and Tanabe, T. (1970). Influence of seedling age, transplanting depth and earthing up on the growth and yield of rice plant. *Proc. Crop Sci. Soc. Japan*.**39**(3): 383-390.

Khander, M. A., Reddi, M. R., Reddy, B. B. and Ramaiah, N. V. (1987).Studied on nitrogen management in wetland (flooded) rice.*Indian J. Agron*.**32**(1): 104-106.

Kim, C. K., Lee, S. Y., Kim, C. H., Lim, M. S. and Cho, C. I. (1987).Effect of nitrogen split application on the rice growth and yield production under machine transplanting in the rice (*Oryza sativa L.).Korean J. Crop Sci*. **32**(1): 48-54

Latchanna, A. and Yogeswara, R. Y. (1977).Effect of level and time of applicaton of nitrogen on rice varieties.*Andhre, J. Agric*., **24**(6): 213-215.

Mahapatra, I. C. and Padalia, C. R. (1971).Effect of depth of planting on high yield varieties 0f rice.*Indian J. Agron*.**16**(2): 152-154.

Matsushima, S. (1976).High yielding rice cultivation.A method for maximizing rice yield through ideal olants. Japan: University of Tokyo Press. pp. 252-255.

Miller, C. E. Turk, L. M. and Roth, H. D. (1965).Fundamentals of Soil Science.4th Edn. New York: John Wiley and Sons. Inc. p. 106.

Mishra, B. K., Mishra, S. Das, A. K. and Jean, D. (2000). Effect of time for urea super granule placement of low land rice. *Ann. Agric. Res*., **20**: 4, 443-447.

Mondal, S. and Swamy, S. N. (2003). Effect of time of N application on yield and yield attributes of rice (*Oryza sativa*) cultivars. *Env. Ecol*. **21**(2): 411-413.

Mongia, A. D. (1992). Efficiency of nitrogen as affected by level and time of its application in wetland rice (*Oryza sativa). Indian J. Agron*., **37**(3): 559-569.

Nair, A. K. and Gautam, R. C. (1992).Effect of rate and schedule of nitrogen on rice (*Oryza sativa)* yield of moderate fertility.*Indian J. Agron*.**37**(2): 349-350.

Nair, R. R.; Pillali, G. R.; Pisharody, P. N. and Gopalakrishna, R. (1978).Transplanting Rice.Most effective dpth.*Indian Fmg*. **22**(12): 37.

Naseem, S. B., Mollah, M. I. U. and Au, M. H. (1995). Yield response of upland rice to varying levels of weeding and nitrogen. *Bangladesh J. Sci. Ind. Res*. **30**(2-3): 65-71.

Padalia, Y. and Mahapatra, I. C. (1965). Depth of transplanting of rice under different manural conditions.*Oryza*. **2**(1): 105-110.

Park, J. S. and Lee, S. S. (1988). Performance of rice varieties at different levels and time of nitrogen application.*Korean J. Crop Sci*. **33**(3): 222-228.

Patel, S. R. and Mishra, V. N. (1994). Effect of different forms of urea and levels of nitrogen on the yield and nitrogen uptake of rice. *Advn. PI. Sci*., **7**(3): 297-401.

Patel, C. L, Patel, H. S. and Patel, H. C. (1983).Optimum spacing for three rice varieties under sourthGujrat condition.*GujratAgril Univ. Res. J* .**8**(2): 125-126.

Paturde, J. T. and Rahate, V. T. (1986). Yield and yield attributory characters of paddy (*Oryza sativa*) variety IR20 as affected by split application of nitrogen at different growth stages under irrigated conditions. *Agric. Sci. Digest*. **61**(1): 38-40.

Prasad, M. K., Singh, S. B. Singh, J. M. and Shinha, R. P. (1999). Growth of rice plants as influenced by the method of seeding, seed rate and split application of nitrogen. *J. Appl. Biol*. **9**(1): 52-54.

Rabinson, J. G. (1992). Dose and time of application of nitrogen for rice.*Madras J. Agric*. **79**(1): 47-48.

Rahman, M. A. (2003). Effect of levels of USG and depth of placement on the growth and yield of transplant *aman* rice. M.S. Thesis, Dept. Agron, Bangladesh Agril. Univ. Mymensingh.p. 100.

Rama, S., Reddy, G. and Reddy, K. (1989). Effect of levels and source of nitrogen on rice.*Indian J. Agron*.**34**(3): 364-366.

Rao, R. V., Satyanarayana, V. and Reddy, G. H. S. (1997). Studies on the effect of time of nitrogen application on growth and yield of direct seeded sona rice under puded conditions. *Andhra Agric. J*. **24**(5): 181-186.

Rao, R. V., Satyanarayana, V. and Reddy, G. H. S. (1986). Studies on the effect of time of nitrogen application on growth and yield of direct seeded sorna rice under puddle condition. *Andhra Agric. J*. **24**(5): 181-186.

Reddy, J. V., Balal, M. S. and Singh, J. I. V. (1990).Fertilizer management in broadcast rice under late transplanting.*Indian J. Agron*.**37**: 181-183.

Reddy, J. V., Singh, J. N. and Verma, A. K. (1985).Effect of time nitrogen on growth of rice (*Oryza sativa L.*).*Agril. Sci. Digest*. **7**(2): 83-85.

Reddy, T. M. M., Rangulh, A.V., Ramaiah, N. V. and Reddy, G. V. (1987).Effect of methods of planting and nitrogen levels on growth, yield attributes and yield of rice under late condition.*J. Res. Andhra-Pradesh Agril. Univ*. **15**(1): 56-58.

Roy, R. N. and Peterson, O. S. (1990).Nitrogen management of rice.*Intl. Rice Commn.Newsl*., 39:118.

Salam, N. A., Tazuddin, E., Varghese, K., Hameed. S. M. S. and Thomas.Y. (1988).Effect of N source and application time on rice.Intl. *Rice Res. Newsl*.**13**(5):25.

Sarker,A. U. Karim S. M. R. and Mamun, A. A. (1986). Effect of depth of planting on the yield of rice cultivars.*Bangladesh J. Agril. Sci*. **13**(2): 57-61.

Sen, A. and Pandey, B. K. (1990).Effect on rice of placement depth of urea supergranules. *Intl. Rice Res. Newsl*.,**15**(4): 18, 51.

Sharma, A. R. (1995). Effect of basal and post-flood nitrogen fertilization on performance of rice (*Oryza sativa*) under conditions intermediate deep water and simulated flush flooding.*Indian J. Agric. Sci*. **65**(6): 399-404.

Shoo, N. C., Mishra, R. K. and Mohanty, J. P. (1989). Effect of single versus split application of nitrogen on growth and physiological growth parameters of rice.*Orissa J. Agril. Res*., **2**(3-4): 194-195.

Singh, S. K. and Modgal, Y. P. (2005) Effect of nitrogen, copper and magnesium fertilization on yield and nutrition of rice.*Pakistan J. Sci. Ind. Res*. **45**(2): 102-107.

Singh, B. K. and Singh, R. P. (1986). Effect of modified urea materials on rainfed low and transplanted rice and their residual effect on succeeding wheat crop. *Indian J. Agron*., **31**(2): 198-200.

Subhendu. M., Swamy, S.N. and Mandal, S. (2003). Effect of time of nitrogen application on yield and yield attributes of rice (*Oryza sativa L.)* cultivars. *Environ. Ecol*., **21**(2): 411-413.

Surekha, K., Reddy, M. N., Kumar, R. M. and Kumar, C. H. M. V. (1999).Effect of nitrogen sources and timing on yield and nutrient uptake of hybrid rice.*Indian J. Agril. Sci*., **69**(7): 477-481.

Surendra, S., Prasad, R. and Sharma, S. N. (1995). Effect of blue green algae, nitrogen levels and modified urea materials on yield attributes and yield of low land rice (*Oryza sativa*).*Indian J. Agron*., **40**(4): 594-597.

Tantawi, B. A., Mahrous, F. N. and Balal, M. S. (1991).Fertilizer management in broadcast rice under late transplanting.*Indian J. Agron*., **36**:281-282.

Ten Have, H. (1971). Improved cultural practices for the new varieties. All Indian Co-ordinated Rice Improvement Project. Bull. 36. p. 2.

Thakur, D. S. and Patel, S. R. (1998).Response of split application of nitrogen on rice (*Oryza sativa L*.) with and without farm yard manure in inceptisols.*Environ. Ecol*., **16**(2): 310-313.

Thakur, R. B. (1991). Eflèct of N levels and fbrms of urea on lowland rice under late transplanting. *Indian J. Agron*.**36**: 28 1-282.

Vaiyapuri, V., Karthikeyan, T. D. Ravichandran, M. and Sriramachandra, M. V. (1995). Effect of time of N application with graded levels of *sesbaniaspecies* on yield, N uptake and nitrogen use efficiency in rice. *Annl.Agril. Res*., **16**(3): 286-288.

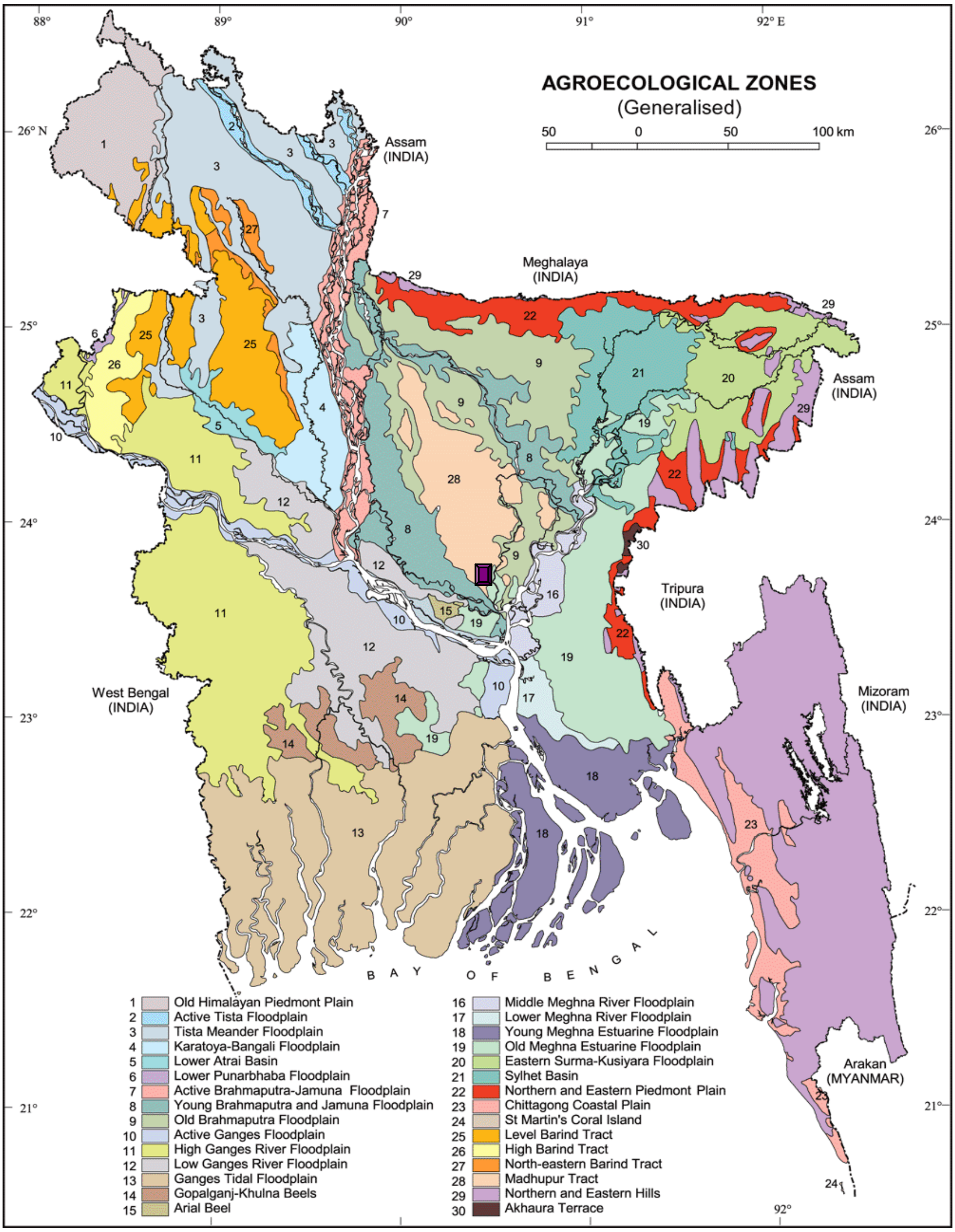
Vijaya, D. and Subbaiah, S. V. (1997). Effect of methods of application of granular forms of fertilizers on growth, nutrient uptake and yield of paddy. *Ann. Agril. Res*., **18**(3): 361-364.

Wagh, R. G. and Thorat, S. T. (1988).Response of rice (*Oryza sativa L.*) variety R24 to different times of application of nitrogen and plant densities in coastal soils.*J. Indian Soc. Coastal Agril. Res*., **6**(2): 133-137.

Xie, P. P., Dubey, S. K. and Bisen, C.R. (2007).Response of rice to different fertility levels.*J. Soils Crops*. **13**(1): 120-122.

APPENDICES

Appendix I. Map showing the experimental site under study



■ The experimental site under study

Appendix II. Characteristics of experimental soil

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Horticulture Garden , 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 temperature, relative humidity, rainfall and sunshine of the experimental site during the period from November 2010 to April 2011

Month	*Temperature (ºc)		*Relative humidity (%)	*Rain fall (mm) (total)	*Sunshine (hr)
	Maximum	Minimum			
November, 2010	19.4	15.3	78	00	6.2
December, 2010	22.4	13.5	74	00	6.3
January, 2011	24.5	12.4	68	00	5.7
February, 2011	27.1	16.7	67	30	6.7
March, 2011	31.4	19.6	54	11	8.2
April, 2011	33.6	23.6	69	163	6.4

* Monthly average,

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

Appendix IV. Analysis of variance of the data on plant height of BRRI dhan50 as influenced by levels of nitrogen and transplanting depths

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
Level of nitrogen (A)	3	51.115**	136.272**	156.674**	290.308**	307.396**
Error	6	0.246	0.790	1.251	2.147	0.544
Transplanting depth (B)	2	4.148*	14.147**	43.239**	34.914**	78.011**
Interaction (A×B)	6	4.150*	7.933*	6.088*	9.66*	1.417*
Error	16	1.002	1.248	1.962	3.550	0.621

**: 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 BRRI dhan50 as influenced by levels of nitrogen and transplanting depths

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
Level of nitrogen (A)	3	9.229**	29.612**	121.363**	75.029**
Error	6	0.064	0.038	0.419	0.034
Transplanting depth (B)	2	1.948**	6.691**	22.680**	19.670**
Interaction (A×B)	6	0.213**	0.309**	1.300**	9.954*
Error	16	0.052	0.086	0.355	0.9522

**: 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 hill^{-1} of BRRI dhan50 as influenced by levels of nitrogen and transplanting depths

Source of variation	Degrees of freedom	Mean square				
		Dry matter plant^{-1} (g) at				
		30 DAT	50 DAT	70 DAT	90 DAT	Harvest
Replication	2	0.0001	0.0001	0.008	0.047	1.752
Level of nitrogen (A)	3	0.066**	5.280**	104.785**	187.621**	662.237**
Error	6	0.001	0.022	0.028	0.318	1.551
Transplanting depth (B)	2	0.027**	1.256**	13.441**	19.301**	113.285**
Interaction (A×B)	6	0.004*	0.057*	1.263**	0.416*	5.063*
Error	16	0.001	0.018	0.252	0.168	1.889

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

Appendix VII. Analysis of variance of the data on effective tillers hill^{-1} , in-effective tillers hill^{-1} & total tillers hill^{-1} and panicle length of BRRI dhan50 as influenced by levels of nitrogen and transplanting depths

Source of variation	Degrees of freedom	Mean square			
		Effective tiller hill^{-1}	In-effective tiller hill^{-1}	Total tiller hill^{-1}	Length of panicle (cm)
Replication	2	0.112	0.020	0.101	0.155
Level of nitrogen (A)	3	32.498**	6.445**	66.763**	18.662**
Error	6	0.126	0.041	0.186	0.065
Transplanting depth (B)	2	3.514**	2.354**	5.263**	19.790**
Interaction (A×B)	6	0.442**	0.393*	1.260**	0.968*
Error	16	0.116	0.145	0.341	0.361

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

Appendix VIII. Analysis of variance of the data on filled grains panicle^{-1}, unfilled grains panicle^{-1} and total grains panicle^{-1} and weight of 1000 grains of BRRI dhan50 as influenced by levels of nitrogen and transplanting depths

Source of variation	Degrees of freedom	Mean square			
		Number of filled grains panicle^{-1}	Number of unfilled grains panicle^{-1}	Number of total grains panicle^{-1}	Weight of 1000 grains (g)
Replication	2	1.252	0.577	1.231	0.010
Level of nitrogen (A)	3	1381.772**	39.689**	953.325**	15.806**
Error	6	2.700	0.104	3.505	0.283
Transplanting depth (B)	2	79.688**	12.339**	31.352**	6.152**
Interaction (A×B)	6	11.043**	2.183**	7.873*	0.344
Error	16	2.810	0.387	2.666	0.138

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

Appendix IX. Analysis of variance of the data on grain yield, straw yield, biological yield and harvest index of BRRI dhan50 as influenced by levels of nitrogen and transplanting depths

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
Level of nitrogen (A)	3	15.742**	8.899**	47.617**	88.150**
Error	6	0.046	0.020	0.093	0.759
Transplanting depth (B)	2	2.005**	1.919**	7.778**	3.532
Interaction (A×B)	6	0.112*	0.081*	0.357**	0.629
Error	16	0.041	0.027	0.067	1.288

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