# PRODUCTIVITY OF BORO RATOON RICE UNDER DIFFERENT LEVELS OF NITROGEN


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# *CERTIFICATE*

*This is to certify that the research work entitled,* ***"Productivity of Boro Ratoon Rice Under Different Levels of Nitrogen"*** *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 successfully carried out by* ***A. F. M. Mamun*** *bearing* **Registration No. 08-3237** *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, as has been availed of during the course of this investigation has duly been acknowledged.*

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***Dated:*** *December 20, 2010*
***Place:*** *Dhaka, Bangladesh*

*Dedicated*

*to my*

*beloved parents*

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## Abstract

An experiment was carried out at the Agronomy Field, Sher-e-Bangla Agricultural University, Dhaka during November 2009 to July 2010 to study the effect of variety and varying levels of nitrogen application to ratoon crop of boro rice. Four varieties (BRRI hybriddhan2, BRRI dhan29, BRRI dhan35 and BRRI dhan47) and four nitrogen doses (0%, 25%, 50% and 75% N of recommended dose applied after harvest of main crops) were tested. These doses of N fertilizer were applied to the ratoon crop just after harvesting of the main crop leaving 15 cm stuble height above the ground level. Among the main crop BRRI hybriddhan2 produced significantly highest grain yield (7.037 t $ha^{-1}$). In the ratoon crop grain yield of BRRI hybriddhan2 and BRRI dhan29 with all levels of N application produced significantly higher grain yield (710-917 kg $ha^{-1}$). So, BRRI hybriddhan2 and BRRI dhan29 with 25% extra N application could be considered for ratoon cropping.

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## LIST OF ABBREVIATIONS

| Abbreviation | Full meaning |
|---|---|
| @ | at the rate of |
| ˚C | Degree Celsius |
| Abst. | Abstract |
| AEZ | Agro-Ecological Zone |
| Agric. | Agriculture |
| Agril. | Agricultural |
| Agron. | Agronomy |
| Anal. | Analogy |
| Biol. | Biology |
| BRRI | Bangladesh Rice Research Institute |
| Bull. | Bulletin |
| CV | Co – efficient Variation |
| df | Degree of Freedom |
| e.g. | For example |
| *et al.* | and others |
| etc | Etcetera |
| g | gram(s) |
| ie. | that is |
| Info. | Information |
| Inst. | Institute |
| Intl. | International |

| | |
|---|---|
| IRC | International Rice Commission |
| IRRI | International Rice Research Institute |
| dS $m^{-1}$ | deciSiemens per metre |
| IRRN | International Rice Research Newsletter |
| J. | Journal |
| LAI | Leaf Area Index |
| LSD | Least Significant Difference |
| N | Nitrogen |
| Newsl. | Newsletter |

## LIST OF ABBREVIATIONS (CONTD.)

| **Abbreviation** | **Full meaning** |
|---|---|
| Pak | Pakistan |
| $P^H$ | Concentrate of $H^+$ |
| Philipp. | Philippines |
| RCBD | Randomized Complete Block Design |
| Res. | Research |
| SAU | Sher-e-Bangla Agricultural University |
| Sci. | Science |
| SD | Standard Deviation |
| SRDI | Soil Resource Development Institute |
| t $ha^{-1}$ | ton per hectare |
| Uni. | University |

| | |
|---|---|
| V | Variety |
| CH | Cutting Height |
| cm | Centimeter |

# CHAPTER I

# INTRODUCTION

Rice (*Oryza sativa* L.) is one of the most important primary cereal crops in the world (Nassiri and Pirdashti, 2003). It is the staple food for more than two-third of the world's population (Singh, 1993). The world population by the year 2050 has been projected to be approximately 11 billion people, of which 90% will reside in the developing countries of the South (Krattiger, 1996). To feed the increasing global population, the world's annual rice production must increase from the present 528 to 760 million ton by 2020 (Kundu and Ladha, 1999).

Three successive rice crops can be grown within one year by adapting suitable short duration rice varieties under irrigated conditions. But in the rainfed areas the cropping intensity is minimum (Krishnamurthty, 1979). About two-thirds of the total rice area of Asia is rainfed which remains fallow after the monsoon season. Intensifying rice cropping in drought areas, soil moisture is the most limiting factor. Increasing rice grain yields per unit of area is one approach to improving total rice production (Santos *et al.*, 2003).

However, the development of ratooning rice is one of the methods to increase the yield all over the world because additional rice yields can be achieved with minimal agricultural inputs (Harrell *et al.*, 2009). Ratoon cropping of rice is the practice of obtaining a second crop from the stubble of a previously harvested (main) crop (Coale and Jones, 1994). Therefore, the benefit in ratooning lies in the facts of avoiding of elaborate land preparation, saving of seed and planting costs (Zandstra and Samson, 1979), economic use of machineries, high water use efficiency (Prashar, 1970) and considerable saving in cropping time as it has the advantage of reduced growth duration (Haque and Coffman, 1980). It reduced production cost by 73 percent (Calendacion *et al.*, 1992). Rice ratooning has several stated advantages: low production costs, high water use efficiency, and reduced growth duration (Jones, 1993). For example, the average yield of the main crop was 12633 kg ha-1 and the ratoon was 7115 kg ha-1 in Fujian province of southeast China (Chen *et al.*, 2007). The field duration of a ratoon crop is less than 50% of the main crop, even when early varieties are employed. Ratooning of rice has been reported to be a practical means of increasing rice production and the cost of production is very low (Mohan *et al.*, 2000). The ratoon crop of rice can extract moisture and nutrients from deeper soil layers by the already established root system and it may be harvested before the onset of drought. Ratooning of rice eliminates two labor-saving operations: raising seedlings in the seedbed and transplanting in the main field (Bahar & Datta, 1977). Ratooning technique has positive characteristics such as high cooking quality, high taste, short growth duration, and less production cost (Karbalaei *et al.,* 1998). Ratoons are also applied to the utilization of rice plant as fodder (Ichii, 1982).

The ratoon cropping systems have been used in India, Thailand, Taiwan, Swaziland, China, the United States and Philippines (Nakano and Morita, 2007). In the USA 50% of the rice crop is ratooned (Flinchum and Evatt, 1972). The non-acceptance of rice ratooning for large scale commercial farming in tropical Asia seems to be due to its low yield potential and vulnerability to pests and diseases (Mahadevappa, 1979). If grain yield of the ratoon crop alone is considered, it may be seen discouraging. However, if consideration is given to the time factor to express yield, ratoon cultures are found to be very encouraging (Quddus and Pendleton, 1990).

On an average, ratoon rice can give a yield roughly equivalent upto 40% of that of the main crop with 40% reduction in crop duration (Samson, 1980). Faria (1984) mentioned that production of irrigated ratoon rice in Brazil covered 30% of that of the first crop and in other countries the corresponding figure was 50%. Ratoon yield is generally less than the main crop but higher yields have also been reported by Santhi *et al.* (1993). Reddy *et al.* (1979) reported that the ratoon crop of Intan rice variety yielded 140% of its main crop yield in Karnataka.

Under Bangladesh context, there are potentials for rice ratooning from the stubble of boro rice with residual soil moisture and monsoon rain. In this country, crop intensification through rice ratooning constitutes one of the important options for the farmers in achieving food security. Here rice crops may be grown thrice in a year in aus, aman and boro seasons. But, it is not always possible to accommodate three crops in a year through conventional rice culture. In this context, ratooning can play a very significant role with its very short growth duration, usually taking only 35 to 60% of the time required for the main crop (Jones, 1985). Ratooning thus helps in adding extra yield. On the other hand, in rice based cropping pattern when transplanted aman (T. aman) is grown after boro rice, crops like mustard, pea etc., whose optimum sowing time is the first week of November, cannot be accommodated. Because, T. aman is harvested only after mid-November

(Alim, 1974). In such a situation ratoon cropping of boro rice can ensure three crops in a year as well as crops like mustard, lentil, pea etc. can also be accommodated in the pattern. It is thought that rice ratooning might play a significant role in increasing total crop production trend in Bangladesh too.

In an effort to better understand the factors influencing rice ratoon crop growth, the International Rice Research Institute (IRRI) published a comprehensive report (Chauhan *et al.,* 1988) identifying key factors influencing a rice cultivar's ratoon potential: plant maturity at main crop harvest, main crop harvest height, main crop cultural practices, temperature, sunlight, leaf senescence, and carbohydrate and N content of main crop stubble.

Ratooning is a natural phenomenon in grass family (*Gramineae*) which is basically a varietal character and differs among cultivars (Chatterjee *et al.,*1982). Zhang *et al.* (2009) have indicated that ratoon yield is affected by variety. Cuevas-perez, (1980). Prakash and Prakash (1988) stated that, there has been considerable effort to select rice cultivars for superior ratoonability. The photosynthetic products and nutrient left in the rice stubbles had a great effect on the growth and development of the ratoon crop (Liu *et al.,* 1993).

Although ratoonability is a varietal characteristic, manipulation of cultural practices can enhance a good ratoon crop of rice (Quddus, 1981). Kasturi and Purushothaman (1992) also observed that grain yield varied with different fertilizer dose. Nitrogen is required by plants in comparatively larger amounts than other elements (Marschner, 1995). Nitrogen (N) fertility is one of the most important factors influencing ratoon crop grain yield and, in general, N application increases ratoon rice yield (Turner and McIlrath, 1988). Application to the ratoon crop of about 75% of the main crop nitrogen fertilization rate is sufficient to obtain high ratoon yield (Evatt and Beachell, 1960). N applied immediately after main crop harvest significantly affected ratoon yield (Nassiri and Pirdashti, 2003). Su (1980) found that ratoon grain yields were maximized by early application of N fertilizer to the ratoon crop. Ratoon rice yield increased significantly from 2677.70 to 3036.20 kg $ha^{-1}$ as the N fertilizer application rate increased from 31.15 and 100.83 kg $ha^{-1}$ but increasing the N fertilizer application rate from 67.21 and 100.83 kg $ha^{-1}$ did not improve ratoon rough rice yields (Bond and Bollich, 2006). It is suggested that N should be applied at 15 days after full heading and 1 day after harvesting main crop, and that the ratio of tillers formation to total N should be increased as N rate increases (Yuan *et al.*, 1996).

However, sufficient information based on research work is still lacking with regard to rice ratooning in Bangladesh. Moreover the farmers are not familiar with the production technology of rice ratoon cropping. There is some evidence which showed that N fertilizer has an impact on ratoon rice yield. A field experiment was conducted in Gazipur, Bangladesh, to study the effect of N source on the growth and yield of rice cv. BR 14. The results indicated that mustard oil cake as N source was superior to urea or cow dung. Among combinations, N as 50% mustard oil cake+50% N as urea gave the highest yields. (Rahman *et al*., 2004). Another experiment was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during the period from December 2003 to August 2004 to study the response of different fertilizer doses was studied on the ratoon crop as well as main crop. In both of the cases yield and yield components of main and ratoon crop were significantly influenced by fertilizer doses performance of ratoon rice as well as ratoon crop of rice have a tremendous response to N doses (Islam *et al.*, 2008).

But no research and study to describe a optimum nitrogen dose to obtain optimum ratoon rice yield is not conducted yet. The present study was, therefore, undertaken to find out the effect of variety and different levels of nitrogen (N) application on ratoonability of boro rice.

**Objectives:**

The research work was conducted to-

- observe the performance of different boro rice varieties under ratoon cropping;
- measure the productivity of ratoon boro rice under different levels of N application;
- asses the optimum level of N to produce optimum yield of rice under ratoon cropping; and
- study the interaction effect of different varieties and different levels of N application.

# CHAPTER II

# REVIEW OF LITERATURE

## 2.1. Effect of variety

Ratooning is thought to be a varietal character. There is a great scope to enhance ratoonability through varietal selection. Rahman *et al.* (2004) conducted a field experiment at the Bangladesh Rice Research Institute (BRRI), Charbadna farm, Barisal, from boro 2001 to aman 2002. Seven photoperiod-sensitive rice varieties including three fine grain aromatic varieties were transplanted in 15 December and 30 December 2001. The ratoon-yields of both aromatic and non-aromatic varieties were encouraging and produced about 2 t $ha^{-1}$ grain yield, which was more than the average yield of local varieties normally cultivated in the transplanted aman season in that region. The highest yield was obtained from BR23 (2.87 t $ha^{-1}$) followed by BRRI dhan37 (2.63 t $ha^{-1}$). From this experiment, it was revealed that the photoperiod-sensitive rice varieties could be planted in the early boro season and the ratoons from this crop also produced a good harvest.

Tang *et al.* (2002) found that among 37 cultivars, yield and yield components of ratoon crops of hybrid rice were better than those of conventional cultivars. He also found that the number of panicles $plant^{-1}$, spikelets $panicle^{-1}$ and the number of grains $panicle^{-1}$ were the important factors that affected the yield of ratoon crop of rice. Plant height and panicle length had significant negative correlation with yields.

Xie *et al.* (2005) used eight hybrid rice combinations to study the source-sink characteristics and yields of main and ratoon crops. The leaf area (LA) index (LAI) and the LA per culm of the ratoon crop were approximately 1/3 and 1/7-1/3 of those of the main crop, respectively. The total sink volume of the ratoon crop was higher by 1.5 - to 2.0-fold than that of the main crop. The ratio of the number of grains to the LA in the ratoon crop was higher than that of the main crop by 1.5- to 2.0-fold. Based on the yield of the ratoon crop and total yields under the climatic conditions of Changsha region, Hunan, China, during 2002, the optimum combination for ratooning was Peiai 64 S/E32, followed by Kangliangyou 2054 and T98A/259.

Lin *et al.* (2001) studied the morphological and functional differences of root systems among the three ratooning rice varieties; Shanyouming 86, Teyou 70 and Shanyou 63, and their correlation. The results showed that Shanyourning 86 had the most flourishing root systems and yields of this variety was the highest both in the main and ratoon crop season. Teyou 70 had a flourishing root system in the first season, dropped sharply after the maturing period and as a result, its yield was high in the main crop and low in the ratoon crop.

According to Cheng *et al.* (2001) during the harvest of the main crop, the soluble carbohydrate content of the tillering stem and stem sheath was not correlated with their ratoonability in hybrid rice, but the soluble carbohydrate content of the main stem was interrelated.

Xu and Xiong (2000) conducted an experiment with thirty-three hybrid rice combinations to study the relationship between ratio of grain to leaf area and ratoonability during 1995 to 1998. The result showed significant negative correlations between the ratio of grain to leaf area and the ratoonability of the main crop. The ratooning ability of varieties could be changed under the ratio of grain to leaf area. The reason was that there were significant positive correlations between dry weight of maternal stems and the ratoonability, and significant negative correlations between the ratio of grain to leaf area and dry weight of the maternal stems. Significant positive correlations between the number of grains per panicle among varieties and the ratio of grain to leaf area of main crop were observed. There were significant negative correlations between the number of grains panicle$^{-1}$ of main crop and the yield of the ratoon rice.

A field experiment was laid-down to evaluate the ratoon grain yield potentials of thirty rice cultivars and advanced lines under lowland conditions during wet season at Philippine Rice Research Institute (PhilRice), Philippines by Oad *et al.* (2002). Grain yield showed positive correlation with plant height, ratoon rating, 1000 grain weight, number of panicles, panicle length, seed length, and tillers at harvest. Path analysis indicated that ratoon crop parameters had low positive direct effects. It was revealed from the contribution of individual characters to the variance of yield that the contribution of the characters to the determination of yield was largest for total tillers at harvest, panicles per plant, panicle length and finally ratoon rating. The study suggests that selecting varieties may base higher ratoon rice grain yields or advanced lines, which has higher tillers, more panicles per plant, lengthy panicles, and high ratoon rating.

Chen *et al.* (2000) conducted an experiment with two-line rice hybrid Peiliangyou 500 and Shanyou 63 that were ratooned after growing as a middle-season crop. Total yield of the main and ratoon crop of Peiliangyou 500 was 12.08 t $ha^{-1}$, which was 37.5% higher than yield of the control cultivar Shanyou 63.

Shi and Shi (1997) conducted an experiment to determine the benefits of ratoon cultivation in rice. In trials during 1992-96, authors found that the main crop yielded 7.60-9.46 t $ha^{-1}$ and the ratoon crop yielded 3.10-6.24 t $ha^{-1}$.

Reddy (1995) conducted two separate experiments, using 135 varieties in the first and 6 high yielding varieties in the second and observed that yield of ratoon crops ranged from 0 to 2.05 t $ha^{-1}$ in Papua New Guinea. The author also mentioned that variety Acc 1981 gave the highest ratoon yield.

Sajjad (1994) evaluated main crop and ratoon crop yields and yield components of rice varieties Wantok, Tambu, Niupela and Senis grown in Papua New Guinea. It was found that grain yield in the main crop was highest (8.5 t $ha^{-1}$ vs. 6.9-7.3 t $ha^{-1}$ in other cultivars) in variety Senis, while in the ratoon crop yield was highest in Tambu (3.9 t $ha^{-1}$) followed by Wantok (3.3 t $ha^{-1}$) and it was lowest in Senis (1.7 t $ha^{-1}$)

Bollich and Turner (1988) gave a trial with five varieties and found that among the varieties the average number of days to heading for Texmont was 82, compared with 81, 87, 90 and 92 days for Maybelle, Skybonnet, Gulfmont and Lemont, respectively. Overall yields of Texmont, were 7.34 t $ha^{-1}$, compared with 7.37, 7.32, 7.02, 6.46, 6.09 and 5.91 t $ha^{-1}$ for Gulfmont, Maybelle, Lemont, Skybonnet, Labelle and Tebonnet respectively. Texmont performed superior ratoonability with ratoon yields ranging from 2.45 to 2.72 t $ha^{-1}$.

Srinivasan and Purushothaman (1993) reported that the ratoon crop of variety Bhavani performed better than Ponni with regard to growth, yield attributes and grain yield. Ratoon grain yield produced by Bhavani was 2.75 t $ha^{-1}$ which was 50.2% of the main crop yield. The ratoon grain yield produced by Ponni was 1.75 t $ha^{-1}$ which was 38% of the main crop yield.

Sutaryo and Suprihatno (1993) conducted an experiment with six F1 hybrids and a control (Dodokan) and reported that ratoon yields ranged from 14 to 22% of the main crop and hybrids of V20A with IR25912, IR64 and 1R28178 gave the highest ratoon yields of 1.3, 1.1 and 1.3 t $ha^{-1}$, respectively.

In an experiment Zhang (1991) observed that hybrid rice ratoon crops yield was 17% more than conventional rice ratoon crops.

Mathew *et al.* (1992) reported that among the 15 rice cultivars tested, 8 cultivars showed potentiality for ratooning, producing ratoon grain yields in the range of varieties IET9862, IET9573 and IET9190 produced the highest yields of >1.0 t $ha^{-1}$.

Tan and Li (1990) conducted an experiment with 24 hybrids and breeding lines in order to observe the differences in ratoonability among them and found that most of the hybrids had good ratoonability of which Dyou 10, Shanyou 66 and Minghui 63 produced higher ratoon tillers $hill^{-1}$.

Palchamy *et al.* (1990) reported that among 3 varieties Bhavani had a significantly higher ratoon grain yield, stem thickness and stubble carbohydrate content than Ponni and IR20 in both boro and aman season.

Mahadevappa (1988) found that varieties differed widely in ratoonability, type of tillers produced, growth period duration, grain quality and yield.

Prakash and Prakash (1988) planted 23 mid-season and late genotypes and found that the main crop yielded from 2.02 to 4.73 t $ha^{-1}$. The ratoon crop yield ranged from 0.1 in Pushpa to 1.81 t $ha^{-1}$ in IET7431. In terms of the ratoon crop yield as a percentage of the main crop yield, BPT2685 was the best with 1.61 t $ha^{-1}$ (71.24%).

Chauhan *et al.* (1988) observed that of 24 advanced photoperiod insensitive summer rice genotypes ratooned by cutting the stems 15 cm above the ground, only 10 showed regeneration and RP 1664-4661-693-1333 had the greatest ratoonability with 94.9% hill regeneration.

Rosamma *et al.* (1988) compared the grain weight and germination of main and ratoon crops of 5 rice varieties and observed varietal differences for both traits. The authors also observed that the highest 1000-grain weight was found in Jaya {28g (main crop), 24g (ratoon crop)}.

Palchamy ans Purushothaman (1988) assessed grain yield in main and ratoon crops in 10 early and mid season varieties and noticed that ratoon crop yields ranged from 0.43 t $ha^{-1}$ (variety Ponni) to 2.20 t $ha^{-1}$ (variety Bhavani).

Qiu and Jin (1988) conducted an experiment to evaluate the ratoonability of 28 varieties in a greenhouse by cutting mature plants to a height of 15 cm and found that 1829, IR30, 1843 and 1864 had relatively high ratoonability, and 13 varieties had intermediate ratoonability.

Singh *et al.* (1987) showed that 10 out of 24 breeding lines had ratoonability and it varied from 59.4 to 94.9%. The author also showed that ratoon grain yield ranged from 0.8 to 1.7 t $ha^{-1}$ and the line 1664-4461-693-1333 gave the highest ratoon grain yield.

Evatt and Beachell (1960) from their investigation reported that the practical means of increasing rice yield could be extended by using early maturing varieties (109-132 days from sowing to maturity). The authors obtained yields of 1.68 to 2.24 t/ha from ratoon crops.

Szokolay (1956) reported that the various rice varieties showed different ratoonability. The author experimented with three varieties of rice, namely, Century patna No.2, Swazi No.1 and Swazi No.2, and obtained 3.06, 1.50, and 3.30 t $ha^{-1}$ ratoon yield, respectively.

Maurya *et al.* (1987) carried out an experiment by harvesting the main rice crop taking only the panicles. In the ratoon crop the number of effective tillers, number of grains, 1000-grain weight and grain yield ranged from 14-16 $plant^{-1}$, 81-90 $panicle^{-1}$ 15.8-17.7 g and 2.0 -2.7 t $ha^{-1}$, respectively; depending on varieties.

Chang *et al.* (1985) carried out an experiment with 163 varieties to assess the variation in ratoonability and showed that ratoonability varied from 0% to 122.9%. The authors also noticed that the indica varieties had an overall higher ratoonability (29%) than the japonica varieties (19.5%).

## 2.2. Effect of nitrogen and other macronutrients dose and time of their application

Ichii and Yoshibumi (1983) found that the time of macronutrient application was of great importance for vigorous ratoons, and more vigorous ratoons were observed in the plot applied on the day of cutting. Among the macronutrients, the most significant effect was recognized for the nitrogen; second for the phosphorus. The effect of the potassium was not significant.

Bond and Bollich (2006) conducted research for 2 years to determine the N fertilizer application rate producing maximum ratoon rice grain yields. The long-grain rice cultivars Cheniere, CL161, Cocodrie, and Cypress were grown using a delayed-flood, drill-seeded production system. Immediately following harvest of the main crop, N fertilizer at rates of 31.15, 67.21, 100.83 or 134.44 kg $ha^{-1}$ was applied as urea. Ratoon rough rice yield increased significantly from 2677.70 to 3036.20 kg $ha^{-1}$ as the N fertilizer application rate increased from 31.15 to 100.83 kg $ha^{-1}$ but increasing the N fertilizer application rate from 67.21 to 100.83 kg $ha^{-1}$ did not improve ratoon rough rice yields. No ratoon rice lodging was observed in any site-year at any N fertilizer application rate. In this study, the N fertilizer application rate producing maximum ratoon rice yields in the Gulf Coast area of the United States was 100.83 kg $ha^{-1}$.

Balasubramanian and Krishnasamy (1997) conducted field experiments during Kharif (monsoon) and Rabi (winter) seasons at Tamil Nadu Agricultural University where rice varieties ADT 36, ASD 16, CO 37 and PMK 1 were given 75, 100 or 125 kg N $ha^{-1}$ and cut at 20 or 30 cm height with a view to ratooning. In the main crop, ADT 36 gave the highest grain yield, whereas in the ratoon crop, yield was highest in CO 37 (2.56 and 2.61 t $ha^{-1}$ in Kharif and Rabi season, respectively) followed by PMK 1. Growth and yield attributes were influenced by cultivars and nitrogen whereas stubble height was found to have no effect on ratoon yield. Productivity was the highest (32.5 and 30.0 kg $ha^{-1}$ in Kharif and Rabi, respectively) in variety C037. The cost benefit ratio was maximum in variety CO 37.

Kumaresan (2001) conducted a field experiment in Coimbatore, Tamil Nadu, India, during 1990-91 to study the nutrient (N, P and K) uptake in ratoon rice as influenced by residual effect of green manure and growth regulators. It is concluded that improved nutrient uptake and increased yield can be obtained with 12.5 t $ha^{-1}$ as basal crop and applied 7 days before transplanting the main crop, and spraying of 2% glucose on the 5th DAHMC+2% DAP at 30 DAP for the ratoon crop.

Kumaresan and Rangasamy (1997) conducted an experiment to find out the residual effect of green manure and growth regulators on the yield of ratoon rice. Sesbania rostrata applied basally at 12.5 t ha-1 for the main rice crop increased the growth parameters, grain yield and straw yield of the ratoon crop. Spraying 2% glucose on the 5th day after harvest of the plant crop (DAHP) plus 2% DAP (Di-ammonium phosphate) at 30 DAHP increased the growth parameters and yield of ratoon rice.

Maharudrappa (1996) studied plant rice cv in a field experiment in 1985-86 at Mudigere, Karnataka. Inter crop was cut to stubble heights of 2.5, 5-7.5 or 7.5-12.5 cm and grown as a ratoon crop and given 0-57 kg N $ha^{-1}$. Grain yield was not affected by stubble height of and was highest with 57 kg N (2.32 t $ha^{-1}$).

Yuan *et al.* (1996) studied N requirement and split application of N fertilizer in ratoon rice. Ratooned rice was given different rates of N fertilizer 15 day after full heading of the main crop and/ or 1 day after harvest of the main crop. Bud formation promoted carbohydrate and N metabolism during late growth of the main crop, enhancing bud growth and thus increasing numbers of tillers and effective panicles in the ratoon crop. Tillers formation promoted growth of the ratoon crop, increasing the percentage of filled spikelets and numbers of filled grains $panicle^{-1}$. It is suggested that N should be applied at both stages, and that the ratio of tillers formation to total N should be increased as N rate increases.

A Field studies were conducted in Japan to investigate the dry matter yield and nitrogen budget of ratoon-cropped forage rice on farm fields receiving 300 kg N $ha^{-1}$ manure, under various combinations of planting densities by Kobayashi *et al.* (2007). The annual dry matter yield over two harvests was the highest at a density of 40 plants $m^{-2}$, and increased as the chemical fertilizer rate increased, exceeding 200 kg $ha^{-1}$ when climatic conditions during the cultivation period favored plant growth.

Jiang *et al.* (2003) studied the effects of N fertilizer rates on uptake and distribution of N in ratooning rice in field experiments in 2000. The relationship between N uptake and its recovery rate with nitrogen application rates for promoting bud and tiller in main rice and ratooning rice was a parabola curve. The grain yield of ratooning crop showed a parabolic correlation with the application rate for promoting buds and tillers. The highest grain yield of ratooning crop was obtained with the N application rate of 241.3 kg $ha^{-1}$

Singh and Devi (2001) found the highest yield by application of 60 kg $ha^{-1}$ when a field experiment was conducted in Imphal, Manipur, India during April-November 1996 and 1997 to study the effects of seedling age, cutting height and nitrogen levels on the yield and economics of ratoon rice.

According to Begum *et al*. (2002) cultivation and cultural practices, including cutting height and fertilizer management, provide a large quantity of reserves at harvest.

**2.3. Effect of environment**

The effects of climate change on the growth and yield of ratoon rice were studied in Zhuxi, Jiangxi, China by Ming *et al.* (2007). Sunlight and temperature were the main factors limiting the yield of ratoon rice. The average temperature and minimum temperature were the most closely related to the yield. Sunshine was another important factor associated with the yield of ratoon rice. Although light and heat resources were abundant in the research area, a large gap between actual yield and potential yield was observed.

Evans (1957), Ganguly and Ralwany (1954) and Kaichu (1958), however, obtained a ratoon crop of up-to 80% of the main crop. This variation of the yield performance of the ratoon crop, however, might be due to the variation in environmental condition, variety, clipping height, cultural practices and other unforeseen factors such as damages of grains by birds and rats.

Ichii (1982) found that ratoon rice grown at 30$^{o}$C produced a higher dry weight than that in plants grow at 20$^{o}$C. In addition, grain yield at 20$^{o}$C was significantly lower than yields at high and normal temperature due to high spikelet sterility. Temperature also affects duration of ratoon rice growing. Crop maturity lengthens from 56 days at high temperature to 96 at low temperature. It was supported by Ziska (1997) and Chawhan *et al.* (2008).

### 2.4. Effect of harvesting time of main crop

Thuamkham (2003) reported that the cutting time had a significant effect on number of effective tillers hill$^{-1}$, panicle m$^{-2}$, percent of filled spikelet, grain yield and harvest index at 0.01 probability level. The highest number of effective tillers hill$^{-1}$ (8.66), panicle m$^{-2}$ (138.60), percent of filling spikelet (82.59), grain yield (1294.10 kg ha$^{-1}$) and harvest index (30.50) were obtained in harvesting physiological maturity. This was perhaps due to decreased to delay cutting time and decreased in temperature cause reduce in yield and component yield. Cutting time had no significant effect on number of tillers hill$^{-1}$, number spikelets panicle$^{-1}$, 1000 grain weight and biological yields.

Xiong *et al.* (1991) conducted an experiment to see the effect of different time of harvest of the main crop by harvesting it at 22, 25, 28, 31 and 34 days after main crop heading on the performance of ratoon crop and reported that cutting the main crop 34 days after heading when axillary buds began sprouting, resulted in the highest yield in the ratoon crop.

Siddique *et al.* (1995) showed that the optimum harvesting time of the main crop was at its physiological maturity for better performance of ratoon crop.

Wang *et al.* (1995) harvested main crop of hybrid rice in different dates and showed that if cut before booting stage then re-growth was done by leaf production, but when cut after panicle emergence stage then re-growth was occurred by tiller production and if cut between these two dates then re-growth was done by both leaf and tiller production. The author also reported that the highest grain and protein yields were given by cutting between panicle emergence and grain filling stage.

According to Haque (1975) and Yang *et al.* (1958) found that, the stage of maturity of the main crop at harvest affected ratooning.

Votong (1975) reported that delaying main-crop harvest to 44-56 days after flowering reduced ratoon crop growth duration.

Reddy *et al.* (1979) found no significant affect ratoon yields Harvesting at 30, 35, 40 and 45 days after main crop flowering.

## 2.5. Effect of cutting height

Andrade *et al*. (1988) conducted an experiment to see the effect of cutting height of 10, 20 or 30 cm above ground level on the yield and grain quality of ratoon crop of 10 rice varieties and found that 10 cm cutting height reduced the ratooning ability of all varieties and the best ratoon crop in terms of yield and quality was occurred with a cutting height of 30 cm.

A recent study conducted by Samson (1980) at IRRI showed that the grain yield of a ratoon crop was higher from a 15 cm than from a 3 cm cutting height of the first crop.

Amorim *et al*. (1986) conducted an experiment with 10 varieties and lines of irrigated rice by cutting the main crop to a height of 10, 20 and 30 cm and observed that grain yield ranged from 218 to 857, 157 to 750 and 315 to 1714 kg $ha^{-1}$, respectively. Other experimental reports showed that clipping height of the primary crop had effects on the maturity period and yield of the ratoon crop. It was supported by Jones (1993).

Chauhan *et al*. (1985) found that tiller regenerated from higher nodes formed more quickly, grew faster, and matured earlier. In contrast the panicles from ratoons coming from lower nodes produced more grains $panicle^{-1}$ than those from upper nodes, but it caused lower fertility percentage.

IRRI (1975a) showed the effects of different cutting heights on the yield of IR28. Four cutting heights used were at ground level, 5, 15 and 20 cm. The optimum cutting height in relation to grain yield production was found to be 15 or 20 cm above ground level.

IRRI (1975b) also reported from another experiment in the same year that cutting the main crop at 15 and 20 cm above ground level produced a significantly higher grain yield in the ratoon crop than the crop was cut at 5 cm. Ratoons were not produced on the majority of the hills when the main crop was cut at ground level and 5 to 7 cm water was maintained. More tillers were produced in the ratoon crop when the cutting height was 15 or 20 cm.

Sun *et al*. (1988) found that panicles from upper nodes contributed more to ratoon grain yields than those from lower nodes.

### 2.6. Effect of other management practices

Santos *et al.* (2003) found that the fungicide applications increased grain yield and reduced incidence of grain discoloration and consequent improvement in the quality of the product.

Esmaili *et al.* (2007) conducted a study in Iran to investigate the effects of plant residue management methods with and without Azolla and ducks, on weed density as well as on yield and harvest index of rice. The lock-lodging and common regional harvest methods had the highest and lowest weed populations, respectively. The number, height and dry weight of weeds were also decreased with Azolla and ducks. The highest yield and harvest index were obtained from lock-lodging due to increased total number of productive tillers, number of panicles $m^{-2}$ and total number of spikelets $spike^{-1}$. The ducks also increased the grain yield of rice due to increases in these parameters and high 1000-grain weight.

Review of literature cited and discussed above revealed that there are so many factors that influenced the different crop characters of ratoon rice e.g. environment; temperature, humidity etc. management practice; irrigation, harvesting of main crop, cutting height, pesticide application, manuring and fertilization etc. In this context some experiment show that variety and N fertilizer application after harvesting main crop have a great and direct impact on yield and quality of ratoon rice production. Because Naydo (2004) stated that, ratooning ability is an important and potential characteristic of rice varieties. On the other hand, nitrogen fertilizer is another important factor that greatly influences growth and yield of ratoons. Nitrogen has been observed to improve tillering and increase grain yield of the ratoon crop (Vergara *et al.* 1988; De Datta and Bernasor, 1988; Bahar and De Datta, 1977).

# CHAPTER III
# MATERIALS AND METHODS

The experiment was conducted at the Agronomy Field, Sher-e- Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from November 2009 to July 2010. A brief description on experimental site, layout of the experimental site, climate, soil, land preparation, layout of the experimental design, intercultural operations, data collection and analysis procedure is stated below.

## 3.1. Experimental Site

The experimental field was located at $90^{o}$ 22'E longitude and $23^{0}$ 41'N latitude at an altitude of 8.6 meters above the sea level. The land was located at “Madhupur Tract” (AEZ 28) (SRDI).

## 3.2. Soil

The field of the experimental site belonged to the Tejgaon series which was characterized by shallow red brown terrace soils. The soil was well drained and medium high. The soil was loam in texture and having soil $P^{H}$ ranges from 5.46 to 5.61. Organic matter content was very low (0.82%). The physiochemical properties of the soil are presented in Appendix II which was referred by Soil Resource Development Institute (SRDI).

## 3.3. Climate

The climate of the experimental area was subtropical that was characterized by high temperature, high humidity and heavy rainfall from April to September, with low temperature and minimum rainfall from October to February. Average temperature and average rainfall were increasing after February to onward. (Appendix III).

## 3.4. Planting materials

Four boro rice varieties released by BRRI was selected as planting materials. Selected varieties were BRRI hybriddhan2, BRRI dhan29, BRRI dhan35 and BRRI dhan47.

### 3.5. Treatments of the experiment

The experiment was consisted of the following treatments:

**Factor A: Variety (V)**

i. $V_1$ = BRRI hybrid dhan2

ii. $V_2$ = BRRI dhan29

iii. $V_3$ = BRRI dhan35 and

iv. $V_4$ = BRRI dhan47

**Factor B**: **Nitrogen dose (N) applied after the harvest of main crop**

i. $N_0$ = No nitrogen

ii. $N_1$ = 25 %  nitrogen of recommended dose for main crop

iii. $N_2$ = 50 % nitrogen of recommended dose for main crop

iv. $N_3$ = 75% % nitrogen of recommended dose for main crop

### 3.6. Design and layout of the experiment

The experiment was laid out in a Split Plot Design allotting nitrogen in the main plots and variety in the subplots with three replications. Therefore, the total number of plots was 48 (16 × 3). The area of unit plot was 3 square meter (2 m x 1.5 m). One meter (1 m) of distance was maintained between plots and between replications.

### 3.7. Description of the variety

The varieties were BRRI hybriddhan2, BRRI dhan29, BRRI dhan35 and BRRI dhan47. They were released for boro season by BRRI. Brief descriptions of these varieties are given as below.

#### 3.7.1. BRRI hybriddhan2

The stem of BRRI hybriddhan2 is strong and leaves are deep green like HYV. Grain is medium fatty & rice is fine. Its life cycle is 145 days & average yield is 8.00 t $ha^{-1}$. The sowing and transplanting time 15 November-15 December and 15 December- 15 January respectively and seed rate is 15-20 kg $ha^{-1}$. Seedling of 30-35 days should be transplanted in the main field with the recommended spacing of 20×15 cm (1-2 seedlings $hill^{-1}$). After 50% ripening of the grain harvesting may be done.

### 3.7.2. BRRI dhan29

BRRI dhan29 is a late variety of boro season. It was permitted for commercial cultivation in 1994. The grain size of this variety is slender and white in color. Its life cycle is completed within 160 days and height is about 95 cm. It is a high yielding variety and gives an average yield of 7.50 t $ha^{-1}$. BRRI dhan29 is the best variety among the all modern variety (BRRI). It can be said that BRRI Dhan29 is the most popular variety in boro season. Its stem is strong enough and yield is highest, but it takes highest amount of nutrient to give a highest yield. BRRI dhan29 is medium resistant to leaf and sheath blight disease. Farmers call it the hybrid rice of Bangladesh. Sowing time of this variety 1-15 November and the seedling of 40-50 days should be transplanted with a space of 15×20 cm. Harvesting time of BRRI dhan29 is 18-30 May.

### 3. 7. 3. BRRI dhan35

Bangladesh Rice Research Institute (BRRI) introduced this variety from IRRI for cultivation in the cold prone area of Bangladesh through a schedule of testing & evaluation. It was permitted to cultivate in boro season titled as BRRI dhan35 by National Seed Board. BRRI dhan35 is cold tolerant. Its height varies from 90-95 cm. The plants remain green until ripening. Grain of BRRI dhan35 is non sticky and medium slender. Its life cycle completed in 140-145 days. It gives a yield up to 5.00 - 5.50 t $ha^{-1}$ within optimum management practices. Sowing time of this variety 15 November- 22 December and can be transplanted during January.

### 3.7.4. BRRI dhan47

The breeding line number of BRRI dhan47 is 633307-4B-4-3. It is developed by crossing between the line IR 515111-B-B-34-B & TCCP266-2-49-B-B-3 of International Rice Research Institute (IRRI). That breeding line was brought to Bangladesh through the PETRRA (Poverty Elimination Through Rice Research Assistance) project & was selected to be cultivated in the saline prone area of Sathkhira with the farmer's participation in Boro season by variety selection method. The seedling of this variety is resistance to 12-14 dS $m^{-1}$ salinity. It can resist 6 dS $m^{-1}$ level of salinity during rest of the life cycle. It is the main feature of this variety. The height of this variety is about 101 cm.

Flag leaf is wide, long & erect. Grains are medium fatty & white spotted which are melted after boiling. Its life cycle is about 152 days. In saline soil it is capable to give a yield of 6.00 t $ha^{-1}$. Sowing time of this variety is 15-30 November and the seedling of 35-40 days should be transplanted with spacing of 20×15 cm.

### 3.8. Cultural operation

The brief description of all cultural operations, performed during the course of experimentation is given below.

#### 3.8.1. Cultural operation for main crop

Following cultural operations were performed for growing main crop.

##### 3.8.1.1. Collection of seed

Seed of 3 high yielding rice variety viz. BRRI dhan29, BRRI dhan35 and BRRI dhan47; and one hybrid rice variety viz. BRRI hybriddhan2 were collected from Bangladesh Rice Research Institute (BRRI), Joydebpur, Gazipur.

##### 3.8.1.2. Sprouting of seed

The seeds were dipped in water in a bucket for 24 hours. The seeds were then taken out of water and kept thickly in gunny bags. The seeds started sprouting after 24 hours and completed sprouting within 48 hours and became suitable for sowing in the seed bed by 72 hours.

##### 3.8.1.3. Preparation of seed bed and seed sowing

A piece of high land was selected in the Agronomy Field of Sher-e-Bangla Agricultural University, Dhaka for raising seedlings. The land was puddle with country plough, cleaned and leveled thoroughly with ladder to get a well puddle and leveled seed bed. The sprouted seeds were sown in the prepared seed beds on 29 November 2009.

#### 3.8.1.4. Land preparation

The land was opened in a water saturated condition with power tiller during last week of the December, 2009. The land was then repeatedly ploughed and cross ploughed with power tiller for preparation. The clods were broken and the land was leveled with tiller ladder. The weeds and stubble were removed.

#### 3.8.1.5. Field layout

Plots were laid out in the field following split plot design on 31 December 2009. Ails, drains and channels were made according to the layout.

#### 3.8.1.6. Fertilizer application

Fertilizers were applied to the plots following the recommendation by BRRI for the specific variety.

**Table1. Fertilizer dose ((kg $ha^{-1}$) recommended by BRRI for the selected rice varieties**

| Variety | N | $P_2O_5$ | $K_2O$ | S | Zn |
|---|---|---|---|---|---|
| BRRI hybriddhan2 | 216.77 | 114.44 | 143.62 | 24.24 | 5.39 |
| BRRI dhan29 | 120.43 | 35.34 | 53.86 | 10.09 | 2.29 |
| BRRI dhan35 | 120.43 | 35.34 | 53.86 | 8.07 | 2.83 |
| BRRI dhan47 | 86.02 | 43.76 | 40.39 | 10.77 | 4.04 |

Source: *BRRI factsheet*

The whole amount of fertilizers except N was applied before final land preparation. Urea was top dressed in three equal splits at 15, 30 and 45 days after transplanting.

#### 3.8.1.7. Uprooting of seedlings and transplanting

The seedlings were uprooted from the seed bed early in the morning on 30 December 2009 with due care so as to avoid injury and kept on soft mud in shade to avoid mechanical injury to the roots. The uprooted thirty-two days old seedlings were transplanted in the main field @ 1 seedling hill$^{-1}$ for hybrid and 2-3 seedlings hill$^{-1}$ for inbreed with proper spacing on 1 January 2010.

#### 3.8.1.8. Gap filling

Seedlings in some hills died off and those were replaced by the healthy seedlings from the same source on 18 January 2010.

#### 3.8.1.9. Water management

Irrigation was provided during the whole growth period of the crop in order to maintain a constant water level in the field. Before top dressing of urea, water was drained off the plots. The plots were again irrigated after the application of urea. Excess water was drained out during the heavy rainfall. Before 15 days of harvest the field was finally drained out to enhance maturity.

#### 3.8.1.10. Weeding

Crops were infested with different weeds. Weeding was done two times by hand pulling on 2 February 2010 and 1 March 2010.

#### 3.8.1.11. Plant protection measures

Proper crop protection measures were taken during the entire course of crop production. The crop was infested by the stem borer and rice bug at the vegetative phase and which were successfully controlled by application of Rigit 10 G @ 6.8 kg ha$^{-1}$ on 18 February 2010 and Ripcord @ 500 ml ha$^{-1}$ (25 ml/10L water) on 12 March 2010, respectively.

#### 3.8.1.12. General observation

The field was observed frequently to notice any change in plant characters, and it was observed that the general condition of the crop was good from transplanting to harvesting.

#### 3.8.1.13. Harvesting of the main crops

The main crop was harvested on different date from 26 April 2010 to 8 May 2010 from different plots depending on the maturity keeping a cutting height of 15 cm from the ground level.

### 3.8.2. Cultural operation for ratoon crop

#### 3.8.2.1. Cultural management

The next day after harvesting of the main crop, the field was hand weeded and urea was top dressed at the rate mentioned as the treatments. It was then mixed thoroughly with soil by a weeder. Some irrigation was necessary as there was little or no rainfall during the growing period of the ratoon crop. Drainage was made as and when was required. Disease infection and insect attack was not significant to take plant protection measure. To protect the crop from birds attack the field was observed frequently. However some grains were lost by birds and rats attack.

#### 3.8.2.2. Harvesting of the ratoon crop

Ratoon crop was harvested from 19 June 2010 to 5 July 2010 depending on the maturity of the grain of the different plots.

## 3.9. Sampling and processing of the data

Ten hills from each plot of main and ratoon crop were randomly selected, uprooted and properly tagged before harvesting for recording the necessary data on crop characters. The crop of each plot was harvested at full maturity when 80% of the grains turned in golden yellow color.

### 3.10. Data collection

Data on the following yield and yield contributing characters of main crop and ratoon crop were collected:

i) Plant height
ii) Total number of tillers hill$^{-1}$
iii) Days to panicle emergence
iv) Number of effective tillers hill$^{-1}$
v) Number of non-effective tillers hill$^{-1}$
vi) Panicle length
vii) Days to maturity
viii) Number of filled grains panicle$^{-1}$
ix) Number of unfilled grains panicle$^{-1}$
x) Number of total grains panicle$^{-1}$
xi) Grain yield hill$^{-1}$
xii) 1000-grain weight
xiii) Grain yield
xiv) Straw yield
xv) Biological yield
xvi) Harvest index

### 3.11. Procedure of data collection

Data was collected on sixteen yield and yield contributing parameters of both main and ratoon crop. A brief outline of data collection procedure is given below.

**Plant height**: Plant height was measured in cm from the ground level to the tip of the longest panicle.

**Total number of tillers hill$^{-1}$:** Tillering ability of the rice plant plays a major role in determining rice grain yield (Li *et al.* 2003). However, tillers which had at least one leaf visible were counted. It included both effective and non-effective tillers.

**Days to panicle emergence:** The emergence of panicle of each plot was observed carefully and days are counted from the transplanting of seedlings.

**Number of effective tillers hill$^{-1}$**: The panicle which had at least one grain was considered as effective tiller.

**Number of non-effective tillers hill$^{-1}$**: The panicle which had no grain was regarded as non-effective tiller.

**Panicle length**: Panicle length (cm) was recorded from the neck-node to the tip of each panicle.

**Days to maturity:** The crops were harvested at full maturity. Required days to maturity of main crops were counted from the seed sowing, and that of the ratoon crops were counted from harvesting of the main crops.

**Number of filled grains panicle$^{-1}$**: Presence of any food material in the spikelet was considered as grain. Total number of grains of ten randomly selected panicle were counted. Average mean of filled grains of these ten panicles was taken as number of filled grains panicle$^{-1}$.

**Number of unfilled grains panicle$^{-1}$**: Grains lacking any food material inside the grain was considered as sterile spikelet and such grains present on the each panicle were counted.

**Number of total grains panicle$^{-1}$**: Sum of the both filled and unfilled grains per panicle considered as number of total grains per panicle.

**Grain yield hill$^{-1}$:** The grain yield (g) of randomly selected 10 hills was taken and average yield of each hill was recorded.

**1000-grain weight:** One thousand clean dried grains were counted from the seed stock obtained from the ten sample plants of each plot and their weight (g) was taken in by using an electric balance.

**Grain yield:** Grains obtained from each unit plot were sun dried and weighed carefully. The dry weights of grains from the plants of the ten sample hills were added to the respective plot yield to record the final grain yield of each plot. The grain yield was eventually converted to t ha$^{-1}$.

**Straw yield:** Straw obtained from each unit plot including the straw of ten sample hills of respective unit plot was dried in the sun and weighed to record the straw yield of each plot and finally converted to t ha$^{-1}$.

**Biological yield:** Biological yield (g) was measured by adding grain and straw yield and recorded.

**Harvest index:** Harvest index is the ratio of economic yield (i.e. grain yield) to biological yield and was calculated with the following formula (Gardner *et al.* 1985).

Harvest index (%) = $\frac{\text{Grain yield}}{\text{Biological yield}}$ x 100

### 3.12. Statistical analysis

The recorded data for different parameters were compiled and tabulated in proper form for statistical analysis. Analysis of variance was done with the help of computer software package MSTAT-C program. The mean differences among the treatments were adjudged by Least Significant Difference (LSD) (Gomez and Gomez, 1984).

# CHAPTER IV

# RESULTS AND DISCUSSION

Findings of the study have been presented and discussed in this chapter. In case of main crop, only effect of the variety on different crop characters was obtained as N treatments were not applied to the main crop plots. But after harvesting main crops the ratoon crops were treated with different N doses. Therefore the effect of variety, N dose and interaction effect of variety and N dose on different crop characters of ratoon crop have been taken under consideration. According to the research hypothesis, all the treatments are applied to the ratoon crop i.e. the treatments exerted effects directly on the ratoon crop. But the effect of variety on main crop is discussed to understand the compatibility of the variety for developing ratoon crop and to compare the yield attributes of ratoon crops to that of the main crops. The results obtained from the study are presented and discussed hereafter under different heads.

## 4.1. Plant height

### 4.1.1. Effect of variety on the plant height of main crop

BRRI dhan35 had significant higher plant height in the main crops (Table 2). Numerically, in the main crops the tallest (97.45 cm) and shortest (92.45 cm) plant height were recorded in BRRI dhan35 and BRRI hybriddhan2, respectively. Effect of other two varieties was statistically identical but numerically different.

### 4.1.2. Effect of variety on the plant height of ratoon crop

Different varieties exerted significant effect on plant height of ratoon crop (Table 2). The effect of three varieties except BRRI dhan47 was statically identical but numerically different. Numerically the highest plant height (68.53 cm) was recorded in BRRI dhan29, whereas the lowest (61.23 cm) in BRRI dhan47.

### 4.1.3. Effect of N on the plant height of ratoon crop

Islam *et al.* (2008) and Zandstra and Samson (1979) stated that pant height increased significantly due to nitrogen application. In every case the plant height of the ratoon crop was lower than the main crop and it ranged from 70-73% of the main crop. It was due to less ability to use the resources in plant body and it was confirmed by Jones (1993).

However in N-applied plots, plant height of ratoon crop was significantly higher than control plots (Table 2). They were statistically identical but numerically different. Numerically, the tallest (69.04 cm) plants were obtained from the treatment $N_3$ (75% N of the recommended dose). On the contrary, the shortest (58.97 cm) plants were produced by control plots.

### 4.1.4. Interaction effect of variety and N on the plant height of ratoon crop

The interaction between variety and N dose did not have significant effect on plant height. Out of sixteen interactions fifteen showed statistically identical but numerically different effects except control plots of BRRI dhan47. Numerically, the tallest plants (73.73 cm) were produced by the interaction of BRRI dhan29 and $N_3$. At the same time shortest (55.73 cm) plants were obtained by the variety BBRI dhan47 without N application.

**Table 2. Effect of variety and N on the plant height of boro rice under ratoon cropping**

| Variety | N dose | V×N Interaction | Plant height at maturity (cm) | |
|---|---|---|---|---|
| | | | Main crop | Ratoon crop |
| BRRI hybriddhan2 ($V_1$) | - | - | 92.45 | 62.84 |
| BRRI dhan29 ($V_2$) | - | - | 95.72 | 68.53 |
| BRRI dhan35 ($V_3$) | - | - | 97.45 | 64.07 |
| BRRI dhan47 ($V_4$) | - | - | 95.27 | 61.23 |
| $LSD_{(0.05)}$ | - | - | 1.06 | 6.86 |
| CV (%) | - | - | 8.42 | |
| - | $N_0$ | - | - | 58.97 |
| - | $N_1$ | - | - | 62.86 |
| - | $N_2$ | - | - | 65.80 |
| - | $N_3$ | - | - | 69.04 |
| - | $LSD_{(0.05)}$ | - | - | 6.856 |
| - | - | $V_1 \times N_0$ | - | 60.73 |
| - | - | $V_1 \times N_1$ | - | 60.40 |
| - | - | $V_1 \times N_2$ | - | 64.00 |
| - | - | $V_1 \times N_3$ | - | 66.23 |
| - | - | $V_2 \times N_0$ | - | 62.23 |
| - | - | $V_2 \times N_1$ | - | 69.30 |
| - | - | $V_2 \times N_2$ | - | 68.87 |
| - | - | $V_2 \times N_3$ | - | 73.73 |
| - | - | $V_3 \times N_0$ | - | 57.20 |
| - | - | $V_3 \times N_1$ | - | 60.53 |
| - | - | $V_3 \times N_2$ | - | 69.73 |
| - | - | $V_3 \times N_3$ | - | 68.80 |
| - | - | $V_4 \times N_0$ | - | 55.73 |
| - | - | $V_4 \times N_1$ | - | 61.20 |
| - | - | $V_4 \times N_2$ | - | 60.60 |
| - | - | $V_4 \times N_3$ | - | 67.40 |
| - | - | $LSD_{(0.05)}$ | - | 13.70 |
| - | | CV (%) | | 10.75 |

$N_0$ = No nitrogen application, $N_1$ = 25% of recommended nitrogen fertilizer, $N_2$ = 50% of recommended nitrogen fertilizer and $N_3$ = 75% of recommended nitrogen fertilizer.

### 4.2. Total number of tillers hill$^{-1}$

#### 4.2.1. Effect of variety on the total number of tillers hill$^{-1}$ of main crop

The total number of tillers hill$^{-1}$ of main crop was highly influenced by the variety (Table 3). Significantly the highest (13.32) total number of tillers hill$^{-1}$ was produced by BRRI dhan29. Total number tillers hill$^{-1}$ of other three varieties was statistically at par. Numerically BRRI dhan35 produced the lowest (10.47) total number of tiller hill$^{-1}$.

#### 4.2.2. Effect of variety on the total number of tillers hill$^{-1}$ of ratoon crop

Ratoon tiller origin varies between cultivars, with some cultivars initiating the majority of ratoons at the either basal, near basal, or axillary nodes (Jones, 1993). Ratoon crop also possesses less tiller producing potentiality than the main crop (Bollich and Turner, 1988). Total number of tiller hill$^{-1}$ of ratoon crop was significantly influenced by variety (Table 3). Like main crop BRRI dhan29 produced the highest (10.98) total number of tiller hill$^{-1}$ during ratoon crop production whereas the lowest (7.83) total number of tillers hill$^{-1}$ was produced by BRRI dhan47. BRRI hybrid dhan2 and BRRI dhan35 produced statistically identical number of tillers hill$^{-1}$.

#### 4.2.3. Effect of N on the number of tillers hill$^{-1}$ of ratoon crop

Lafarge (2000) stated that the effect of N fertilizer rates on and number of tillers hill$^{-1}$ was significant. N-doses did not have significant effect on the total number of tillers hill$^{-1}$ (Table 3). Treatment $N_2$ (50% N of recommended dose) and $N_3$ (75% of recommended N) produced significantly higher total number of tillers hill$^{-1}$ compared to $N_0$ and $N_1$. But numerically highest (10.39) number of tillers hill$^{-1}$ was produced by treatment $N_3$. On the other hand the lowest (8.42) one was produced by control plots. Similar results were found by Chuang and Ding (1992), Mengel and Wilson (1981), Yuan *et al*. (1996) and Kavoosi *et al*. (2004).

#### 4.2.4. Interaction effect of variety and N on the total number of tillers hill$^{-1}$ of ratoon crop

The interaction of variety and N dose had non-significant effect on total number of tillers hill$^{-1}$. BRRI dhan29 with $N_2$ and $N_3$ produced significantly higher total number of tillers hill$^{-1}$ (Table 3). Numerically the highest (12.47) total number of tillers hill$^{-1}$ was recorded from the interaction of BRRI dhan29 and $N_2$, whereas the minimum (6.93) one was recorded in control plots of BRRI dhan47.

**Table 3. Effect of variety and N on the total number of tillers hill$^{-1}$ of boro rice under ratoon cropping**

| Variety | N dose | V×N Interaction | Total number of tillers hill$^{-1}$ | |
|---|---|---|---|---|
| | | | Main crop | Ratoon crop |
| BRRI hybriddhan2 ($V_1$) | - | - | 10.92 | 9.64 |
| BRRI dhan29 ($V_2$) | - | - | 13.32 | 10.98 |
| BRRI dhan35 ($V_3$) | - | - | 10.47 | 9.63 |
| BRRI dhan47 ($V_4$) | - | - | 11.67 | 7.83 |
| $LSD_{(0.05)}$ | - | - | 1.30 | 0.73 |
| CV (%) | - | - | 13.46 | - |
| - | $N_0$ | - | - | 8.42 |
| - | $N_1$ | - | - | 9.18 |
| - | $N_2$ | - | - | 10.09 |
| - | $N_3$ | - | - | 10.39 |
| - | $LSD_{(0.05)}$ | - | - | 0.73 |
| - | - | $V_1 \times N_0$ | - | 8.97 |
| - | - | $V_1 \times N_1$ | - | 9.33 |
| - | - | $V_1 \times N_2$ | - | 10.0 |
| - | - | $V_1 \times N_3$ | - | 10.27 |
| - | - | $V_2 \times N_0$ | - | 9.10 |
| - | - | $V_2 \times N_1$ | - | 10.20 |
| - | - | $V_2 \times N_2$ | - | 12.47 |
| - | - | $V_2 \times N_3$ | - | 12.13 |
| - | - | $V_3 \times N_0$ | - | 8.67 |
| - | - | $V_3 \times N_1$ | - | 9.43 |
| - | - | $V_3 \times N_2$ | - | 9.73 |
| - | - | $V_3 \times N_3$ | - | 10.67 |
| - | - | $V_4 \times N_0$ | - | 6.93 |
| - | - | $V_4 \times N_1$ | - | 7.73 |
| - | - | $V_4 \times N_2$ | - | 8.17 |
| - | - | $V_4 \times N_3$ | - | 8.50 |
| - | - | $LSD_{(0.05)}$ | - | 1.47 |
| - | | CV (%) | | 9.25 |

$N_0$ = No nitrogen application, $N_1$ = 25% of recommended nitrogen fertilizer, $N_2$ = 50% of recommended nitrogen fertilizer and $N_3$ = 75% of recommended nitrogen fertilizer.

### 4.3. Days to panicle emergence

#### 4.3.1. Effect of variety on the days to panicle emergence of main crop

Days to the panicle emergence of main crop was not significantly affected by different varieties (Table 4). Numerically, BRRI dhan35 required the minimum (107.90) days to panicle emergence which was statistically identical to that of BRRI dhan29. BRRI dhan47 required the maximum (115.90) days to panicle emergence.

#### 4.3.2. Effect of variety on the days to panicle emergence of ratoon crop

Different varieties had significant effect on the days to panicle emergence of ratoon crop (Table 4). Numerically BRRI dhan47 required the minimum (27.25) days to panicle emergence which was statistically identical to that of BRRI dhan35. The maximum (39.83) days to panicle emergence was recorded in BRRI hybrid dhan2 followed by BRRI dhan29. It was observed that the ratoon crop required short duration to panicle emergence. There were some tillers at the lower nodes in the main crop which were late and shorten and probably were in panicle emergence stage that probably attributed to the shorten duration for panicle emergence as the crop was harvested leaving 15 cm hill above ground.

#### 4.3.3. Effect of N on the days to panicle emergence of ratoon crop

Effect of N doses on panicle emergence of ratoon crop was statistically at par, but numerically different (Table 4). Treatment of 50% N application took the minimum (31.75) days to panicle emergence, whereas control plots took the maximum (33.33) days to panicle emergence.

#### 4.3.4. Interaction effect of variety and N on the panicle emergence of ratoon crop

The panicle emergence was non-significantly influenced by the interaction of variety and N dose (Table 4). The interaction of BRRI dhan35 with $N_3$; BRRI dhan47 with $N_0$, $N_1$ and $N_2$ took minimum days to panicle emergence. However, numerically the least (24.00) number of days required to panicle emergence by BRRI dhan47 with 50% N application. BRRI hybriddhan2 with all the N treatments took maximum days to panicle emergence. BRRI hybriddhan2 required the highest (41.67) number of days to panicle emergence in control plots.

**Table 4. Effect of variety and N on the days to panicle emergence of boro rice under ratoon cropping**

| Variety | N dose | V×N Interaction | Days to panicle emergence | |
|---|---|---|---|---|
| | | | Main crop* | Ratoon crop** |
| BRRI hybriddhan2 ($V_1$) | - | - | 110.90 | 39.83 |
| BRRI dhan29 ($V_2$) | - | - | 108.60 | 33.42 |
| BRRI dhan35 ($V_3$) | - | - | 107.90 | 29.67 |
| BRRI dhan47 ($V_4$) | - | - | 115.9 0 | 27.25 |
| $LSD_{(0.05)}$ | - | - | 1.50 | 2.72 |
| CV (%) | - | - | 1.63 | - |
| - | $N_0$ | - | - | 33.33 |
| - | $N_1$ | - | - | 33.08 |
| - | $N_2$ | - | - | 31.75 |
| - | $N_3$ | - | - | 32.00 |
| - | $LSD_{(0.05)}$ | - | - | 2.72 |
| - | - | $V_1 \times N_0$ | - | 41.67 |
| - | - | $V_1 \times N_1$ | - | 41.00 |
| - | - | $V_1 \times N_2$ | - | 40.00 |
| - | - | $V_1 \times N_3$ | - | 36.67 |
| - | - | $V_2 \times N_0$ | - | 34.33 |
| - | - | $V_2 \times N_1$ | - | 33.67 |
| - | - | $V_2 \times N_2$ | - | 33.33 |
| - | - | $V_2 \times N_3$ | - | 32.33 |
| - | - | $V_3 \times N_0$ | - | 31.00 |
| - | - | $V_3 \times N_1$ | - | 30.00 |
| - | - | $V_3 \times N_2$ | - | 29.67 |
| - | - | $V_3 \times N_3$ | - | 28.00 |
| - | - | $V_4 \times N_0$ | - | 26.33 |
| - | - | $V_4 \times N_1$ | - | 27.67 |
| - | - | $V_4 \times N_2$ | - | 24.00 |
| - | - | $V_4 \times N_3$ | - | 31.00 |
| - | - | $LSD_{0.05}$ | - | 5.43 |
| - | - | CV (%) | - | 10.01 |

* From sowing

** From main crop harvest

** Data included the shortest tertiary tillers of the main crops which emerged at the earliest

$N_0$ = No nitrogen application, $N_1$ = 25% of recommended nitrogen fertilizer, $N_2$ = 50% of recommended nitrogen fertilizer and $N_3$ = 75% of recommended nitrogen fertilizer.

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

#### 4.4.1. Effect of variety on the number of effective tillers hill$^{-1}$ of main crop

A rice plant may produce a number of tillers during its early growth period but all of them are not effective, that is, they do not bear panicles. So, the number of effective tillers hill$^{-1}$ is the major components of ratoon yield (Nair and Rosamma, 2002). Different varieties had significant effect on number of effective tillers hill$^{-1}$ (Fig.1). The effect of variety on the effective tillers hill$^{-1}$ was statistically identical but numerically different in main crop production. BRRI dhan29 produced the highest (11.35) number of effective tillers hill$^{-1}$ whereas BRRI dhan35 produced the minimum (9.95) number of effective tillers hill$^{-1}$

#### 4.4.2. Effect of variety on the number of effective tillers hill$^{-1}$ of ratoon crop

Effect of variety on number of effective tillers hill$^{-1}$ of ratoon crop was statistically significant (Fig.1). BRRI dhan29 produced the highest (9.93) number of effective tillers hill$^{-1}$ in ratoon rice production while BRRI dhan47 produced the minimum (4.04). BRRI dhan35 and BRRI hybrid dhan2 produced statistically similar number of effective tillers hill$^{-1}$.

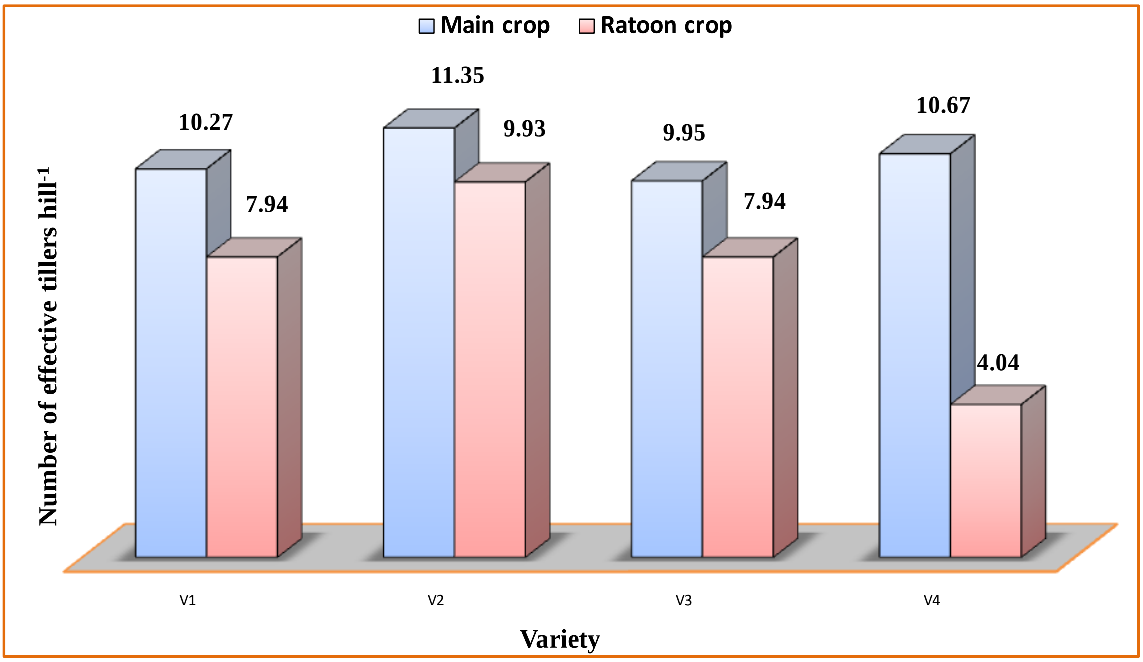


**Fig.1. Effect of variety on the effective tillers hill$^{-1}$ of main and ratoon crop {$LSD_{(0.05)}$ = 1.70 (main crop), 1.25 (ratoon crop)}**

### 4.4.3. Effect of N on the number of effective tillers hill$^{-1}$ of ratoon crop

Various N-doses had significant effect on the number of effective tillers hill$^{-1}$ (Fig. 2). N-applied plots gave higher number of effective tillers hill$^{-1}$ than control plots. It was due to less number of effective tillers as well as less nutrient use efficiency. This result was supported by Bollich *et al*. (1994).The highest (8.30) number of effective tillers hill$^{-1}$ was observed by $N_3$ and the lowest (6.43) one was observed at control plots.

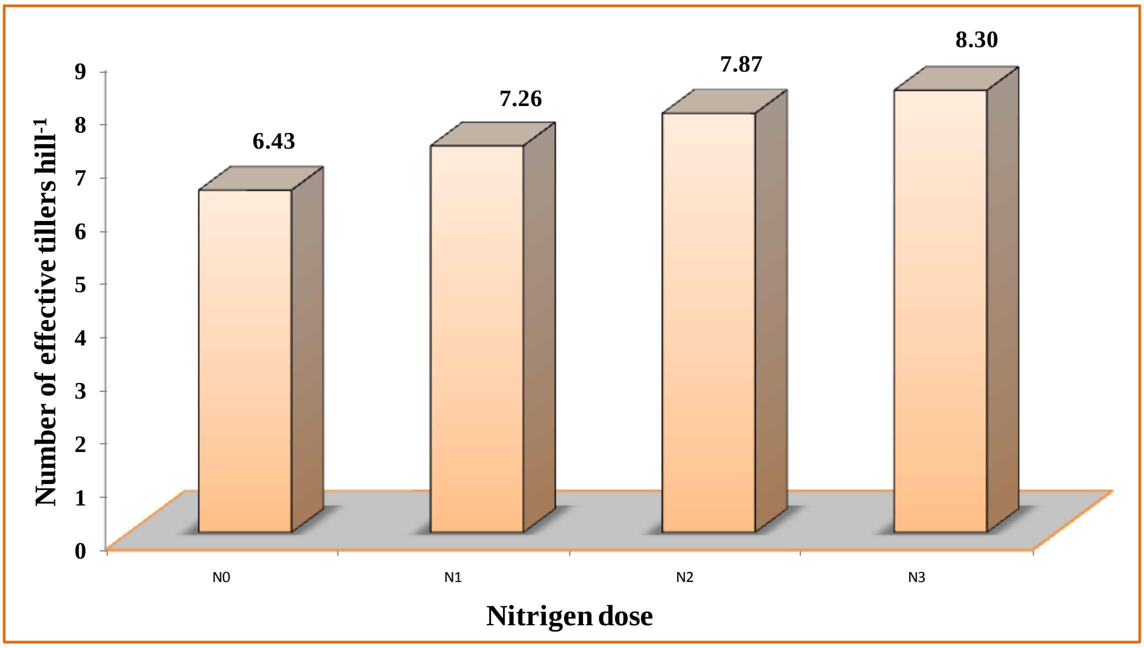


**Fig.2. Effect of N on the number of effective tillers hill$^{-1}$ of the ratoon crop ($LSD_{(0.05)}$ = 1.25)**

### 4.4.4. Interaction effect of variety and N on the number of effective tillers hill$^{-1}$ of ratoon crop

The interaction effect of variety and N on effective tillers hill$^{-1}$ of ratoon crop was significant (Fig.3). The number of effective tillers hill$^{-1}$ produced by BRRI dhan29 in all levels of N applied plots was significantly higher. Numerically the highest (11.30) number of effective tillers hill$^{-1}$ was produced by the interaction of BRRI dhan29 and $N_3$. BRRI dhan47 with all the treatments gave lower number of effective tillers hill$^{-1}$. The lowest (3.50) number of effective tillers hill$^{-1}$ was produced by BRRI dhan47 without any N fertilizer treatment.

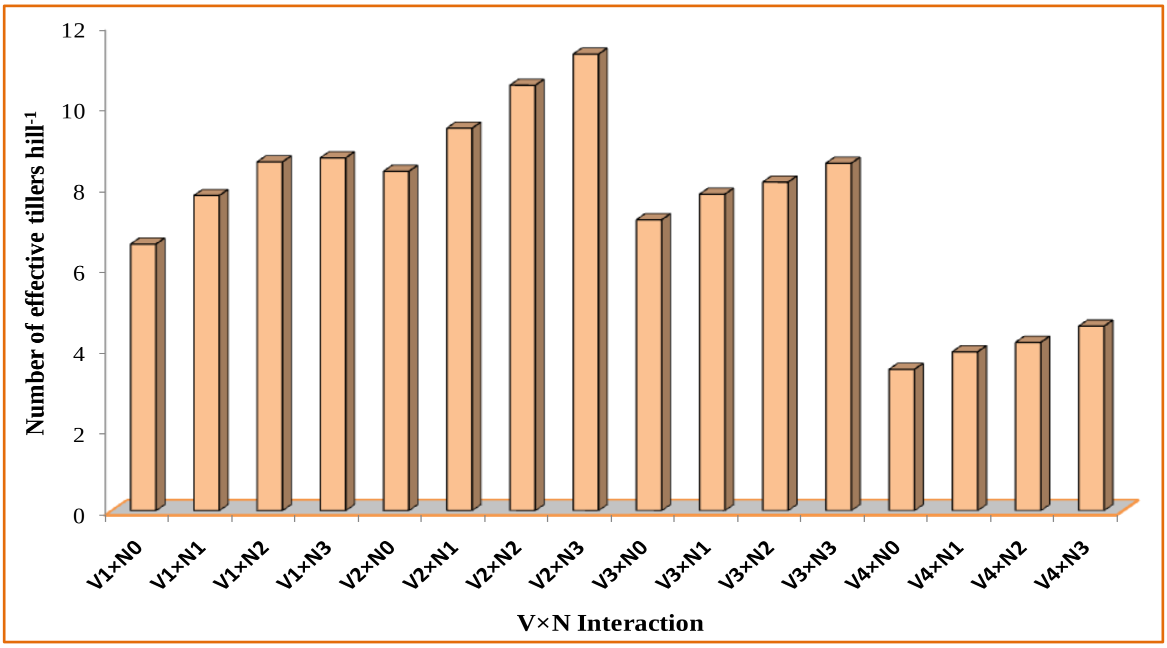


**Fig.3. Interaction effect of variety and N on the number of effective tillers hill$^{-1}$ of ratoon crop ($LSD_{(0.05)}$ = 2.49)**

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

#### 4.5.1. Effect of variety on the number of non-effective tillers hill$^{-1}$ of main crop

Number of non-effective tillers hill$^{-1}$ of main crop was not significantly influenced by the variety (Table 5). Numerically, the lowest number of non-effective tillers hill$^{-1}$ (1.00) was produced by BRRI dhan35, whereas the highest (1.35) non-effective tillers hill$^{-1}$ (1.35) was produced by BRRI dhan29.

#### 4.5.2. Effect of variety on the number of non-effective tillers hill$^{-1}$ of ratoon crop

The effect of variety on number of non-effective tillers hill$^{-1}$ of the ratoon crop was not significant (Table 5). The lowest (0.60) number of non-effective tillers hill$^{-1}$ was produced by BRRI dhan29 and the highest (1.30) was produced by BRRI hybriddhan2.

#### 4.5.3. Effect of N on the number of non-effective tillers hill$^{-1}$of ratoon crop

N dose had significant effect on the number of non-effective tillers hill$^{-1}$ of ratoon crop (Table 5). Number of non-effective tillers hill$^{-1}$ in N-applied plots was significantly lower than control plots but they were different in numerical values. Numerically, the lowest (0.49) number of non-effective tillers hill$^{-1}$ was recorded by application of 75% N of recommended dose and the highest (1.49) was produced by control plots.

#### 4.5.4. Interaction effect of variety and N on the number of non-effective tillers hill$^{-1}$ of ratoon crop

Maximum interaction of variety and N dose produced significantly lower number of non-effective tillers hill$^{-1}$ (Table 5). Numerically, the interaction of BRRI dhan29 and $N_3$ produced the lowest (0.33) number of non-effective tillers hill$^{-1}$. Control plots of BRRI hybriddhan2, BRRI dhan35 and BRRI dhan47 and BRRI hybriddhan2 in 25% N applied plots produced significantly higher number of non-effective tillers hill$^{-1}$. But the control plots of BRRI dhan47 produced the highest (2.47) number of non-effective tillers hill$^{-1}$ in ratoon crops.

**Table 5. Effect of variety and N on the number of non-effective tillers hill$^{-1}$ of boro rice under ratoon cropping**

| Variety | N dose | V×N Interaction | No. of non-effective tillers hill$^{-1}$ | |
|---|---|---|---|---|
| | | | Main crop | Ratoon crop |
| BRRI hybriddhan2 ($V_1$) | - | - | 1.18 | 1.30 |
| BRRI dhan29 ($V_2$) | - | - | 1.35 | 0.60 |
| BRRI dhan35 ($V_3$) | - | - | 1.00 | 1.00 |
| BRRI dhan47 ($V_4$) | - | - | 1.10 | 1.24 |
| $LSD_{(0.05)}$ | - | - | 0.73 | 0.56 |
| CV (%) | - | - | 75.88 | |
| - | $N_0$ | - | - | 1.94 |
| - | $N_1$ | - | - | 0.98 |
| - | $N_2$ | - | - | 0.72 |
| - | $N_3$ | - | - | 0.49 |
| - | $LSD_{(0.05)}$ | - | - | 0.56 |
| - | - | $V_1 \times N_0$ | - | 2.23 |
| - | - | $V_1 \times N_1$ | - | 1.67 |
| - | - | $V_1 \times N_2$ | - | 0.80 |
| - | - | $V_1 \times N_3$ | - | 0.50 |
| - | - | $V_2 \times N_0$ | - | 0.93 |
| - | - | $V_2 \times N_1$ | - | 0.63 |
| - | - | $V_2 \times N_2$ | - | 0.47 |
| - | - | $V_2 \times N_3$ | - | 0.33 |
| - | - | $V_3 \times N_0$ | - | 2.13 |
| - | - | $V_3 \times N_1$ | - | 0.70 |
| - | - | $V_3 \times N_2$ | - | 0.70 |
| - | - | $V_3 \times N_3$ | - | 0.47 |
| - | - | $V_4 \times N_0$ | - | 2.47 |
| - | - | $V_4 \times N_1$ | - | 0.93 |
| - | - | $V_4 \times N_2$ | - | 0.90 |
| - | - | $V_4 \times N_3$ | - | 0.67 |
| - | - | $LSD_{(0.05)}$ | - | 1.13 |
| - | - | CV (%) | - | 65.28 |

$N_0$ =No nitrogen application, $N_1$ = 25% of recommended nitrogen fertilizer, $N_2$ =50% of recommended nitrogen fertilizer and $N_3$ =75% of recommended nitrogen fertilizer.

### 4.6. Panicle length

#### 4.6.1. Effect of variety on the panicle length of main crop

Different variety significantly affected the panicle length of the main crop (Fig. 4). Numerically, BRRI dhan47 produced the longest (25.57 cm) panicle. BRRI hybriddhan2, BRRI dhan29 and BRRI dhan35 produced statistically at par panicle length but they were numerically different. Among the varieties BRRI hybriddhan2 produced the shortest (22.56 cm) panicle.

#### 4.6.2. Effect of variety on the panicle length of ratoon crop

Variety showed significant effect on panicle length of ratoon crop (Fig. 4). The longest (21.53 cm) panicle was produced by BRRI dhan29 whereas the shortest (15.38 cm) one was produced by BRRI hybriddhan2. Other two varieties showed statistically similar panicle length.

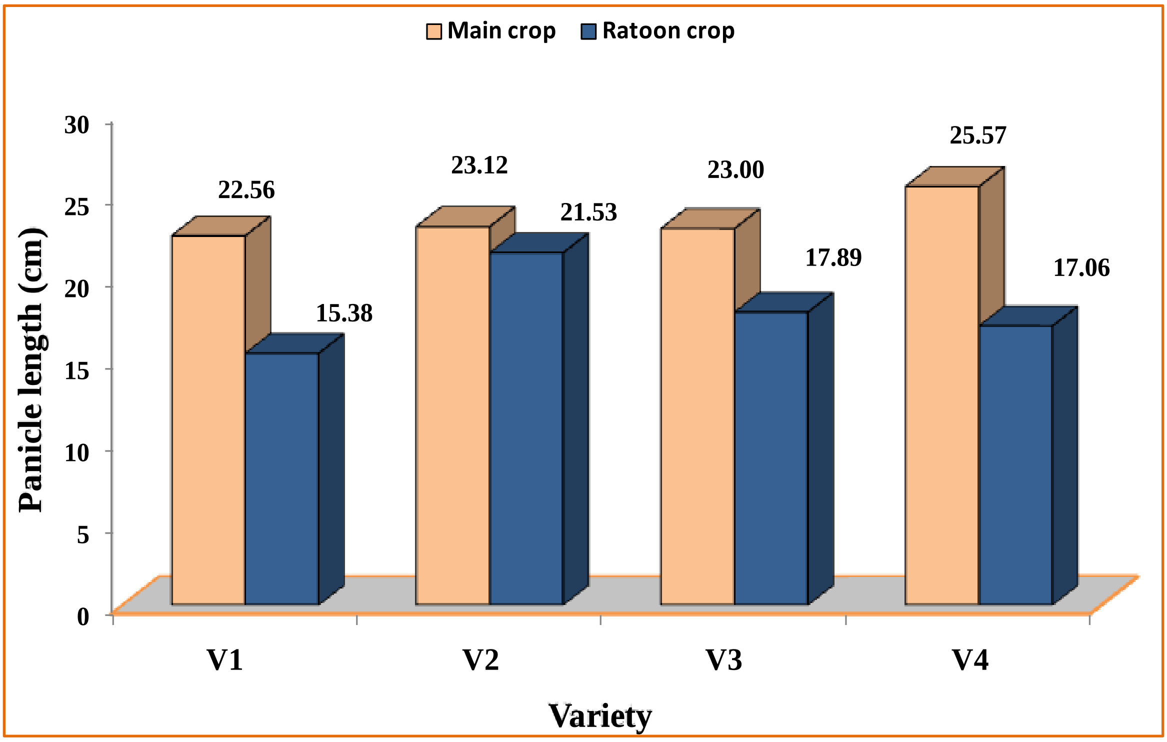


**Fig.4. Effect of variety on the panicle length of main and ratoon crop {($LSD_{(0.05)}$ = 1.18 (main crop), 0.97 (ratoon crop)}**

### 4.6.3. Effect of N dose on the panicle length of the ratoon crop

Different nitrogen doses significantly affected panicle length of ratoon crop (Fig.5). All the N-applied plots produced statistically higher panicle length than control plots which were numerically different. However the longest (16.68 cm) panicle was found by application of 75% recommended N and the shortest (16.70 cm) one was found in control plots.

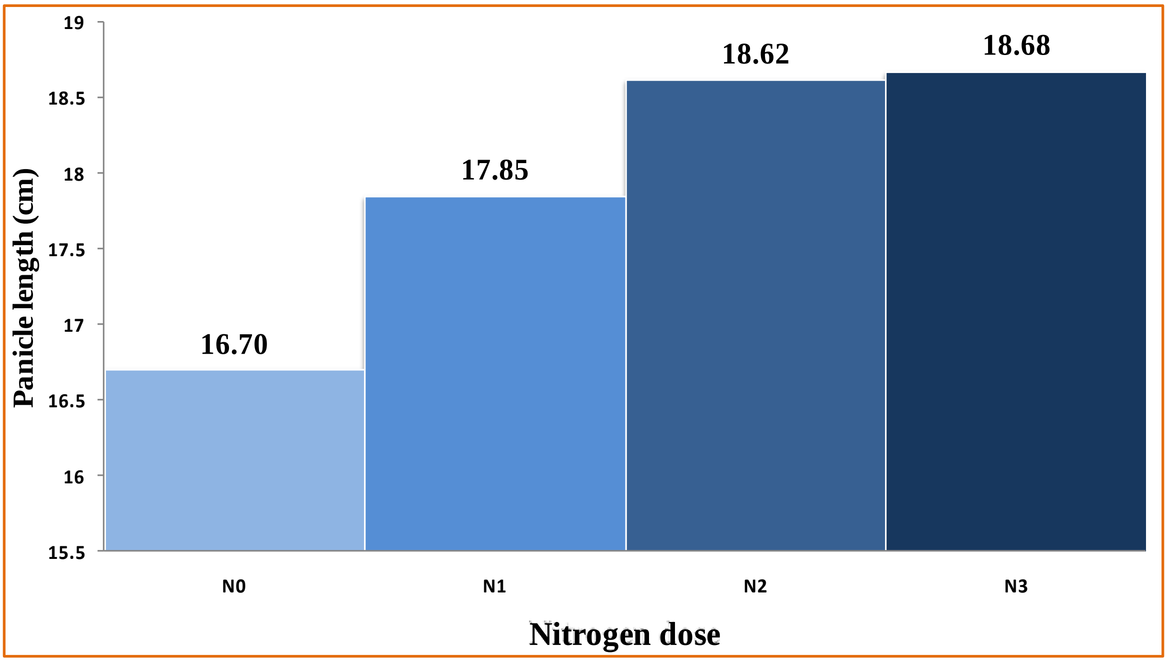


**Fig.5. Effect of N on the panicle length of the ratoon crop ($LSD_{(0.05)}$ = 0.97)**

### 4.6.4. Interaction effect of variety and N dose on the panicle length of ratoon crop

The panicle length was significantly affected by the interaction of variety and N dose (Fig. 6). BRRI dhan29 in N-applied plots gave longer panicles. Numerically the longest (22.51 cm) panicle was produced by BRRI dhan29 with $N_2$ followed by the same variety with $N_3$. Shorter panicles were found in the control and 25% N applied plots of BRRI hybriddhan2. But the shortest (13.98 cm) panicle was produced by BRRI hybriddhan2 in control plots.

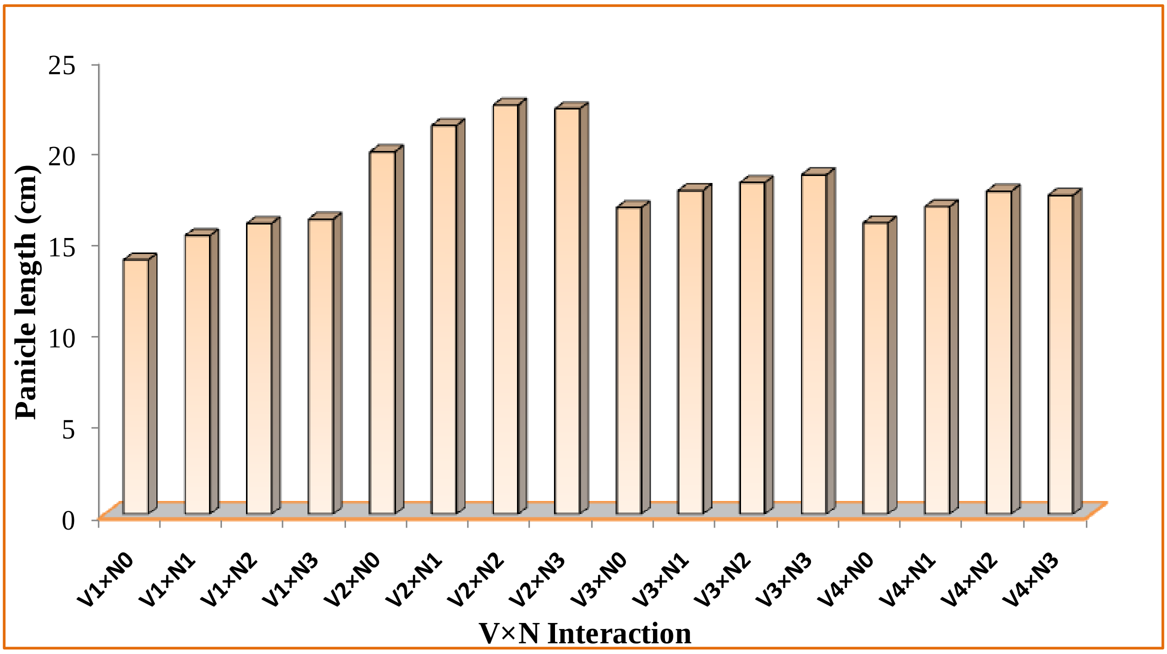


**Fig.6. Interaction effect variety and N on the panicle length of the ratoon crop ($LSD_{(0.05)}$ = 1.95)**

## 4.7. Days to Maturity

### 4.7.1. Effect of variety on the days to maturity of main crop

Dustin *et al*. (2009) noted that harvesting stage had significant effect on seed yield. Variety had significant effect on the days to maturity of main crop (Fig.7). BRRI hybriddhan2 required the minimum (145.90) days to become matured whereas BRRI dhan47 required the maximum (158.50) days to maturity. Other two varieties required statistically identical days to maturity, which were numerically different. In every case the duration of ratoon crop was much shorter than main crop. This result is supported by Santos et al. (2003) and Haque and Coffman (1980). Jones and Snyder (1987) reported that ratoon rice needs very short growth duration usually taking only 35% to 60% of the time required for the main crop.

### 4.7.2. Effect of variety on days to maturity of ratoon crop

Effect of variety on days to maturity of ratoon crop was significant (Fig.7). BRRI hybriddhan2 and BRRI dhan29 required significantly higher number of days to maturity than other two varieties. BRRI dhan47 required the minimum (45.08) days whereas BRRI hybriddhan2 required the maximum (61.17) days to become mature followed by BRRI dhan29.

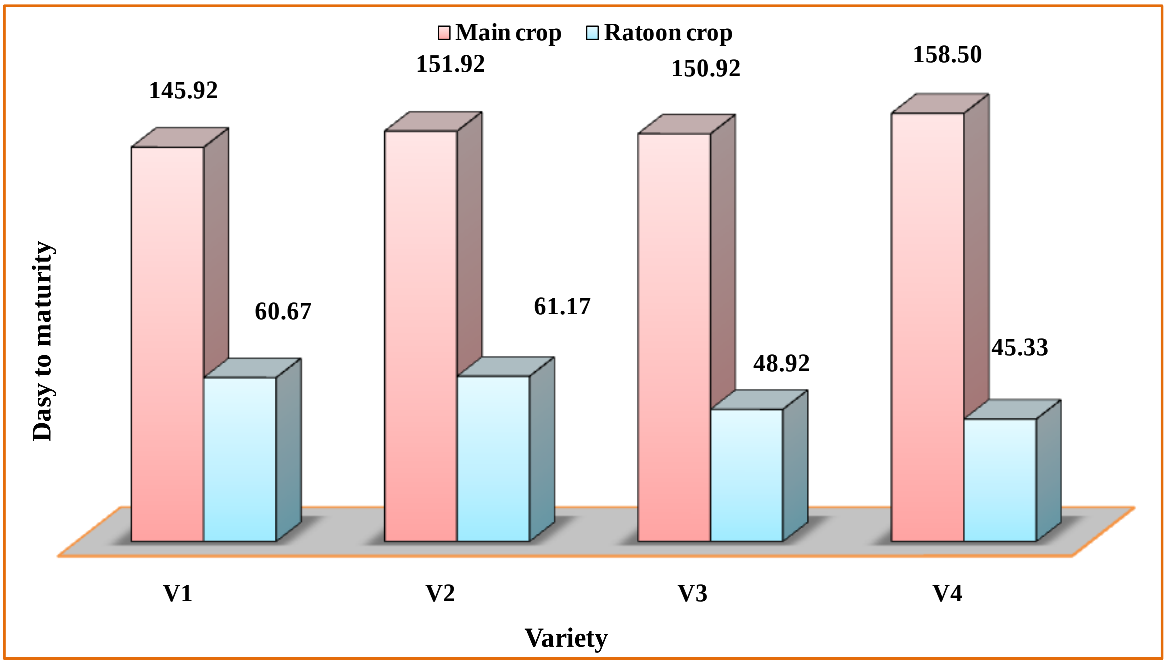


**Fig.7. Effect of variety on the days to maturity of main and ratoon crop {$LSD_{(0.05)}$ = 1.97 (main crop) 1.69 (ratoon crop)}**

### 4.7.3. Effect of N on the days to maturity of ratoon crop

A significant effect of N on the number of days to maturity of ratoon crop was found by Calendacion *et al.* (1992) Calendacion and De Datta (1987). Days to maturity of ratoon crop increased with the increasing amount of N application (Fig. 8). All the N-applied plots required statistically higher number of days to maturity. Thus N affect negatively the days to maturity of ratoon crop. However the lowest (51.25) number of days to maturity was found in control plots, whereas the highest N applied plots took the highest (55.67) number of days to become mature.

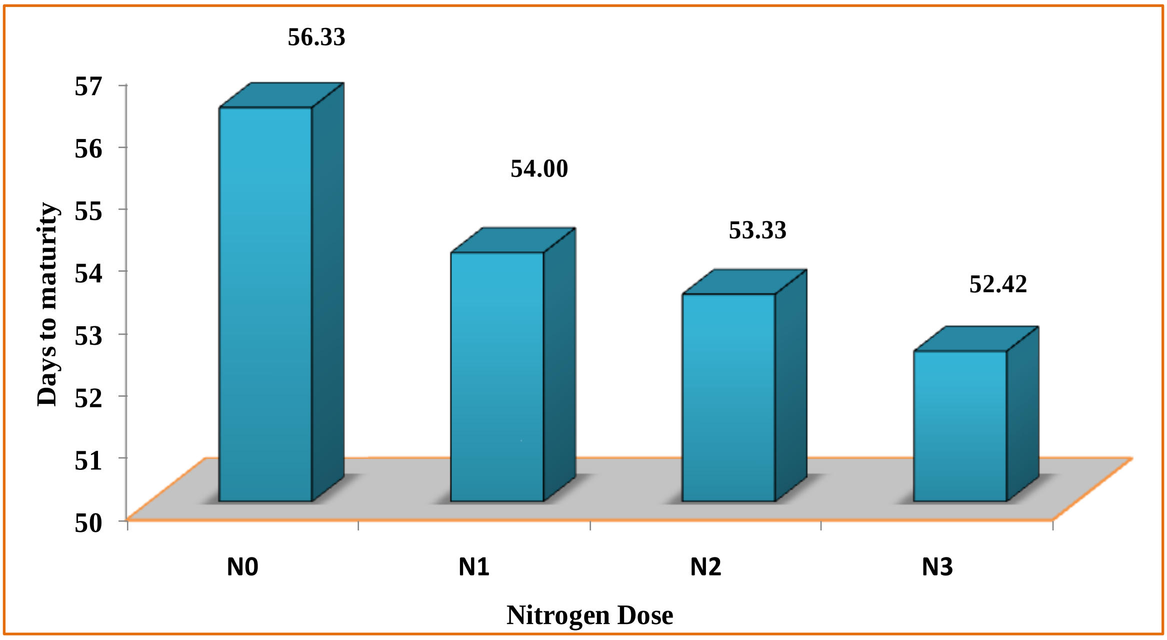


**Fig.8. Effect of N on the days to maturity of ratoon crop ($LSD_{(0.05)}$ = 1.69)**

### 4.7.4. Interaction effect of variety and N on the days to maturity of the ratoon crop

The interaction effect of variety and N dose on days to maturity of ratoon crop was significant (Fig.9). BRRI dhan35 with $N_3$ and BRRI dhan47 with all N applied plots required statistically higher number of days to mature. However, the minimum (43.33) days to maturity was taken by BRRI dhan47 in control plots. BRRI hybriddhan2 and BRRI dhan29 in all N applied plots took statistically at par days to mature. BRRI hybriddhan2 required the maximum (63.33) days to become mature with the highest dose of N application.

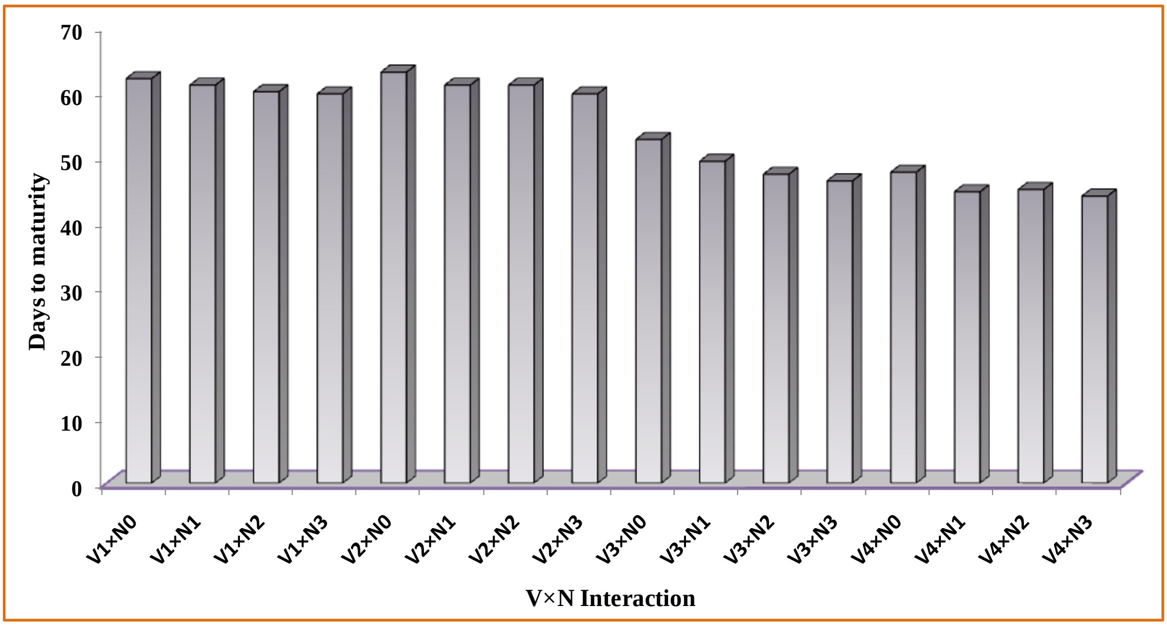


**Fig.9. Interaction effect of variety and N on the days to maturity of ratoon crop ($LSD_{(0.05)}$ = 3.37)**

### 4.8. Number of filled grains panicle$^{-1}$

#### 4.8.1. Effect of variety on the number of filled grains panicle$^{-1}$ of main crop

Variety showed significant effect on the number of filled grains panicle$^{-1}$ of the main crop (Table 6). BRRI dhan47 produced the highest (251.70) number of filled grains panicle$^{-1}$. BRRI hybriddhan2 and BRRI dhan35 produced significantly lower number of filled grains panicle$^{-1}$. Numerically the lowest (196.60) on was produced by BRRI dhan35.

#### 4.8.2. Effect of variety on the number of filled grains panicle$^{-1}$ of ratoon crop

Variety showed significant effect on filled grains panicle$^{-1}$ of ratoon crop (Table 6). The highest (86.97) number of filled grains panicle$^{-1}$ was produced by the BRRI dhan35, whereas the lowest (60.28) one was found in plots of BRRI dhan47. BRRI dhan29 and BRRI hybriddhan2 produced statistically at par but numerically different number of filled grains panicle$^{-1}$.

#### 4.8.3. Effect of N on the filled grains panicle$^{-1}$ of ratoon crop

Increasing N doses increased significantly the number of filled grain panicle$^{-1}$ (Table 6). The highest (99.23) filled grains panicle$^{-1}$ was produced by application of 75% recommended N. At the same time, the lowest (52.53) filled grains panicle$^{-1}$ was produced by control plots. That was due to improper grain filling with this dose. This result is supported by Evatt and Beachell (1969).

#### 4.8.4. Interaction effect of variety and N on the filled grains panicle$^{-1}$ of ratoon crop

The effect of interaction between variety and N dose on the filled grains panicle$^{-1}$ was significant (Table 6). BRRI dhan35 and BRRI dhan29 produced statistically higher number of filled grains panicle$^{-1}$ with $N_3$ (75% of recommended N fertilizer) followed by BRRI hybrid dhan2 in all N-applied plots; BRRI dhan29 with $N_2$; BRRI dhan35 with $N_1$ and $N_2$ and BRRI dhan47 with $N_3$. Numerically the highest (117.6) number of filled grains panicle$^{-1}$ was produced by BRRI dhan35 interaction with $N_3$. Interaction of BRRI dhan29 and $N_0$; BRRI dhan47 with $N_0$ and $N_1$ produced significantly lower number of filled grains panicle$^{-1}$ which were statistically at par. But the lowest (37.87) number of filled grains panicle$^{-1}$ was produced by BRRI dhan29 without N application.

**Table 6. Effect of variety and N on the number of filled grains panicle$^{-1}$ of boro rice under ratoon cropping**

| Variety | N dose | V×N Interaction | Filled grains panicle$^{-1}$ | |
|---|---|---|---|---|
| | | | Main crop | Ratoon crop |
| BRRI hybriddhan2 ($V_1$) | - | - | 197.6 | 76.35 |
| BRRI dhan29 ($V_2$) | - | - | 222.8 | 70.58 |
| BRRI dhan35 ($V_3$) | - | - | 196.6 | 86.97 |
| BRRI dhan47 ($V_4$) | - | - | 251.7 | 60.28 |
| $LSD_{(0.05)}$ | - | - | 22.92 | 7.960 |
| CV (%) | - | - | 12.66 | - |
| - | $N_0$ | - | - | 52.53 |
| - | $N_1$ | - | - | 64.49 |
| - | $N_2$ | - | - | 77.92 |
| - | $N_3$ | - | - | 99.23 |
| - | $LSD_{(0.05)}$ | - | - | 7.960 |
| - | - | $V_1 \times N_0$ | - | 64.53 |
| - | - | $V_1 \times N_1$ | - | 76.20 |
| - | - | $V_1 \times N_2$ | - | 82.93 |
| - | - | $V_1 \times N_3$ | - | 81.73 |
| - | - | $V_2 \times N_0$ | - | 37.87 |
| - | - | $V_2 \times N_1$ | - | 55.87 |
| - | - | $V_2 \times N_2$ | - | 76.07 |
| - | - | $V_2 \times N_3$ | - | 112.5 |
| - | - | $V_3 \times N_0$ | - | 65.67 |
| - | - | $V_3 \times N_1$ | - | 75.00 |
| - | - | $V_3 \times N_2$ | - | 89.57 |
| - | - | $V_3 \times N_3$ | - | 117.60 |
| - | - | $V_4 \times N_0$ | - | 42.07 |
| - | - | $V_4 \times N_1$ | - | 50.90 |
| - | - | $V_4 \times N_2$ | - | 63.10 |
| - | - | $V_4 \times N_3$ | - | 85.03 |
| - | - | $LSD_{(0.05)}$ | - | 15.92 |
| - | - | CV (%) | - | 12.98 |

$N_0$ =No nitrogen application, $N_1$ = 25% of recommended nitrogen fertilizer, $N_2$ =50% of recommended nitrogen fertilizer and $N_3$ =75% of recommended nitrogen fertilizer.

## 4.9. Number of unfilled grains panicle$^{-1}$

### 4.9.1. Effect of variety on the number of unfilled grains panicle$^{-1}$ of main crop

Number of unfilled grains panicle$^{-1}$ of main crop was affected significantly by variety (Table 7). BRRI dhan35 and BRRI hybriddhan2 produced statistically higher number of unfilled grains panicle$^{-1}$ than BRRI dhan29 and BRRI dhan47. BRRI dhan35 and BRRI dhan29 produced the lowest (20.34) and highest (37.43) number of unfilled grains panicle$^{-1}$ respectively during main crop production.

### 4.9.2. Effect of variety on the number of unfilled grains panicle$^{-1}$ of ratoon crop

Different varieties had significant effect on unfilled grains panicle$^{-1}$ of ratoon crop (Table 7). All the varieties of ratoon crop produced statistically at par number of unfilled grains panicle$^{-1}$. But numerically, BRRI dhan47 and BRRI dhan29 produced the lowest (35.20) and highest (52.53) number unfilled grains panicle$^{-1}$ respectively. The number of unfilled grains panicle$^{-1}$ was higher in ratoon crop than the main crop.

### 4.9.3. Effect of N on the number of unfilled grains panicle$^{-1}$ of ratoon crop

Yuan *et al.* (1996) showed that N application promoted growth of the ratoon crop, increasing the percentage of filled spikelets and numbers of filled grains panicle$^{-1}$. N doses did not have significant effect on the number of unfilled grains panicle$^{-1}$ (Table 7). The effects of N doses were statistically similar but numerically different. The lowest (38.23) number of unfilled grains was produced without N application whereas the highest (49.67) number of unfilled grains panicle$^{-1}$ was produced by 25% of recommended N application.

### 4.9.4. Interaction effect of variety and N on the number of unfilled grain panicle$^{-1}$ of ratoon crop

The effect of interaction between variety and N dose on the number of unfilled grains panicle$^{-1}$ was significant (Table 7). The interaction of BRRI dhan47 with $N_0$ and $N_2$ produced statistically lower number of unfilled grains panicle$^{-1}$. All other interaction of variety and N dose produced statistically higher number of unfilled grains panicle$^{-1}$.

Numerically, the lowest (26.67) and the highest (67.73) number of unfilled grains panicle$^{-1}$ was produced by control plots of BRRI dhan47 and 75% recommended N-applied plots of BRRI dhan29.

**Table 7. Effect of variety and N on the number of unfilled grains panicle$^{-1}$ of boro rice under ratoon cropping**

| Variety | N dose | V×N Interaction | Unfilled grains panicle$^{-1}$ | |
|---|---|---|---|---|
| | | | **Main crop** | **Ratoon Crop** |
| BRRI hybriddhan2 ($V_1$) | - | - | 21.13 | 37.10 |
| BRRI dhan29 ($V_2$) | - | - | 37.43 | 52.53 |
| BRRI dhan35 ($V_3$) | - | - | 20.34 | 50.43 |
| BRRI dhan47 ($V_4$) | - | - | 33.72 | 35.20 |
| $LSD_{(0.05)}$ | - | - | 25.55 | 16.16 |
| CV (%) | - | - | 12.66 | - |
| - | $N_0$ | - | - | 38.23 |
| - | $N_1$ | - | - | 49.67 |
| - | $N_2$ | - | - | 38.33 |
| - | $N_3$ | - | - | 49.03 |
| - | $LSD_{(0.05)}$ | - | - | 16.16 |
| - | - | $V_1 \times N_0$ | - | 30.40 |
| - | - | $V_1 \times N_1$ | - | 42.13 |
| - | - | $V_1 \times N_2$ | - | 36.40 |
| - | - | $V_1 \times N_3$ | - | 39.47 |
| - | - | $V_2 \times N_0$ | - | 40.53 |
| - | - | $V_2 \times N_1$ | - | 57.87 |
| - | - | $V_2 \times N_2$ | - | 44.00 |
| - | - | $V_2 \times N_3$ | - | 67.73 |
| - | - | $V_3 \times N_0$ | - | 55.33 |
| - | - | $V_3 \times N_1$ | - | 52.13 |
| - | - | $V_3 \times N_2$ | - | 43.87 |
| - | - | $V_3 \times N_3$ | - | 50.40 |
| - | - | $V_4 \times N_0$ | - | 26.67 |
| - | - | $V_4 \times N_1$ | - | 46.53 |
| - | - | $V_4 \times N_2$ | - | 29.07 |
| - | - | $V_4 \times N_3$ | - | 38.53 |
| - | - | $LSD_{(0.05)}$ | - | 32.32 |
| - | - | CV (%) | - | 44.24 |

$N_0$ = No nitrogen application, $N_1$ = 25% of recommended nitrogen fertilizer, $N_2$ = 50% of recommended nitrogen fertilizer and $N_3$ = 75% of recommended nitrogen fertilizer.

### 4.10. Total number of grains panicle$^{-1}$

#### 4.10.1. Effect of variety on the total number of grains panicle$^{-1}$ of main crop

The total number of grains panicle$^{-1}$ of the main crop was significantly affected by the variety (Fig.10). The highest (285.34) total number of grains panicle$^{-1}$ was recorded in BRRI dhan47. It was statistically similar to BRRI dahn29. The lowest (217.51) total number of grains panicle$^{-1}$ was observed in BRRI dhan35 which was statistically similar to BRRI hybriddhan2.

#### 4.10.2. Effect of variety on the total number of grains panicle$^{-1}$ of ratoon crop

Different varieties produced significant effect on the total number of grains panicle$^{-1}$ of ratoon crop. (Fig.10). Total number of grains panicle$^{-1}$ produced by different varieties was statistically similar. Total number of grains panicle$^{-1}$ of BRRI dhan29 and BRRI dhan35 was significantly higher than that of other two varieties. Numerically BRRI dhan35 produced the highest (137.40) total number of grains panicle$^{-1}$ followed by BRRI dhan29 (123.20). The lowest (95.47) total number of grains panicle$^{-1}$ was produced by BRRI dahn47.

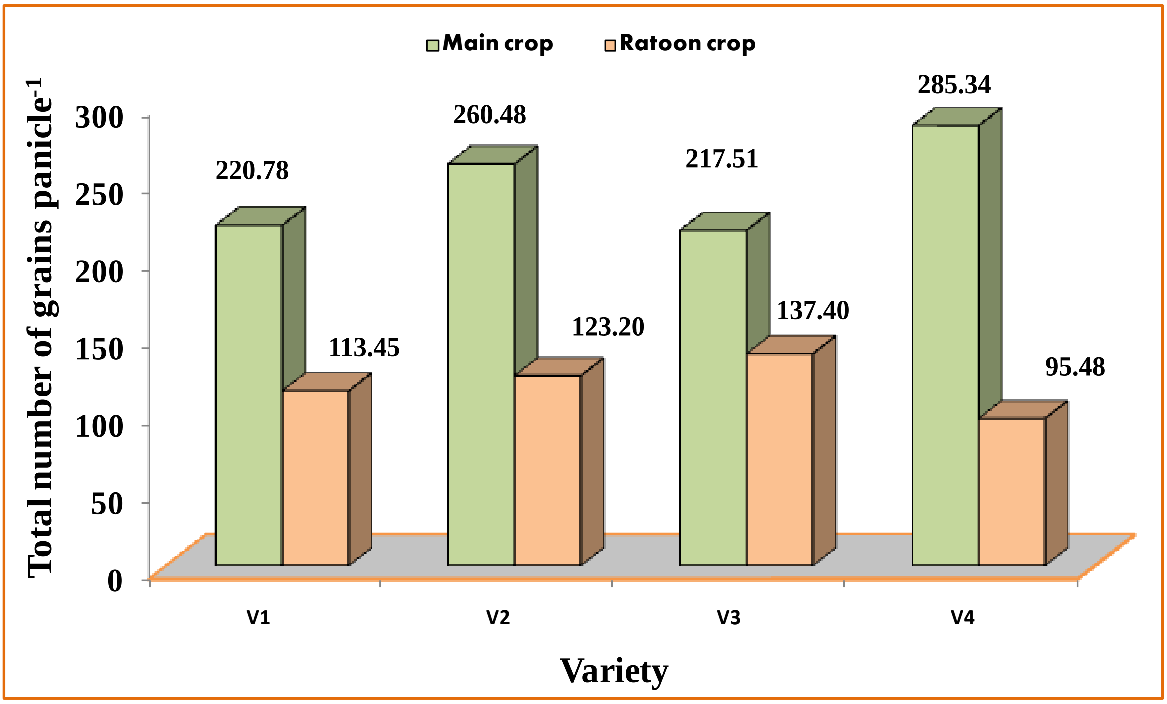


**Fig.10. Effect of variety on the total number of grains panicle$^{-1}$ of main crop and ratoon crop {LSD$_{(0.05)}$ = 25.15 (main crop) 8.56 (ratoon crop)}**

### 4.10.3. Effect of N dose on the total number of grains panicle$^{-1}$ of ratoon crop

Nassiri and Pirdashti (2003) stated that, N applied immediately after main crop harvest significantly affected total grain number panicle$^{-1}$ of ratoon crop.

The total number of grains per panicle of the ratoon crop was significantly affected by N doses (Fig.11). The highest (148.3) total number of grains panicle$^{-1}$ was recorded in the 75% recommended N-applied plots. The lowest (90.83) total number of grains panicle$^{-1}$ was produced without N application. Other two varieties produced statistically similar effect. Numerically BRRI dhan29 produced third highest (114.2) total number of grains panicle$^{-1}$.

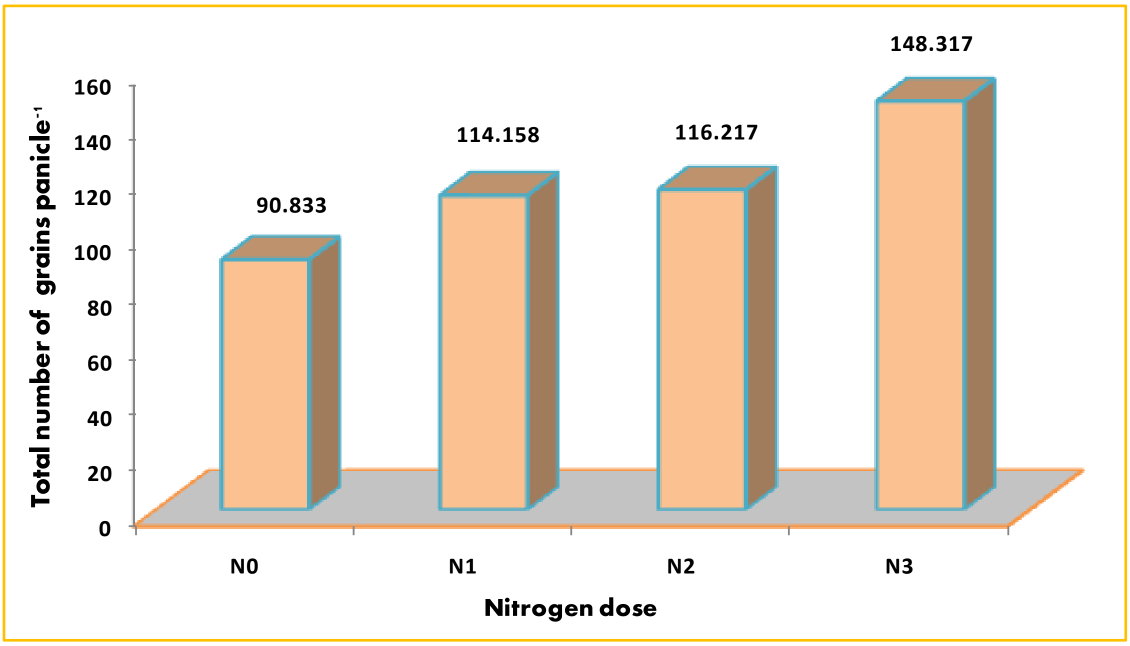


**Fig.11. Effect of N on the total number of grains panicle$^{-1}$ of ratoon crop ($LSD_{(0.05)}$ = 18.56)**

### 4.10.4. Interaction effect of variety and N on the total number of grains panicle$^{-1}$ of ratoon crop

The interaction effect of variety and N dose on the total number of grains panicle$^{-1}$ of ratoon crop was non-significant (Fig.12). $N_3$ (75% of recommended N) treated plots of BRRI dhan29 and BRRI dhan35 produced significantly higher number of total grains panicle$^{-1}$ followed by interaction of BRRI dhan35 with $N_2$. Numerically, the highest (180.50) total number of grains panicle$^{-1}$ was produced by BRRI dhan29 with application of $N_3$. Control plots of BRRI hybriddhan2 and BRRI dhan29, BRRI dhan47 and interaction of $N_1$ and $N_2$ with BRRI dhan47 produced significantly lower total number of grains panicle$^{-1}$. The lowest (69.00) one was produced by BRRI dhan47 without N application.

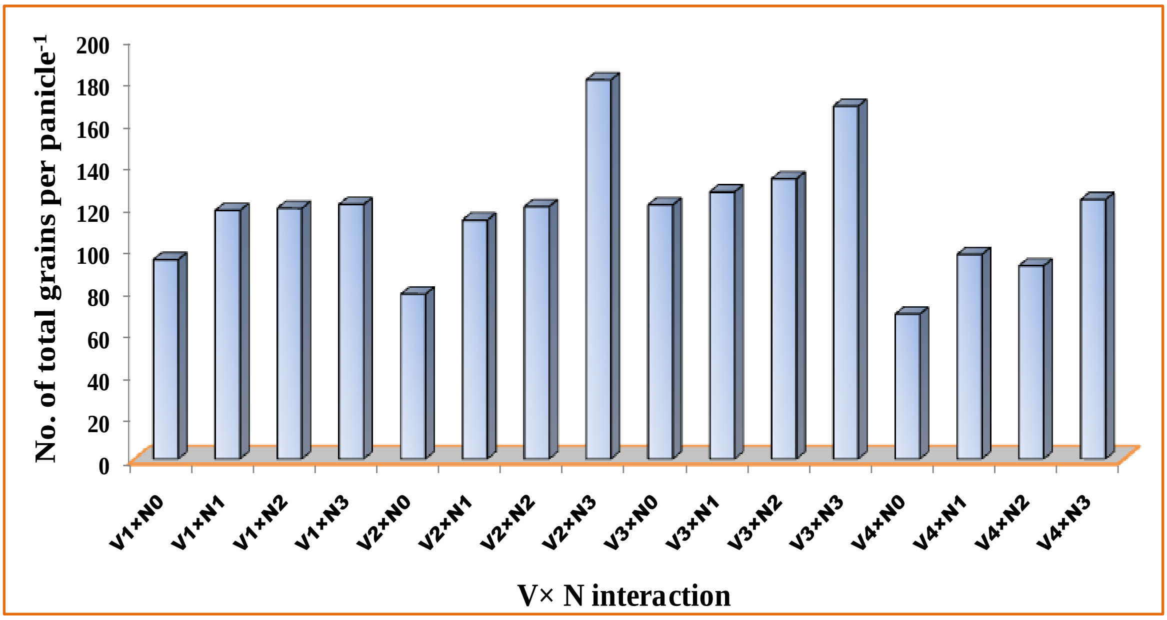


**Fig.12. Interaction effect of variety and N on the number of total grains panicle$^{-1}$ of ratoon crop ($LSD_{(0.05)}$ = 37.13)**

### 4.11. Grain yield hill$^{-1}$

#### 4.11.1. Effect of variety on the grain yield hill$^{-1}$ of main crop

The grain yield hill$^{-1}$ of main crop was significantly affected by the variety (Fig.13). The highest grain yield hill$^{-1}$ (29.72 g) was produced by the main crop variety BRRI dhan29. It might be due to better grain quality as its varietal characteristics. The lowest one (16.83 g) was produced by BRRI dhan47.

#### 4.11.2. Effect of variety on the grain yield hill$^{-1}$ of ratoon crop

Different varieties had significant effect on the grain yield hill$^{-1}$ of ratoon crop (Fig.13). In ratoon crop, the highest (12.63 g) grain yield hill$^{-1}$ was produced by BRRI dhan29 whereas the lowest one (7.621 g) was produced by BRRI dhan47. These effects showed resembles to that of main crop. Therefore we can assume that, this factor was dominated by varietal characteristics.

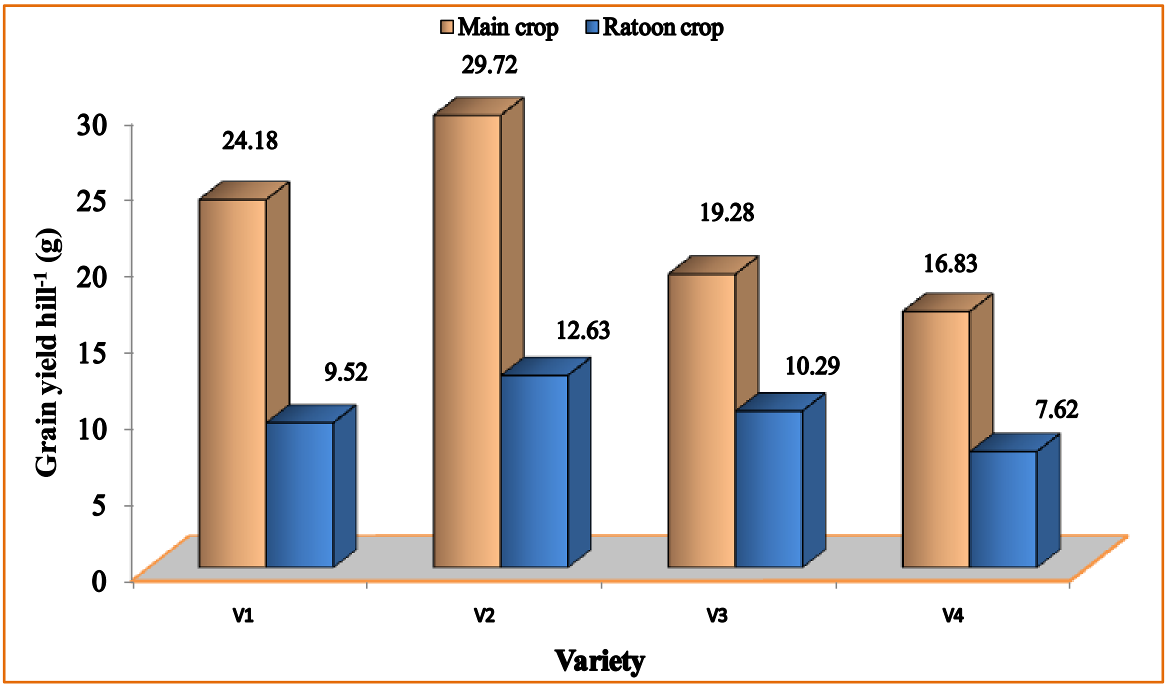


**Fig.13. Effect of variety on the grain yield hill$^{-1}$ of main crop and ratoon crop {$LSD_{(0.05)}$ = 4.00 (main crop) 0.86 (ratoon crop)}**

### 4.11.3. Effect of N on the grain yield hill$^{-1}$ of ratoon crop

Various N doses exerted a significant effect on grain yield hill$^{-1}$ of ratoon crop (Fig.14). All levels of N application increased the grain yield hill$^{-1}$ significantly. The highest grain yield hill$^{-1}$ (11.87 g) was produced by the fourth treatment (75% of N dose) followed (10.57 g) by the immediate before dose. The lowest (8.10 g) grain yield hill$^{-1}$ was produced without any N fertilizer application.

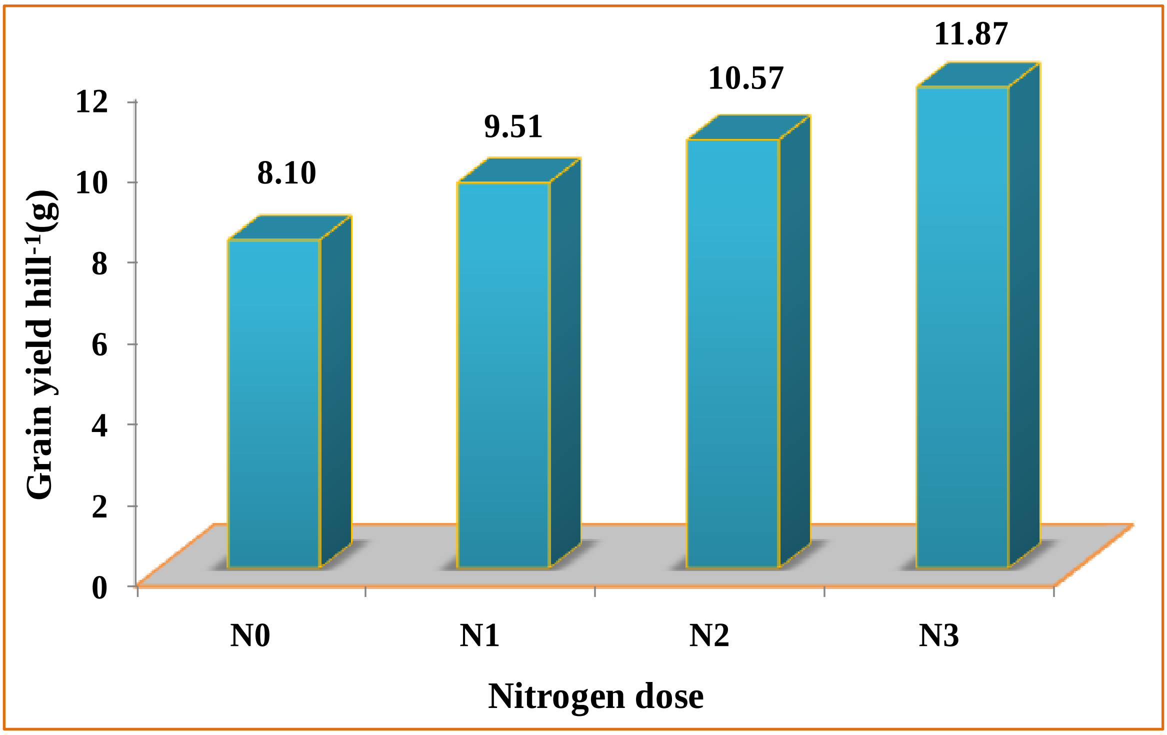


**Fig.14. Effect of N on the grain yield hill$^{-1}$ of ratoon crop ($LSD_{(0.05)}$ = 0.86)**

### 4.11.4. Interaction Effect of variety and N on the grain yield hill$^{-1}$ of ratoon crop

The interaction effect of variety and N dose on the grain yield hill$^{-1}$ was non-significant (Fig.15). Numerically BRRI dhan29 interaction with $N_3$ (75% of recommended N) gave the highest (15.62 g) grain yield hill$^{-1}$. The interaction of the same variety with $N_1$ and $N_2$ produced statistically at par grain yield hill$^{-1}$ and followed the highest one. BRRI dhan47 with $N_0$ and $N_1$ produced statistically lower grain yield hill$^{-1}$ than other interaction. But numerically BRRI dhan47 in control plots gave the lowest (6.21 g) effect yield hill$^{-1}$. From the result shown in the table, it was assumed that N dose had limited effect on variety on producing higher grain yield hill$^{-1}$.

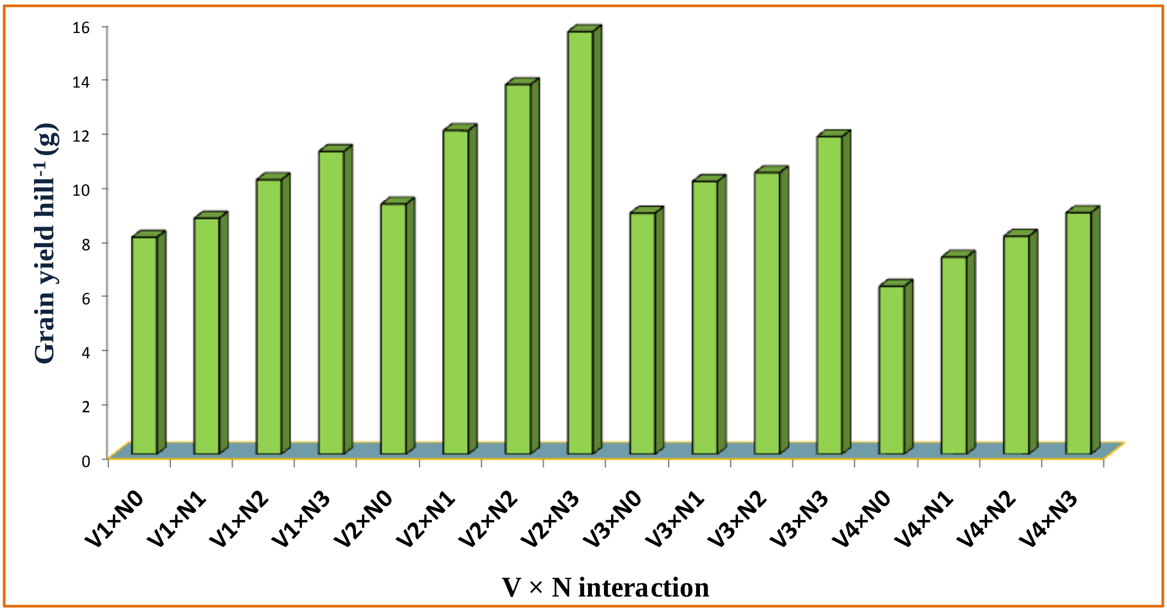


**Fig.15. Interaction effect of variety and N on the grain yield hill$^{-1}$ of main crop and ratoon crop ($LSD_{(0.05)}$ = 1.73)**

### 4.12. 1000-grain weight

#### 4.12.1. Effect of variety on the 1000-grain weight of main crop

Our present study reflects that 1000-grain weight of main crop was significantly affected by the variety (Table 8). Numerically, the highest (24.59 g) 1000- grain weight was observed when the main crop was BRRI dhan47 whereas the lowest (19.82 g) 1000-grain weight was recorded in BRRI dhan35.

#### 4.12.2. Effect of variety on the 1000-grain weight of ratoon crop

Oad *et al.* (2002) found that ratoon grain yield was associated with 100-grain weight. The 1000-grain weight of ratoon crop was significantly affected by the variety of main crop (Table 8). Except BRRI dhan47 1000-grain weight produced by three varieties was statistically at par, but numerically different. Numerically, the highest (18.81 g) 1000-grain weight was observed in BRRI hybrid dhan2 followed by BRRI dhan29 (18.51 g). At the same time the lowest (10.23 g) one was produced by BRRI dhan47.

#### 4.12.3. Effect of N on the 1000-grain weight of ratoon crop

Kasturi and Purushothaman (1992) found that N application had significant effect on grain yield and 1000-grain weight. Various N doses exerted significant effect on 1000-grain weight (Table 8) which was statistically similar but numerically different. 1000-grain weight of $N_2$ and $N_3$ was statistically higher than that of $N_0$ and $N_1$ treatments. Numerically $N_3$ produced the highest (18.92 g) 1000-grain weight. Control plots gave the lowest (15.25 g) 1000-grain weight. Fageria *et al*. (1997) also found similar results.

#### 4.12.4. Interaction effect of variety and N on the 1000-grain weight of ratoon crop

The interaction effect of variety and N dose had significant effect on 1000-grain weight (Table 8). All the N-applied plots of BRRI hybriddhan2 and BRRI dhan29 and 75% of recommended N-applied plots of BRRI dhna35 gave significantly higher 1000-grain weight than other interactions. Numerically the highest (21.23 g) 1000-grain weight was found in BRRI hybriddhan2 with 75% of recommended N fertilizer application, followed by BRRI dhan29 (20.92 g) with same N dose. On the other hand BRRI dhan47 with $N_0$,

$N_1$ and $N_2$ produced statistically at par 1000-grain weight and was lower than others. But numerically the lowest 1000-grain weight was found in BRRI dhan47 without N fertilizer application.

**Table 8. Effect of variety and N on the number of 1000-grain weight of boro rice under ratoon cropping**

| Variety | N dose | V×N Interaction | 1000- grain weight (g) | |
|---|---|---|---|---|
| | | | Main crop | Ratoon crop |
| BRRI hybriddhan2 ($V_1$) | - | - | 22.51 | 18.81 |
| BRRI dhan29 ($V_2$) | - | - | 23.49 | 18.51 |
| BRRI dhan35 ($V_3$) | - | - | 19.82 | 16.91 |
| BRRI dhan47 ($V_4$) | - | - | 24.59 | 10.23 |
| $LSD_{(0.05)}$ | - | - | 0.35 | 2.17 |
| CV (%) | - | - | 10.05 | - |
| - | $N_0$ | - | - | 13.45 |
| - | $N_1$ | - | - | 15.09 |
| - | $N_2$ | - | - | 17.00 |
| - | $N_3$ | - | - | 18.92 |
| - | $LSD_{(0.05)}$ | - | - | 2.17 |
| - | - | $V_1 \times N_0$ | - | 16.33 |
| - | - | $V_1 \times N_1$ | - | 18.23 |
| - | - | $V_1 \times N_2$ | - | 19.45 |
| - | - | $V_1 \times N_3$ | - | 21.23 |
| - | - | $V_2 \times N_0$ | - | 15.23 |
| - | - | $V_2 \times N_1$ | - | 17.37 |
| - | - | $V_2 \times N_2$ | - | 20.53 |
| - | - | $V_2 \times N_3$ | - | 20.92 |
| - | - | $V_3 \times N_0$ | - | 14.83 |
| - | - | $V_3 \times N_1$ | - | 15.77 |
| - | - | $V_3 \times N_2$ | - | 16.90 |
| - | - | $V_3 \times N_3$ | - | 20.13 |
| - | - | $V_4 \times N_0$ | - | 7.41 |
| - | - | $V_4 \times N_1$ | - | 9.00 |
| - | - | $V_4 \times N_2$ | - | 11.10 |
| - | - | $V_4 \times N_3$ | - | 13.40 |
| - | - | $LSD_{(0.05)}$ | - | 4.33 |
| - | - | CV (%) | - | 10.75 |

$N_0$ =No nitrogen application, $N_1$ = 25% of recommended nitrogen fertilizer, $N_2$ =50% of recommended nitrogen fertilizer and $N_3$ =75% of recommended nitrogen fertilizer.

### 4.13. Grain yield

### 4.13.1. Effect of variety on the grain yield of main crop

Grain yield is the main objective of rice cultivation. Generally the yield contributing characters like, number of effective tillers hill$^{-1}$, number of grains panicle$^{-1}$, weight of individual grains or thousand grain weights combinely contribute to the yield of rice. In this study, the grain yield was significantly affected by the variety of rice (Table 9). The highest (7.04 t ha$^{-1}$) grain yield was produced by BRRI hybrid dhan2 followed by BRRI dhan29 (5.97 t ha$^{-1}$). The yield of BRRI dhan29 was statistically similar to, but numerically higher than BRRI dhan35. It may be due to varietal characteristics band initial soil fertility. The lowest (5.00 t ha$^{-1}$) yield was obtained by BRRI dhan35. The result showed similarity with the varietal performance mentioned by BRRI.

### 4.13.2. Effect of variety on the grain yield of ratoon crop

Variety of rice had significant effect on the grain yield of ratoon crop (Table 9). BRRI hybriddhan2 and BRRI dhan29 gave statistically higher grain yield than BRRI dhan35 and BRRI dhan47. The highest grain yield (0.83 t ha$^{-1}$) was produced by BRRI dhan29, followed by BRRI hybriddhan2. The lowest (0.21 t ha$^{-1}$) grain yield was recorded in BRRI dhan47. BRRI dhan29 produced the highest (13.95) percentage of grain yield of main crop followed by BRRI hybriddhan2 (11.50). BRRI dhan47 produced the lowest (3.70) percentage grain yield of that of main crop.

### 4.13.3. Effect of N on the grain yield of ratoon crop

Bond *et al.* (2005) reported increases in ratoon rice yields with increasing N fertilizer rate. Turner and McIlrath (1988) also observed that N application following main crop harvest consistently increases ratoon crop yield. This was supported by Kasturi and Purushothaman (1992).

Application of various N doses showed significant effect on the grain yield of ratoon crop (Table 9). All the N-applied plots gave significantly higher grain yield than control plots. Numerically, the highest grain yield (0.65 t $ha^{-1}$) was obtained from 75% N application during ratoon crop production. The lowest yield (0.52 t $ha^{-1}$) was produced in control plots. The grain yield percentage of main crop produced by ratoon crop increased by the increasing level of N. Numerically $N_3$ gave the highest (10.95) percentage of grain yield of main crop followed (9.93) by $N_2$. The lowest (9.93) percentage of grain yield of main crop was produced by control plots. This result was in agreement with Choi and Kwon (1985), Szokolay (1956) and Maharudrappa (1996).

### 4.13.4. Interaction effect of variety and N on the grain yield of ratoon crop

The interaction of variety and N dose had significant effect on grain yield of ratoon crop (Table 9). N application to the BRRI hybriddhan2 and BRRI dhan29 gave significantly higher yield than others. Apparently, the highest (0.92 t $ha^{-1}$) grain yield was obtained from the interaction of BRRI dhan29 and 75% recommended N application, followed by the interaction of BRRI hybriddhan2 with the same N dose. BRRI dhan47 gave significantly lower grain yield with application of N. The lowest (0.12 t $ha^{-1}$) grain yield was obtained from 25% recommended N-applied plots of BRRI dhan47. It was also reflected in case of percentage analysis. BRRI dhan29 with 75% N application produced the highest (15.11) grain yield percentage of that of main crop followed by the same variety with treatment $N_2$. BRRI hybriddhan2 also produced higher percentage of grain yield of that of main crop. BRRI dhan47 with all the N treatment showed lower percentage than other variety and N interaction effect. However the lowest (2.03 t $ha^{-1}$) grain yield percentage of main crop was found by ratoon crop of BRRI dhan47 with interaction of $N_1$ (i.e. 25% recommended N).

**Table 9. Effect of variety and N on the grain yield of boro rice under ratoon cropping**

| Variety | N dose | V×N Interaction | Grain yield (t $ha^{-1}$) | | % of main crop* |
|---|---|---|---|---|---|
| | | | Main crop | Ratoon crop | |
| BRRI hybriddhan2 ($V_1$) | - | - | 7.04 | 0.74 | 11.50 |
| BRRI dhan29 ($V_2$) | - | - | 5.96 | 0.83 | 13.95 |
| BRRI dhan35 ($V_3$) | - | - | 5.00 | 0.45 | 8.97 |
| BRRI dhan47 ($V_4$) | - | - | 5.71 | 0.21 | 3.70 |
| $LSD_{(0.05)}$ | - | - | 0.36 | 0.10 | - |
| CV (%) | - | - | 22.51 | - | - |
| - | $N_0$ | - | - | 0.52 | 8.70 |
| - | $N_1$ | - | - | 0.55 | 9.27 |
| - | $N_2$ | - | - | 0.58 | 9.93 |
| - | $N_3$ | - | - | 0.66 | 10.95 |
| - | $LSD_{(0.05)}$ | - | - | 0.10 | - |
| - | - | $V_1 \times N_0$ | - | 0.69 | 9.65 |
| - | - | $V_1 \times N_1$ | - | 0.80 | 10.99 |
| - | - | $V_1 \times N_2$ | - | 0.83 | 12.18 |
| - | - | $V_1 \times N_3$ | - | 0.89 | 13.28 |
| - | - | $V_2 \times N_0$ | - | 0.71 | 12.12 |
| - | - | $V_2 \times N_1$ | - | 0.86 | 14.73 |
| - | - | $V_2 \times N_2$ | - | 0.86 | 13.83 |
| - | - | $V_2 \times N_3$ | - | 0.92 | 15.11 |
| - | - | $V_3 \times N_0$ | - | 0.34 | 6.54 |
| - | - | $V_3 \times N_1$ | - | 0.43 | 8.72 |
| - | - | $V_3 \times N_2$ | - | 0.48 | 9.79 |
| - | - | $V_3 \times N_3$ | - | 0.54 | 11.01 |
| - | - | $V_4 \times N_0$ | - | 0.34 | 5.96 |
| - | - | $V_4 \times N_1$ | - | 0.12 | 2.03 |
| - | - | $V_4 \times N_2$ | - | 0.15 | 2.78 |
| - | - | $V_4 \times N_3$ | - | 0.23 | 3.98 |
| - | - | $LSD_{(0.05)}$ | - | 0.20 | - |
| - | - | CV (%) | - | 21.30 | - |

* Fig. in the parenthesis represents percentage (%) of the value obtained in the main crop,

$N_0$ =No nitrogen application, $N_1$ = 25% of recommended nitrogen fertilizer, $N_2$ =50% of recommended nitrogen fertilizer and $N_3$ =75% of recommended nitrogen fertilizer.

### 4.14. Straw yield

#### 4.14.1. Effect of variety on the straw yield of main crop

The straw yield was significantly influenced by variety (Table 10). The lowest (8.16 t $ha^{-1}$) straw yield was produced by BRRI hybridhan2 whereas the highest (10.73 t $ha^{-1}$) by BRRI dhan47. The second highest straw yield (9.53 t $ha^{-1}$) was recorded in case of BRRI dhan29.

#### 4.14.2. Effect of variety on the straw yield of ratoon crop

The variety significantly influenced the straw yield of ratoon crop (Table 10). BRRI dhan35 and BRRI dhan47 gave statistically lower straw yield. The lowest (1.49 t $ha^{-1}$) straw yield was produced by BRRI dhan47. Significantly higher straw yield was observed in BRRI hybriddhan2 and BRRI dhan29. The highest (2.00 t $ha^{-1}$) straw yield was recorded in BRRI hybriddhan2 followed by BRRI dhan29 (1.97 t $ha^{-1}$).

#### 4.14.3. Effect of N on the straw yield of ratoon crop

Straw yield of ratoon crop was significantly affected by N dose (Table 10). Results indicated that except $N_3$ other three N doses produced statistically similar but numerically dissimilar effect on straw yield. $N_2$ and $N_3$ produced significantly lower straw yield. The lowest (1.54 t $ha^{-1}$) straw yield was recorded by 75% recommended N application. The highest (2.03 t $ha^{-1}$) straw yield was produced when no N was applied. But Setty *et al*. (1993), Kasturi and Purushothaman (1992) and Yuan *et al*. (1996) found that straw yield was increased by increasing N application.

#### 4.14.4. Interaction effect of variety and N on the straw yield of ratoon crop

Straw yield of ratoon crop was significantly affected by interaction of variety and N (Table 10). All the N-applied plots of BRRI dhan35 and BRRI dhan47 gave statistically lower straw yield. However the lowest (1.20 t $ha^{-1}$) straw yields was recorded from BRRI dhan47 with 75% of recommended N application. Interaction of BRRI hybriddhan2 and BRRI dhan29 with $N_0$, $N_1$ and $N_2$; BRRI dhan47 with $N_0$ gave significantly higher straw yield which were statistically at par but numerically different. The highest straw yield (2.27 t $ha^{-1}$) was found in the variety BRRI hybriddhan2 with no N application. It was followed (2.33 t $ha^{-1}$) by same N treatment with BRRI dhan29.

**Table 10. Effect of variety and N on the straw yield of boro rice under ratoon cropping**

| Variety | N dose | V×N Interaction | Straw yield (t $ha^{-1}$) | |
|---|---|---|---|---|
| | | | Main crop | Ratoon crop |
| BRRI hybriddhan2 ($V_1$) | - | - | 8.16 | 1.99 |
| BRRI dhan29 ($V_2$) | - | - | 9.53 | 1.97 |
| BRRI dhan35 ($V_3$) | - | - | 8.94 | 1.56 |
| BRRI dhan47 ($V_4$) | - | - | 10.73 | 1.48 |
| $LSD_{(0.05)}$ | - | - | 0.59 | 0.19 |
| CV (%) | - | - | 7.58 | - |
| - | $N_0$ | - | - | 2.03 |
| - | $N_1$ | - | - | 1.75 |
| - | $N_2$ | - | - | 1.67 |
| - | $N_3$ | - | - | 1.55 |
| - | $LSD_{(0.05)}$ | - | - | 0.19 |
| - | - | $V_1 \times N_0$ | - | 2.27 |
| - | - | $V_1 \times N_1$ | - | 2.00 |
| - | - | $V_1 \times N_2$ | - | 1.90 |
| - | - | $V_1 \times N_3$ | - | 1.80 |
| - | - | $V_2 \times N_0$ | - | 2.23 |
| - | - | $V_2 \times N_1$ | - | 1.97 |
| - | - | $V_2 \times N_2$ | - | 1.90 |
| - | - | $V_2 \times N_3$ | - | 1.78 |
| - | - | $V_3 \times N_0$ | - | 1.73 |
| - | - | $V_3 \times N_1$ | - | 1.57 |
| - | - | $V_3 \times N_2$ | - | 1.53 |
| - | - | $V_3 \times N_3$ | - | 1.42 |
| - | - | $V_4 \times N_0$ | - | 1.89 |
| - | - | $V_4 \times N_1$ | - | 1.46 |
| - | - | $V_4 \times N_2$ | - | 1.37 |
| - | - | $V_4 \times N_3$ | - | 1.20 |
| - | - | $LSD_{(0.05)}$ | - | 0.38 |
| - | - | CV (%) | - | 5.14 |

$N_0$ =No nitrogen application, $N_1$ = 25% of recommended nitrogen fertilizer, $N_2$ =50% of recommended nitrogen fertilizer and $N_3$ =75% of recommended nitrogen fertilizer.

### 4.15. Biological yield

### 4.15.1. Effect of variety on the biological yield of main crop

All the variety showed significant effect on the biological yield of main crop (Table 11). Numerically the highest (16.41 t $ha^{-1}$) biological yield was observed in BRRI dhan47 whereas the lowest one (13.93 t $ha^{-1}$) was observed at BRRI dhan35. BRRI dhan29 showed the second highest biological yield.

### 4.15.2. Effect of variety on the biological yield of ratoon crop

Biological yield of ratoon crop was significantly affected by all the varieties (Table 11). The biological yield of BRRI hybriddhan2 and BRRI dhan29 was significantly higher than other varieties. The highest (2.80 t $ha^{-1}$) biological yield was recorded in BRRI hybriddhan2 followed by BRRI dhan29. The lowest biological yield (1.80 t $ha^{-1}$) was given by BRRI dhan47. BRRI hybriddhan2 gave the highest (18.52) percentage biological yield followed (18.15) by BRRI dhan29. The lowest (9.95) percentage value was obtained by BRRI dhan47.

### 4.15.3. Effect of N on the biological yield of ratoon crop

All the N-applied plots showed significant effect on biological yield of ratoon crop which were statistically similar but numerically different (Table 11). Control plots and plots treated with $N_1$ gave higher biological yield than $N_2$ and $N_3$. Numerically during ratoon crop production the highest (2.49 t $ha^{-1}$) biological yield was observed at control plots, and the lowest (2.20 t $ha^{-1}$) one was found by $N_3$ (i.e. 75% N application). Control plots and the highest dose of N fertilizer showed the highest (16.49) and the lowest (14.01) biological yield percentage of main crop respectively. Control plots gave higher biological yield. It might be due to higher straw yield by control plots.

### 4.15.4. Interaction effect of variety and N on the biological yield of ratoon crop

Interaction effect of variety and N dose on the biological yield of ratoon crop was significant (Table11). BRRI hybriddhan2 and BRRI dhan29 with all the N levels showed statistically at par effect, but numerically they were different. However, the highest (2.95 t $ha^{-1}$) straw yield was recorded in BRRI hybriddhan2 with control plots. On the other hand BRRI dhan35 and BRRI dhan47 with all the interaction and control plots showed statistically similar but numerically dissimilar effect. But all N-applied plots of BRRI dhan47 gave significantly lower yield than others. The lowest (1.43 t $ha^{-1}$) one was found in BRRI dhan47 with 75% recommended N application. BRRI dhan29 in control plots gave the highest (19.40) biological yield percentage of main crop followed (19.36) by BRRI hybriddhan2 in control plots. BRRI dhan47 with $N_3$ produced the lowest (8.14) percentage of biological yield of main crop.

**Table 11. Effect of variety and N on the biological yield of boro rice under ratoon cropping**

| Variety | N dose | V×N Interaction | Biological yield (t $ha^{-1}$) | | % of main crop* |
|---|---|---|---|---|---|
| | | | Main crop | Ratoon crop | |
| BRRI hybriddhan2 ($V_1$) | - | - | 15.11 | 2.80 | 18.52 |
| BRRI dhan29 ($V_2$) | - | - | 15.40 | 2.79 | 18.15 |
| BRRI dhan35 ($V_3$) | - | - | 13.93 | 2.01 | 14.42 |
| BRRI dhan47 ($V_4$) | - | - | 16.41 | 1.63 | 9.95 |
| $LSD_{(0.05)}$ | - | - | 0.65 | 0.21 | 1.426 |
| CV (%) | - | - | 5.14 | - | - |
| - | $N_0$ | - | - | 2.49 | 16.49 |
| - | $N_1$ | - | - | 2.29 | 14.97 |
| - | $N_2$ | - | - | 2.26 | 15.30 |
| - | $N_3$ | - | - | 2.20 | 14.01 |
| - | $LSD_{(0.05)}$ | - | - | 0.21 | - |
| - | - | $V_1×N_0$ | - | 2.95 | 19.36 |
| - | - | $V_1×N_1$ | - | 2.79 | 18.00 |
| - | - | $V_1×N_2$ | - | 2.73 | 18.45 |
| - | - | $V_1×N_3$ | - | 2.72 | 18.28 |
| - | - | $V_2×N_0$ | - | 2.94 | 19.40 |
| - | - | $V_2×N_1$ | - | 2.81 | 18.34 |
| - | - | $V_2×N_2$ | - | 2.76 | 18.28 |
| - | - | $V_2×N_3$ | - | 2.67 | 16.67 |
| - | - | $V_3×N_0$ | - | 2.07 | 15.27 |
| - | - | $V_3×N_1$ | - | 2.00 | 14.47 |
| - | - | $V_3×N_2$ | - | 2.01 | 14.16 |
| - | - | $V_3×N_3$ | - | 1.96 | 13.83 |
| - | - | $V_4×N_0$ | - | 2.00 | 12.14 |
| - | - | $V_4×N_1$ | - | 1.57 | 9.44 |
| - | - | $V_4×N_2$ | - | 1.52 | 10.21 |
| - | - | $V_4×N_3$ | - | 1.43 | 8.14 |
| - | - | $LSD_{(0.05)}$ | - | 0.42 | - |
| - | - | CV (%) | - | 11.14 | - |

* Fig. in the parenthesis represents percentage (%) of the value obtained of the main crop

$N_0$ = No nitrogen application, $N_1$ = 25% of recommended nitrogen fertilizer, $N_2$ = 50% of recommended nitrogen fertilizer and $N_3$ = 75% of recommended nitrogen fertilizer.

### 4.16. Harvest index

#### 4.16.1. Effect of variety on the harvest index of main crop

Harvest index, the ratio of economic yield to the biological yield, is a measure of the efficiency of conversion of photosynthetic into economic yield (Gautom and Sharma, 1989). In general, grain yield is the economic yield in rice while both grain and straw yields together refer to the biological yield. In this study the harvest index was significantly affected by the variety (Fig.16). Numerically, the highest harvest index (46.84) was recorded from the variety BRRI hybriddhan2 whereas the lowest (34.81) one was produced by BRRI dhan47.

#### 4.16.2. Effect of variety on the harvest index of ratoon crop

All the variety showed significant effect on harvest index of ratoon crop (Fig.16). Harvest index of BRRI hybrid dhan2 and BRRI dhan29 was significantly higher than other two varieties. Numerically, BRRI dhan29 showed the highest (19.74) harvest index followed by BRRI hybrid dhan2 (19.05). The lowest harvest index was found in plots of BRRI dhan47.

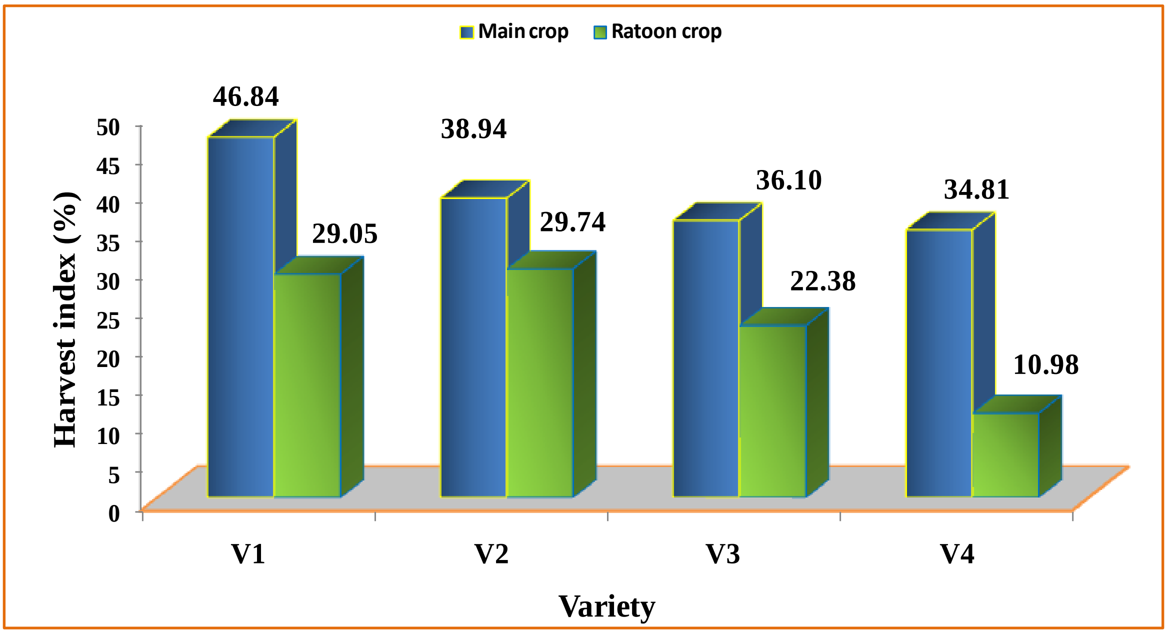


**Fig.16. Effect of variety on the Harvest index of main crop and ratoon crop {$LSD_{(0.05)}$ = 2.11 (main crop) 2.15 (ratoon crop)}**

#### 4.16.3. Effect of N on the harvest index of ratoon crop

Islam *et al.* (2008) found that there were no significant differences in harvest index due to fertilizer doses in both main crop and ratoon crop. Harvest index increased significantly with N application (Fig.17). Numerically, the highest value (27.71) of harvest index was found in 75% recommended N-applied plots and the lowest value (17.35) of harvest index was found in control plots.

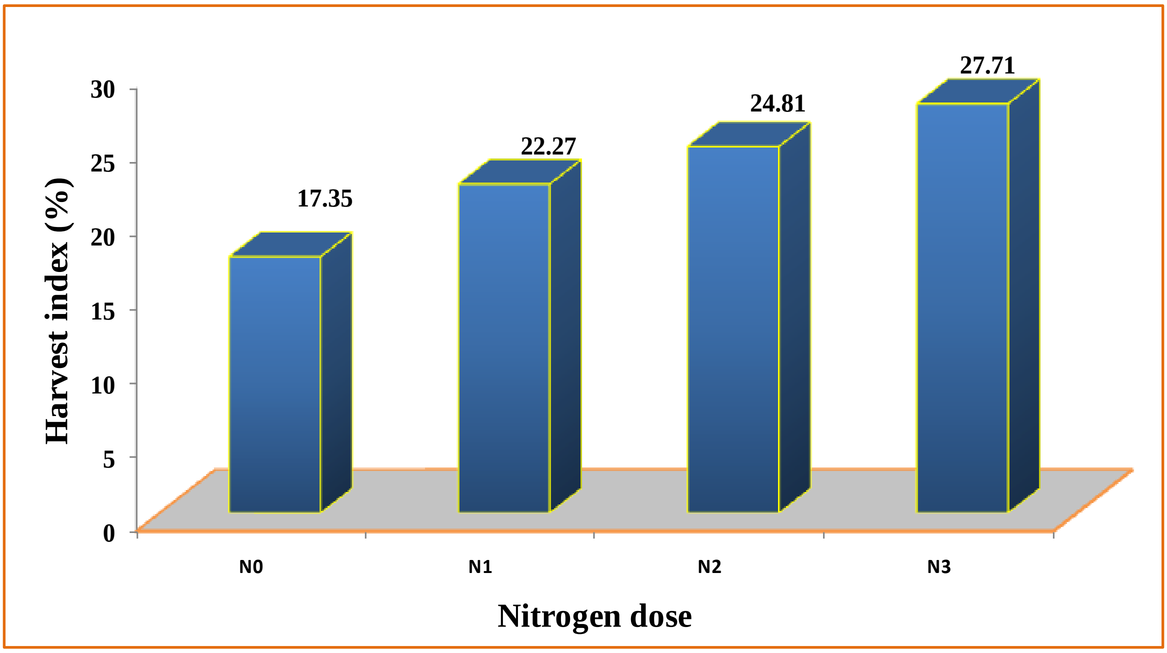


**Fig.17. Effect of N on the harvest index of ratoon crop ($LSD_{(0.05)}$ = 2.15)**

### 4.16.4. Interaction effect of variety and N on the harvest index of ratoon crop

BRRI dhan29 and BRRI hybriddhan2 showed significantly higher harvest index with N-applied plots than control plots (Fig.18). The highest (33.70) harvest index was found in the BRRI hybrid dhan2 treated with 75% recommended N, followed (33.42) by BRRI dhan29 with same N level. BRRI dhan47 with $N_0$ and $N_1$ nitrogen levels showed lower harvest index whereas the lowest value (5.61) was recorded in BRRI dhan47 without N fertilization.

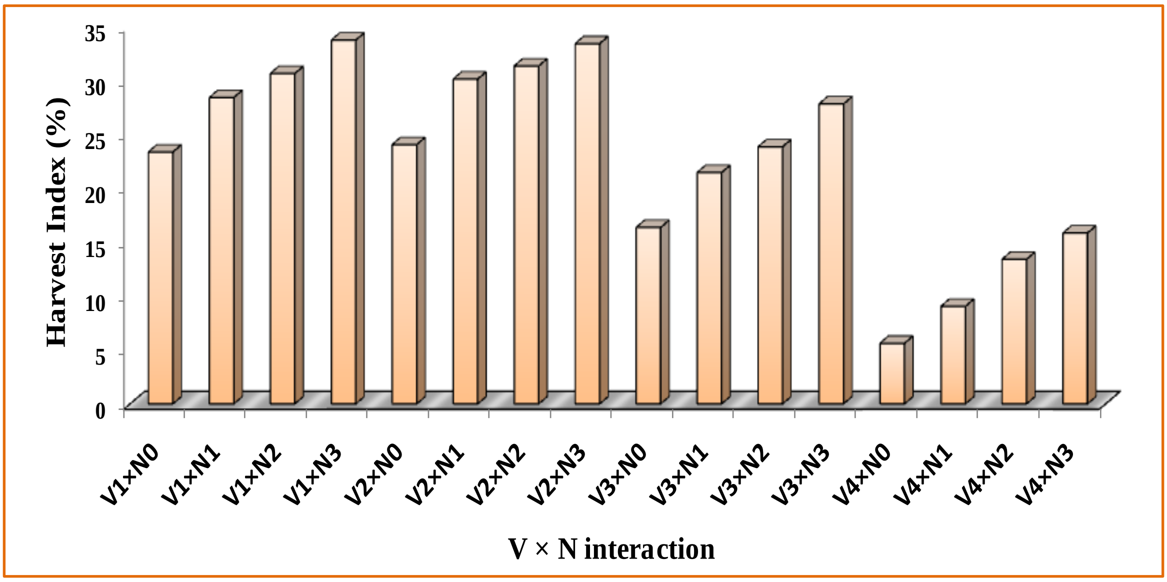


**Fig.18. Interaction effect of variety and N on the harvest index ratoon crop ($LSD_{(0.05)}$ = 4.29)**

# CHAPTER V

# SUMMARY AND CONCLUSION

The experiment was carried out at the Agronomy Field, Sher-e-Bangla Agricultural University, Dhaka during the period from November 2009 to July 2010 with a view to study the effects of variety of main crop and N dose (applied after the harvesting of main crops) on the performance of ratoon crop of boro rice. The experiment was carried out in a Split Plot Design, where two factors were selected as variety and Nitrogen dose. The plot size was 3 square meters (2 m ×1.5 m). The plots were replicated three times and thus the total number of plots was 48. BRRI released four varieties (BRRI hybriddhan2, BRRI dhan29, BRRI dhan35 and BRRI dhan47) and four N doses (0%, 25%, 50% and 75% of the specific recommended doses for selected varieties) were selected treatments.

Thirty-two days old seedlings of main crop varieties were transplanted on 1 January 2010 @ one seedling hill$^{-1}$ for hybrid and two-three seedlings hill$^{-1}$ for inbreed. The field was fertilized with urea, triple super phosphate (TSP), muriate of potash (MoP), gypsum and zinc sulphate at the rate as per recommendation of BRRI in order to supply nitrogen, phosphorus, potassium, sulphur and zinc, respectively. Except urea, the whole amount of other fertilizers was applied before final land preparation. Urea was top dressed in three equal splits at 15, 30 and 45 days after transplanting. Proper crop protection management was taken including gap filling, irrigation and application of pesticide. Ten hills were harvested randomly from each plot prior to harvesting of entire plots to record the data on yield contributing characters. The entire crop of each plot was harvested on different dates from 26 April 2010 to 8 May 2010 depending on the maturity and leaving 15 cm cutting height from ground level. The straw and grain yield of 10 sample hills was added to that of the entire plots to calculate the yield. It was done to compare the yield contributing characteristics of ratoon crop to that of the main crop.

The guided rate of N fertilizer was 216.77 kg ha$^{-1}$ and 86.02 kg ha$^{-1}$ for hybrid variety BRRI hybrid dhan2 and inbreeds variety BRRI dhan47 respectively. BRRI dhan29 and BRRI dhan35 required same amount of N i.e. 120.43 kg ha$^{-1}$. According to experiment, treatment were selected as 0, 25, 50, 75 percent N of recommended dose. Those fertilizers were applied on the day after harvesting main crop. Data collection procedure of ratoon crop was same as the main crop. Ratoon crop of different plots was harvested on different date from19 June 2010 to 5 July 2010 depending on the maturity of the grains.

Data on sixteen different yield and yield contributing characters of main crop and ratoon crop was recorded. Collected data were analyzed statistically and the mean differences were adjudged by Least Significant difference (LSD).

All the crop characters except number of non-effective tillers hill$^{-1}$ and days to panicle emergence of main crop were significantly affected by variety. As the N treatment was not applied to the plots of main crop, they showed the best performance in terms of various crop characters and yield performance according to their varietal ability and performance. Grain yield is the ultimate objective of crop cultivation and it is affected by the performance of other crop characters. BRRI hybriddhan2 gave significantly higher (7.04 t ha$^{-1}$) grain yield during main crop production. The second highest (5.96 t ha$^{-1}$) yield was given by BRRI dhan29.

Variety had significant effect on the entire yield and yield contributing characters of ratoon crop except number of non-effective tillers hill$^{-1}$ and number of unfilled grain panicle$^{-1}$. BRRI hybriddhan2 and BRRI dhan29 gave significantly higher and statistically at par grain yield. They also gave higher straw and biological yield. BRRI hybriddhan2 and BRRI dhan29 also showed better performance relevantly in other yield contributing characters like plant height, number of tillers hill$^{-1}$, number of effective tillers hill$^{-1}$, days to maturity, filled grains panicle$^{-1}$, grain yield hill$^{-1}$ and 1000-grain weight. Numerically BRRI dhan29 produced the highest (0.83 t ha$^{-1}$) grain yield followed (0.74 t ha$^{-1}$) by BRRI hybriddhan2. BRRI dhan29 and BRRI hybriddhan2 gave significantly higher (13.95 and 11.50 respectively) percentage of grain yield of main crop.

The yield of ratoon crop was increasing simultaneously with the increasing rate of N application. But N doses did not show significant variance in productivity of ratoon rice. Effect of N dose on the plant characters was significant except number of unfilled grains panicle$^{-1}$ of ratoon crop. However, numerically 75% recommended N application produced highest grain yield. This treatment also showed the best performance in case of all the parameters except days to panicle emergence and biological yield. But grain yield by 25% and 50% recommended N application was statistically similar with the highest one. So, it can be assumed that 25% extra N application to the ratoon crop may increases grain yield significantly.

BRRI dhan35 showed better result in some yield attributing characters. But BRRI dhan47 showed least performance in ratooning under N application.

The interaction effect of variety and nitrogen dose to ratoon crop had significant effect on all the parameters of ratoon rice except panicle emergence. BRRI dhan29 with 75% extra N application gave the highest performance in plant height, number of tillers hill$^{-1}$, number of effective tillers hill$^{-1}$, non effective tillers hill$^{-1}$, total grains panicle$^{-1}$, grain yield panicle$^{-1}$ and grain yield. BRRI hybriddhan2 with interaction of 76% N produced best performance in 1000-grain weight and harvest index. BRRI dhan35 gave the highest number of filled grains panicle$^{-1}$ with the application of the highest N. The highest number of tiller hill$^{-1}$ and highest panicle length was found in the interaction of BRRI dhan29 and 50% recommended N application. But 25% and 50% N applied plots of BRRI hybriddhan2 and BRRI dhan29 showed statistically better result in many yield and yield contributing characters. In terms of grain yield BRRI hybriddhan2 and BRRI dhan29 in all the N-applied plots produced significantly higher (796 – 916) kg ha$^{-1}$ yield than others. In percentage analysis, all the N-applied plots of BRRI hybriddhan2 and BRRI dhan29 showed higher (10.99 – 15.11) grain yield percentage of main crop. Although 75% recommended N applied plots of BRRI dhan29 gave the highest (916 kg ha$^{-1}$) grain yield which was the highest (15.11) percentage of main crop yield.

**Recommendation**

The ultimate objective of this experiment was to test the varieties in terms of their grain yield under different levels of N fertilizer. Based on the present study it can be said that for ratooning of boro rice under the agro-ecological conditions of experimental field, BRRI hybrid dhan2 and BRRI dhan29 gave significantly higher yield with N application. Using 25% extra N to ratoon crop after the harvest of main crops may give most economic yield of ratoon crop of BRRI hybriddhan2 or BRRI dhan29. But, the yield was not economically so much higher as found in the previous literature. So some other variety may be tested for the commercial ratoon crop cultivation.

**Some core recommendations can be stated as-**

- To select a high performance ratoon rice variety under Bangladesh context more comprehensive study should be conducted.
- Decisions about the appropriate application rate of N fertilizer demands further field specific research based on findings on the benefit over cost of N application.

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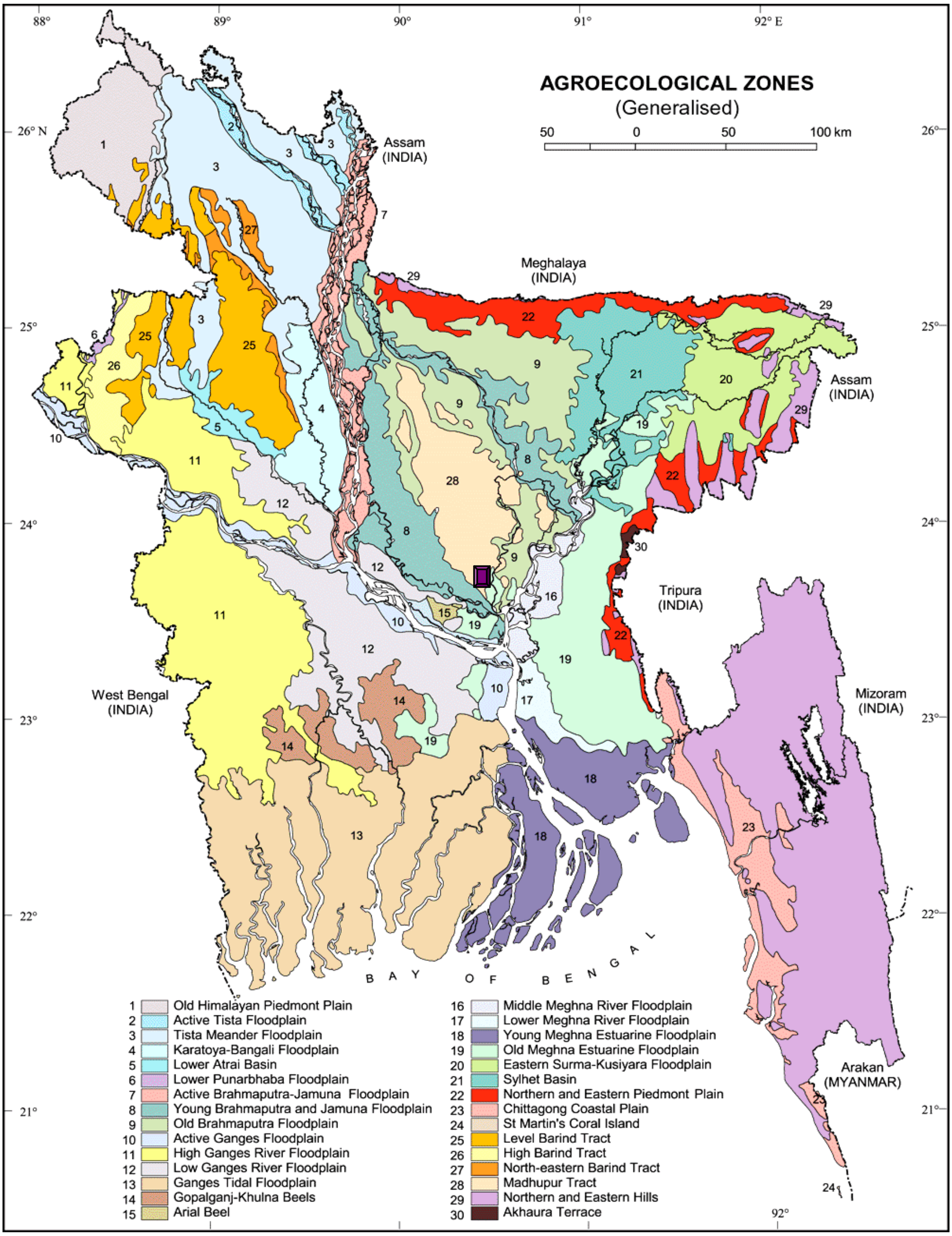
# APPENDICES

## Appendix I. Map showing the experimental site under study



**Appendix II. Physical and chemical properties of soil (0-15 cm depth) of the experimental field**

**A. Physical properties of soil**

| | |
|---|---|
| % sand (0.2-.02 mm) | 21.75 |
| % silt (0.02-.002 mm) | 66.60 |
| % clay (< 0.002 mm) | 11.65 |
| Textural class | Silty loam |
| Consistency | Granular |

**B. Chemical properties of soil**

| | |
|---|---|
| Soil pH | 6.4 |
| Organic carbon (%) | 1.30 |
| Organic matter (%) | 1.28 |
| Total nitrogen (%) | 0.11 |
| Available phosphorus (ppm) | 27 |
| Exchangeable potassium (me/100 g soil) | 0.12 |
| Available sulphur (ppm) | 9.00 |

Source: *Soil Resource Development Institute, Dhaka-1207*

**Appendix III. Monthly total rainfall, average air temperature, relative humidity during the experimental period between November 2009 to April 2010 at the SAU area, Dhaka-1207**

| **Month** | **Monthly average air temperature ($^0C$)** | | | **Monthly total rainfall (mm)** | **Average relative humidity (%)** |
|---|---|---|---|---|---|
| | **Maximum** | **Minimum** | **Average** | | |
| November | 27.00 | 14.81 | 20.91 | 00 | 72.00 |
| December | 28.50 | 16.40 | 22.45 | 92.2 | 76.75 |
| January | 30.56 | 22.14 | 26.35 | 96.6 | 78.57 |
| February | 32.80 | 23.34 | 28.07 | 266 | 82.50 |
| March | 34.60 | 16.50 | 25.55 | 45.00 | 67.00 |
| April | 35.80 | 20.30 | 28.05 | 88.00 | 65.00 |

Source: *Bangladesh Metrological Department (Climate Division) Agargaon, Dhaka-1207.*