# EFFECT OF SEEDLINGS PER HILL ON YIELD AND YIELD COMPONENTS OF HYBRID AND INBRED RICE VARIETIES

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## CERTIFICATE

This is to certify that the thesis entitled **‘Effect of Seedlings per Hill on Yield and Yield Components of Hybrid and Inbred Rice Varieties’** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of **Master of Science** in **Agronomy**, embodies the result of a piece of *bonafide* research work carried out by **Mosa. Fimatuz Johora**, Registration No.: **14-06341** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated:
Dhaka, Bangladesh


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*Dedicated To*

*My Respectable Parents*

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***The Author***

**EFFECT OF SEEDLINGS PER HILL ON YIELD AND YIELD COMPONENTS OF HYBRID AND INBRED RICE VARIETIES**

## ABSTRACT

The experiment was conducted at the farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period of July to November 2014 to find out the effect of seedlings $hill^{-1}$ on yield and yield components of hybrid and inbred rice varieties. The experiment comprised of two factors. Factor A: Rice variety (2) designated as $V_1$: Hybrid (Chamak); $V_2$: Inbred (BRRI dhan62) and Factor B: Number of seedlings $hill^{-1}$ (5 levels) named as $S_1$: 1 seedling $hill^{-1}$, $S_2$: 2 seedlings $hill^{-1}$, $S_3$: 3 seedlings $hill^{-1}$, $S_4$: 4 seedlings $hill^{-1}$ and $S_5$: 5 seedlings $hill^{-1}$. The experiment was laid out in split-plot design with three replications. Experimental results showed that varieties had the significant effects on plant height, number of tillers $hill^{-1}$, dry weight $hill^{-1}$, total tillers $hill^{-1}$, panicle length, number of filled and unfilled grains per panicle, 1000 seed weight, grain yield, straw yield and harvest index. The highest grain yield (4.06 t $ha^{-1}$) was observed from Chamak (hybrid) while the BRRI dhan62 (Inbred) gave the lowest grain yield (3.04 t $ha^{-1}$). The highest straw yield was observed from $V_1$ (4.67 t $ha^{-1}$) and the lower straw yield was recorded from $V_2$ (4.21 t $ha^{-1}$). Number of seedlings $hill^{-1}$ also significantly affected all the parameters under study. The maximum number of effective tillers $hill^{-1}$ was found from $S_2$ (12.20), whereas the minimum number of effective tillers $hill^{-1}$ from $S_5$ (10.27). The highest grain yield was found from $S_2$ (4.10 t $ha^{-1}$), whereas the lowest grain yield from $S_5$ (2.93 t $ha^{-1}$). The highest straw yield was found from $S_2$ (4.80 t $ha^{-1}$), whereas the lowest straw yield from $S_5$ (4.14 t $ha^{-1}$) which was statistically similar to $S_4$ (4.21 t $ha^{-1}$). In case of interaction effect of varieties and number of seedlings $hill^{-1}$, the highest grain yield was recorded from the combination of $V_1S_2$ (4.74 t $ha^{-1}$) and the lowest grain yield was found from $V_2S_5$ (2.55 t $ha^{-1}$) which was statistically similar with $V_2S_3$ (3.79 t $ha^{-1}$). From the above results it was appeared that Hybrid (Chamak) variety provided best yield with 2 seedlings per $hill^{-1}$.

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## LIST OF ABBREVIATED TERMS

| ABBREVIATION | FULL NAME |
|---|---|
| AEZ | Agro-Ecological Zone |
| BBS | Bangladesh Bureau of Statistics |
| BRRI | Bangladesh Rice Research Institute |
| BR | Bangladesh Rice |
| cm | Centimeter |
| CV % | Percent Coefficient of variation |
| cv. | Cultivar (s) |
| DAT | Days After Transplanting |
| *et al.* | and others |
| etc. | Etcetera |
| e.g. | *exampli gratia* (L), for example |
| FAO | Food and Agriculture Organization |
| g | Gram (s) |
| i.e. | *id est* (L), that is |
| IRRI | International Rice Research Institute |
| Kg | Kilogram (s) |
| LSD | Least Significance Difference |
| $m^2$ | Square meter |
| mm | Millimeter |
| MoP | Muriate of Potash |
| No. | Number |
| ppm | Parts per million |
| SAU | Sher-e-Bangla Agricultural University |
| SRDI | Soil Resources Development Institute |
| $t\ ha^{-1}$ | Ton per hectare |
| TSP | Triple Super Phosphate |
| var. | Variety |
| $^0C$ | Degree Celsius |
| % | Percentage |

# CHAPTER I

# INTRODUCTION

Rice (*Oryza sativa* L.) is the most important food in tropical and subtropical regions (Singh *et al*., 2012) and the staple food of more than three billion people in the world (IRRI, 2009). It is the staple food of not only Bangladesh but also for South Asia (Hien *et al.*, 2006). Rice production and consumption is concentrated in Asia, where more than 90% of all rice is consumed (FAO, 2006). The slogan 'Rice is life' is most appropriate for Bangladesh as this crop plays a vital role in our food security and is a means of livelihood for millions of rural peoples. About 84.67% of cropped area of Bangladesh is used for rice production, with annual production of 30.42 million tons from 10.4 million hectare of land (BBS, 2014).

The population of Bangladesh is increasing at an alarming rate and the cultivable land is reducing due to urbanization and industrialization resulting in shortage of food. The nation is still adding about 2.3 million mouth every year to its total of 150 million people (Momin and Husain, 2009). Thus, the present population will swell progressively to 223 million by the year 2030 which will require additional 48 million tons of food grains (Julfiquar *et al*., 2008). Population growth demands a continuous increase in rice production in Bangladesh. So, the highest priority has been given to produce more rice (Bhuiyan, 2004). Production of rice has to be increased by at least 60% to meet up food requirement of the increasing population by the year 2020 (Masum, 2009). Rice yields are either decelerating/ stagnating/ declining in post green revolution era mainly due to imbalance in fertilizer use, soil degradation, irrigation and weeding schedule, type of cropping system practiced, lack of suitable rice genotypes/ variety for low moisture adaptability and disease resistance (Prakash, 2010). In Bangladesh, the average yield of rice is about 2.92 t $ha^{-1}$ (BBS, 2014) which is very low compared to other rice growing countries of the World, like China (6.30 t $ha^{-1}$), Japan (6.60 t $ha^{-1}$) and Korea (6.30 t $ha^{-1}$) (FAO, 2009).

The possibility of horizontal expansion of rice production area has come to a standstill. As there is very little scope for horizontal expansion of rice production in Bangladesh, farmers and agricultural scientists are diverting their attention towards vertical expansion for increased crop production. Therefore, attempts should be taken to increase the yield per unit area. For vertical expansion, the use of modern production technologies should be included, such as, use of quality seeds, high yielding and hybrid varieties, optimum age of seedling, optimum number of seedling hill$^{-1}$, adopting proper plant protection measures, seedling raising techniques, fertilizer management and so on. Growth and yield of rice are strongly influenced by genotype as well as environmental factors (BRRI, 2003). Variety is the key component to produce higher yield of rice depending upon their differences in genotypic characters, input requirements and response, growth process and off course the prevailing environmental conditions during the growing season. The growth process of rice plants under a given agro-climatic condition differs with variety (Alam *et al*., 2012).

The genetic potentiality of a rice variety is almost fixed, but grain yield can be increased by the manipulation of management practices (BRRI, 1999). Now day's different hybrid rice varieties are available in Bangladesh which has more yield potential than conventional high yielding varieties (Akbar, 2004). Generally the yield of hybrid rice is 10-15% higher than the improved inbred varieties. Improvement of rice grain yield is the main target of breeding program to develop rice varieties for diverse ecosystems, controlled by many genes and highly affected by environment. In addition, grain yield also related with other characteristics such as plant type, growth duration and yield components (Yoshida, 1981). Very recently various new rice varieties were developed and available as BRRI dhan and maximum of them is exceptionally high yielding. On the other hand, compared with conventional cultivars, the hybrids had larger panicles, heavier seeds, resulting in an average grain yield increase of 7.27% (Bhuiyan *et al*., 2014). This variety however, needs further evaluation under different adaptive condition to interact with different environmental conditions.

Number of seedlings $hill^{-1}$ is an important factor for successful rice production because it affects plant population per unit area, availability of sunlight and nutrients, photosynthesis and respiration, which ultimately influence the yield contributing characters and yield (Chowdhury *et al.,* 1993). Among various factors number of seedlings $hill^{-1}$ is now considered as the major reason for low yield of rice in Bangladesh (Islam *et al*., 2012). Optimum number of seedlings $hill^{-1}$ may facilitate the rice plant to grow properly both in its aerial and underground parts by utilizing maximum radiant energy, nutrient, space and water and also can reduce seedling cost. Excess number of seedlings $hill^{-1}$ may produce higher number of tillers $hill^{-1}$ resulting in shading, lodging and thus favor the production of straw instead of grain. On the other hand, the lesser number of seedlings $hill^{-1}$ may cause insufficient tiller number, thus keeping space and nutrients underutilized and at the end, total number of panicles $unit^{-1}$ area may be reduced resulting in poor gain yield. It is, therefore, necessary to determine the optimum number of seedlings $hill^{-1}$ for obtaining higher yield from a HYV of rice. Alam (2006) reported that the highest number of total tillers and number of effective tillers were obtained from 2 seedlings $hill^{-1}$. Obulamma and Reddeppa (2002) revealed that one seedling $hill^{-1}$ gave the highest grain yield, crop growth rate and net assimilation rate while 3 seedlings $hill^{-1}$ had the highest dry matter prosecution, leaf area index and leaf area density.

Based on above proposition, this research work was designed to evaluate the yield and yield components performance of some selected hybrid and inbred rice varieties in different number of seedlings $hill^{-1}$ with the following objectives:

- To find out the effect of number of seedlings $hill^{-1}$ on yield and yield components of rice.
- To find out the effect of varieties on yield and yield components of rice.
- To find out the interaction effect of varieties with number of seedlings $hill^{-1}$ on yield and yield components of rice.

# CHAPTER II

# REVIEW OF LITERATURE

Rice is the main food crop of the people of Bangladesh and the World. Yield and yield contributing characteristics of rice are considerably depended on manipulation of basic ingredients of agriculture. The basic ingredients include varieties of rice, environment and agronomic practices (planting time, number of seedlings hill$^{-1}$, plant density, fertilizer, irrigation etc.). Research on this crop is going on various aspects in increase its potential yield including number of seedlings hill$^{-1}$ and varieties which are responsible for the growth and yield of rice. High yielding varieties (HYV) are generally more adaptive to appropriate number of seedlings hill$^{-1}$. An attempt was taken to review the available literature that are related to the effect of number of seedlings hill$^{-1}$ and variety on the yield and yield attributes of rice as below under the following headings-

## 2.1 Effect of seedlings number per hill on rice

Number of seedlings hill$^{-1}$ is an important factor for the improvement of yield of rice. It affects plant population per unit area. Optimum number of seedlings hill$^{-1}$ depends upon different factors such as variety, planting time, fertilizer and manure application, irrigation, spacing and other management practices. Literature in respect of number of seedlings hill$^{-1}$ for hybrid varieties is scarcely available. Moreover, available literatures which are related to the number of seedlings hill$^{-1}$ are cited and stated below-

### 2.1.1 Plant height

Asbur (2013) carried out an experiment to determine the effects of seedling number per hill and seedling age on plant growth, and grain yield Ciherang rice and reported that reducing seedling number per hill from 5 to 3 and 1, respectively, increased plant growth significantly.

An experiment was carried out by Alam *et al*. (2012) at Agronomy Field Laboratory, Department of Agronomy and Agricultural Extension, University of

Rajshahi during the kharif season to study the effect of variety, spacing and number of seedlings $hill^{-1}$ on the yield potentials of transplant aman rice. The experiment consisted of three high yielding varieties viz. BRRI dhan32, BRRI dhan33 and BR11, four levels of spacing and four levels of number of seedlings $hill^{-1}$ viz. 2 seedlings $hill^{-1}$, 3 seedlings $hill^{-1}$, 4 seedlings $hill^{-1}$ and 5 seedlings $hill^{-1}$. Effect of the number of seedlings $hill^{-1}$ was also significant on almost all the yield enhancing characters. The highest plant height were found when 2 seedlings were transplanted $hill^{-1}$.

The experiment was conducted by Sarkar *et al*. (2011) to observe the effect of row arrangement, age of tiller seedlings and number of tiller seedlings $hill^{-1}$ on the vegetative characters, yield and yield contributing characters of transplant aman rice. The experiment consisted of three levels of row arrangement, two types of tiller seedlings, and three levels of number of tiller seedling $hill^{-1}$ viz. 2, 4 and 6 seedlings $hill^{-1}$. Plant height were the highest when 2 tiller seedlings were transplanted $hill^{-1}$.

Ali (2008) conducted an experiment in Bangladesh to study the effect of spacing and number of seedlings per $hill^{-1}$ on the performance of BRRI dhan41. The experiment included two sets of treatment namely (A) Spacing and (B) Number of seedlings $hill^{-1}$ namely 1, 2, 3 and 4 seedlings $hill^{-1}$. Number of seedlings $hill^{-1}$ had significant influence on plant height.

### 2.1.2 Tillering pattern

A field experiment was carried out by Biswas *et al*. (2015) to investigate the optimization of row spacing and hill density on the yield of transplant aman rice cv. BRRI dhan52 at the Agronomy Field Laboratory of Patuakhali Science and Technology University, Dumki, Patuakhali. There were four row spacing were considered as main plot, while four different hill density viz., $S_1$= two, $S_2$= four, $S_3$= six and $S_4$= eight seedlings per hill were considered. The result of the experiment showed that hill density had significantly influence independently and also in combination on yield and yield components of transplant aman rice var. BRRI dhan52. Number of effective tillers per hill (13.67) were found the highest at four seedlings per hill treatment.

An experiment was conducted by Islam *et al*. (2012) at the Agronomy Farm of Bangladesh Agricultural University, Mymensingh to investigate the effect of hill density and number of seedlings hill$^{-1}$ on the yield performance of fine rice (cv. Kalizira). The experiment consisted of three hill densities, viz. 25 cm × 20 cm, 25 cm × 15 cm, 25 cm × 10 cm and two levels of number of seedlings hill$^{-1}$ viz. 2 and 4. The highest number and the lowest of non-effective tillers hill$^{-1}$ were found in case of 2-seedilings hill$^{-1}$ and 4-seeedlings hill$^{-1}$, respectively.

Bhowmik *et al*. (2012) conducted an experiment at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh to find out the effect of spacing and number of seedlings hill$^{-1}$ on the performance of *Aus* rice cv. NERICA 1. Four spacing and four number of seedlings hill$^{-1}$ viz. 2, 3, 4 and 5 were included in the experiment. The highest value of total tillers m$^{-2}$, number of effective tillers m$^{-2}$ were obtained from five seedlings hill$^{-1}$.

An experiment was conducted by Sarkar *et al*. (2011) to observe the effect of row arrangement, age of tiller seedlings and number of tiller seedlings hill$^{-1}$ on the vegetative characters, yield and yield contributing characters of transplant aman rice. The experiment consisted of three levels of row arrangement, two types of tiller seedlings, and three levels of number of tiller seedling hill$^{-1}$ viz. 2, 4 and 6 seedlings hill$^{-1}$. Number of total tillers hill$^{-1}$ and number of non-bearing tillers hill$^{-1}$ were the highest when 6 tiller seedlings were transplanted hill$^{-1}$.

A field experiment was conducted by Faruk *et al*. (2009) at the Agronomy Research Field, Hajee Mohammad Danesh Science and Technology University, Dinajpur to find out the effect of age of seedling and number of seedlings hill$^{-1}$ on the yield of short duration transplant *aman* rice named BRRI dhan33. The treatments consisted of four seedling ages viz. 2, 3, 4 and 5 weeks old and three levels of number of seedling hill$^{-1}$ viz. one, two and three. Different levels of number of seedlings hill$^{-1}$ significantly influenced the yield parameters. Two seedlings hill$^{-1}$ were the best performer in respect of yield and yield components. Effective tillers hill$^{-1}$ were higher than one or three seedlings hill$^{-1}$.

Ali (2008) conducted an experiment in Bangladesh to study the effect of spacing and number of seeding per hill$^{-1}$ on the performance of BRRI dhan41. The experiment included two sets of treatment namely (A) Spacing and (B) Number of seedlings hill$^{-1}$ namely 1, 2, 3 and 4 seedlings hill$^{-1}$. Number of seedlings hill$^{-1}$ had significant influence on tiller number.

Hossain *et al.* (1989) carried out an experiment with rice cv. Basmati and observed that the number of tillers increased up to 16.4 hill$^{-1}$ with increasing number of seedlings hill$^{-1}$.

Haque and Nasiruddin (1988) conducted an experiment where aus rice was established at initial densities of 50, 100, 150, 200, 225 or 350 seedlings m$^{-2}$, tillering increased linearly with density up to the rainfed stage with an average total of 5.8 tillers plant$^{-1}$ in low density plots, 3 tillers plant$^{-1}$ in medium density plots. Tillers number decreased at high rainfed condition by 13.6, 21.4 and 20.2% in low, medium and higher density plots respective panicle density at maturity varied only from 186 to 224 panicles m$^{-2}$.

Muhammad *et al.* (1987) reported that when rice Basmati 370 was grown with 2 seedlings hill$^{-1}$ and at 6, 11, 25 or 44 hills m$^{-2}$, the number of tillers hill$^{-1}$, the number of panicle bearing tillers hill$^{-1}$ decreased with increasing plant density.

Tsai (1987) conducted an experiment where rice cvs. Pegonil and Tainung 67 grown at high weed infestation with 1 or 4-6 plants hill$^{-1}$ with the wider spacing and several seedlings hill$^{-1}$ headed earlier and produced lower tiller and panicle numbers than Tainung 67 while closer planting tended to decreased panicle number hill$^{-1}$ and significantly increased panicle number unit area$^{-1}$.

Islam *et al*. (1980) conducted a field experiment to determine the suitable number of seedlings hill$^{-1}$ for transplant aus rice variety. The results revealed that 2-3 seedlings hill$^{-1}$ were as good as 3-4 seedling hill$^{-1}$ with respect to effective tillers hill$^{-1}$ production.

**2.1.3 Dry matter**

Bhowmik *et al*. (2012) conducted an experiment at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh to find out the effect of spacing and number of seedlings hill$^{-1}$ on the performance of *Aus* rice cv. NERICA 1. Four spacing and four number of seedlings hill$^{-1}$ viz. 2, 3, 4 and 5 were included in the experiment and the highest value of dry matter content plant$^{-1}$ was obtained from five seedlings hill$^{-1}$.

A field experiment was conducted by Faruk *et al*. (2009) at the Agronomy Research Field, Hajee Mohammad Danesh Science and Technology University, Dinajpur to find out the effect of age of seedling and number of seedlings hill$^{-1}$ on the yield of short duration transplant *aman* rice named BRRI dhan33. The treatments consisted of four seedling ages viz. 2, 3, 4 and 5 weeks old and three levels of number of seedling hill$^{-1}$ viz. one, two and three. Different levels of number of seedlings hill$^{-1}$ significantly influenced dry matter content.

Singh and Singh (1992) conducted an experiment with 2, 4 or 6 seedlings hill$^{-1}$ to study their effect on the yield and yield components of rice cv. Madhukar and found that for all factors 4 seedlings hill$^{-1}$ was better for dry matter content.

Muhammad *et al.* (1987) reported that when rice Basmati 370 was grown with 2 seedlings hill$^{-1}$ and at 6, 11, 25 or 44 hills m$^{-2}$ and reported that dry matter content decreased with increasing plant density.

Islam (1986) conducted a field experiment to determine the number of seedlings hill$^{-1}$ for transplant aus rice. The results revealed that 2-3 seedlings hill$^{-1}$ were as good as 3-4 seedlings hill$^{-1}$ with respect to dry matter content.

### 2.1.4 Yield attributes

A field experiment was carried out by Biswas *et al*. (2015) to investigate the optimization of row spacing and hill density on the yield of transplant aman rice cv. BRRI dhan52 at the Agronomy Field Laboratory of Patuakhali Science and Technology University, Dumki, Patuakhali. There four row spacing were considered as main plot, while four different hill density viz., $S_1$= two, $S_2$= four, $S_3$= six and $S_4$= eight seedlings per hill were considered as sub plot. The result of the experiment showed that hill density had significantly influence independently and also in combination on yield and yield components of transplant aman rice var. BRRI dhan52. Panicle length (25.16 cm), number of filled grains per panicle (142.63) and 1000 grain weight (27.75 g) were found the highest at four seedlings per hill treatment.

Bhowmik *et al*. (2012) conducted an experiment at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh to find out the effect of spacing and number of seedlings hill$^{-1}$ on the performance of *Aus* rice cv. NERICA 1. Four spacing and four number of seedlings hill$^{-1}$ viz. 2, 3, 4 and 5 were included in the experiment. The highest value of total grains panicle$^{-1}$ were obtained from five seedlings hill$^{-1}$.

An experiment was carried out by Alam *et al*. (2012) at Agronomy Field Laboratory, Department of Agronomy and Agricultural Extension, University of Rajshahi during the kharif season to study the effect of variety, spacing and number of seedlings hill$^{-1}$ on the yield potentials of transplant aman rice. The experiment consisted of three high yielding varieties viz. BRRI dhan32, BRRI dhan33 and BR11, four levels of spacing and four levels of number of seedlings hill$^{-1}$ viz. 2 seedlings hill$^{-1}$, 3 seedlings hill$^{-1}$, 4 seedlings hill$^{-1}$ and 5 seedlings hill$^{-1}$. Effect of the number of seedlings hill$^{-1}$ was also significant on almost all the yield enhancing characters. Results revealed that the highest panicle length, fertile spikelets panicle$^{-1}$ and 1000-grain weight were found when 2 seedlings were transplanted hill$^{-1}$.

The experiment was conducted by Sarkar *et al*. (2011) to observe the effect of row arrangement, age of tiller seedlings and number of tiller seedlings hill$^{-1}$ on the vegetative characters, yield and yield contributing characters of transplant aman rice. The experiment consisted of three levels of row arrangement, two types of tiller seedlings, and three levels of number of tiller seedling hill$^{-1}$ viz. 2, 4 and 6 seedlings hill$^{-1}$. Panicle length was highest when 2 tiller seedlings were transplanted hill$^{-1}$.

A field experiment was conducted by Faruk *et al*. (2009) at the Agronomy Research Field, Hajee Mohammad Danesh Science and Technology University, Dinajpur to find out the effect of age of seedling and number of seedlings hill$^{-1}$ on the yield of short duration transplant *aman* rice named BRRI dhan33. The treatments consisted of four seedling ages viz. 2, 3, 4 and 5 weeks old and three levels of number of seedling hill$^{-1}$ viz. one, two and three. Different levels of number of seedlings hill$^{-1}$ significantly influenced grains panicle$^{-1}$, grain and straw yields were higher than one or three seedlings hill$^{-1}$. The 1000-grain weight was unaffected by the number of seedlings hill$^{-1}$.

Ali (2008) conducted an experiment in Bangladesh to study the effect of spacing and number of seeding per hill$^{-1}$ on the performance of BRRI dhan41. The experiment included two sets of treatment namely (A) Spacing and (B) Number of seedlings hill$^{-1}$ namely 1, 2, 3 and 4 seedlings hill$^{-1}$. Number of seedlings hill$^{-1}$ had significant influence on no of filled and unfilled grains panicle$^{-1}$.

**2.1.5 Grain and straw yield**

A field experiment was carried out by Biswas *et al*. (2015) to investigate the optimization of row spacing and hill density on the yield of transplant aman rice cv. BRRI dhan52 at the Agronomy Field Laboratory of Patuakhali Science and Technology University, Dumki, Patuakhali. There four row spacing were considered as main plot, while four different hill density viz., $S_1$= two, $S_2$= four, $S_3$= six and $S_4$= eight seedlings per hill were considered as sub plot. The result of the experiment showed that hill density had significantly influence and also in combination on yield and yield components of transplant aman rice var. BRRI dhan52. Grain yield (5.64 t $ha^{-1}$) was found the highest at four seedlings per hill treatment.

Asbur (2013) carried out an experiment to determine the effects of seedling number per hill and seedling age on plant growth, and grain yield Ciherang rice and reported that reducing seedling number per hill from 5 to 3 and 1, respectively, increased grain yield significantly.

Laboratory, Bangladesh Agricultural University, Mymensingh to find out the effect of spacing and number of seedlings $hill^{-1}$ on the performance of *Aus* rice cv. NERICA 1. Four spacing and four number of seedlings $hill^{-1}$ viz. 2, 3, 4 and 5 were included in the experiment. The highest value of grain yield, straw yield, biological yield and harvest index were obtained from five seedlings $hill^{-1}$.

An experiment was carried out by Alam *et al.* (2012) at Agronomy Field Laboratory, Department of Agronomy and Agricultural Extension, University of Rajshahi during the kharif season to study the effect of variety, spacing and number of seedlings $hill^{-1}$ on the yield potentials of transplant aman rice. The experiment consisted of three high yielding varieties viz. BRRI dhan32, BRRI dhan33 and BR11, four levels of spacing and four levels of number of seedlings $hill^{-1}$ viz. 2 seedlings $hill^{-1}$, 3 seedlings $hill^{-1}$, 4 seedlings $hill^{-1}$ and 5 seedlings $hill^{-1}$. Effect of the number of seedlings $hill^{-1}$ was also significant on almost all the yield enhancing characters and consequently it produced the highest grain yield (5.78 t $ha^{-1}$).

An experiment was conducted by Islam *et al*. (2012) at the Agronomy Farm of Bangladesh Agricultural University, Mymensingh to investigate the effect of hill density and number of seedlings $hill^{-1}$ on the yield performance of fine rice (cv. Kalizira). The experiment consisted of three hill densities, viz. 25 cm × 20 cm, 25 cm × 15 cm, 25 cm × 10 cm and two levels of number of seedlings $hill^{-1}$ viz. 2

and 4. Results indicated that relatively higher hill density and higher number of seedlings hill$^{-1}$ produced higher yield.

An experiment was conducted by Sarkar *et al*. (2011) to observe the effect of row arrangement, age of tiller seedlings and number of tiller seedlings hill$^{-1}$ on the vegetative characters, yield and yield contributing characters of transplant aman rice. The experiment consisted of three levels of row arrangement, two types of tiller seedlings, and three levels of number of tiller seedling hill$^{-1}$ viz. 2, 4 and 6 seedlings hill$^{-1}$. Grain yield and harvest index were the highest when 2 tiller seedlings were transplanted hill$^{-1}$.

A field experiment was conducted by Faruk *et al*. (2009) at the Agronomy Research Field, Hajee Mohammad Danesh Science and Technology University, Dinajpur to find out the effect of age of seedling and number of seedlings hill$^{-1}$ on the yield of short duration transplant *aman* rice named BRRI Dhan33. The treatments consisted of four seedlings ages and three levels of number of seedling hill$^{-1}$ viz. one, two and three. Different levels of number of seedlings hill$^{-1}$ significantly influenced grain and straw yields. Two seedlings hill$^{-1}$ gave the higher yield than one or three seedlings hill$^{-1}$. Finally, this variety may preferably be cultivated with two seedlings hill$^{-1}$ to obtain appreciably good yield in *aman* season.

Ali (2008) conducted an experiment in Bangladesh to study the effect of spacing and number of seedling per hill$^{-1}$ on the performance of BRRI dhan41. The experiment included two sets of treatment namely (A) Spacing and (B) Number of seedlings hill$^{-1}$ namely 1, 2, 3 and 4 seedlings hill$^{-1}$. Number of seedlings hill$^{-1}$ had significant influence on grain yield, straw yield, biological yield and harvest index.

Ingale *et al.* (2005) carried out a study was number of seedlings per hill (one or two) and nitrogen rates (50, 100 and 150 kg/ha) on the yields of Sahyadri rice hybrid. Transplanting two seedlings hill$^{-1}$ at 20×15 cm spacing produced significantly a higher yield than transplanting of one seedling hill$^{-1}$.

Srivastava and Tripathi (2000) carried out an experiment with rice cv. hybrid 6201 and R 320-300 grown at different weed density at 1, 2 or 3 seedlings hill$^{-1}$ and observed that cv. R 320-300 grown at the low weed density at 2 seedlings hill$^{-1}$ produced the highest grain yield of 7.59 t ha$^{-1}$.

Asif *et al.* (1998) conducted an experiment with rice cv. Basmati 385 grown at l, 2 or 3 seedlings hill$^{-1}$ and observed that grain yield was highest at 2 seedlings hill$^{-1}$ but different grain quality parameters were not significantly affected by plant density.

Banik *et al.* (1997) conducted a field experiment in Bihar with 30, 40, 50, or 60 day old rice cv. Pankaj and Patnation seedlings were direct seeded at 2, 4, 6 or 8 seedlings hill$^{-1}$. There was no significant variation in yield between the cultivars. Mean grain yield was the highest (4.74 t ha$^{-1}$) from pots of direct seeded with 40 day old seedlings, yield was the highest with 4 seedlings hill$^{-1}$ (4.22 t ha$^{-1}$).

Chowdhury *et al.* (1993) conducted an experiment with 2, 4 and 6 seedlings hill$^{-1}$ to study their effect on the yield and yield components of rice cv. BR23 during the aus season. It reported that 6 seedlings hill$^{-1}$ gave the highest grain yields.

Rao and Reddy (1993) conducted a field experiment with rice cv. Rasi in the *Kharif* (monsoon) season at 33, 44, 50, 67 or 200 hills m$^{-2}$ with 1, 2, 4, 6, 8 or 10 seedlings hill$^{-1}$. They reported that grain yield increased with decreasing weeding density from 30-200 hills m$^{-2}$ with 1 seeding hill$^{-1}$, when 10 seedlings hill$^{-1}$ were planted yield decreased even at the very low weed population.

Prasad *et al.* (1992) conducted an experiment with 2, 3, 4 and 5 seedlings hill$^{-1}$ to study their effect on the yield and yield components of rice cv. Sarjoo-52 and found that 4 seedlings hill$^{-1}$ was better for grain yield.

Singh and Singh (1992) conducted an experiment with 2, 4 or 6 seedlings $hill^{-1}$ to study their effect on the yield and yield components of rice cv. Madhukar and found that for all factors 4 seedlings $hill^{-1}$ was better for grain yield.

BRRI (1991) conducted an experiment in Barishal sub-station to study the effect of seedling number (2, 3, 4 and 5 seedlings $hill^{-1}$) on the yield and yield components of BR3, BR9 and BR14. The results showed that there was no significant effect of seedling number on the yield of BR3 and BR14. Planting of 4-5 seedlings $hill^{-1}$ gave significantly higher yield for BR9 than 2-3 seedlings $hill^{-1}$ although such differences were not apparent in yield components.

Hossain and Haque (1990) reported that the number of basal tillers per plot increased with increasing seedling number. Rainfed tolerance decreased with increased seedlings $hill^{-l}$. Grain yields were the highest with 2 seedlings $hill^{-1}$.

Mohapatra (1989) found that the number of seedlings $hill^{-1}$ had significant effect on yield. He stated that the highest grain and straw yields were produced by 4 seedlings $hill^{-1}$ while 1 seedling $hill^{-1}$ yielded the lowest. On the other hand, Pande *et al.* (1987) obtained higher yield by planting 2 seedlings $hill^{-1}$ over 1, 3 and 4 seedlings $hill^{-1}$.

Islam (1986) conducted a field experiment to determine the number of seedlings $hill^{-1}$ for transplant aus rice. The results revealed that 2-3 seedlings $hill^{-1}$ were as good as 3-4 seedlings $hill^{-1}$ with respect to grain yield.

Reddy and Mittra (1984) investigated the effect of time of planting, age and number of seedlings $hill^{-1}$ on the yield of aus rice varieties. They found that grain yields were the highest at earlier sowing dates and were unaffected by number of seedlings $hill^{-1}$.

Relwani (1982) studied the effect of seedling number $hill^{-1}$ on grain yield and reported that 6 seedlings $hill^{-1}$ produced significantly higher yield than 4 seedlings $hill^{-1}$ which was significantly superior to 2 seedlings $hill^{-1}$.

## 2.2 Performances of different rice varieties

Rice is the staple food and around ninety per cent of rice is grown and consumed in South and Southeast Asia, the highly populated area. Bangladesh produces hybrid rice varieties and most of them have excellent production and eating quality for regular consumption. Different researcher reported the effect of rice varieties on yield contributing component and grain yield. However, some of the important and informative works and research findings related to the yield and quality of hybrid, so far been done at home and abroad, reviewed below-

### 2.2.1 Plant height

Bhuiyan *et al*. (2014) conducted an experiment with aimed to determine the adaptability and performance of different hybrid rice varieties and to identify the best hybrid rice variety in terms of plant growth and recommend it to rice farmers. Based on the findings of the study, the different hybrid rice varieties evaluated had significant effects on plant height at maturity.

An experiment was carried out by Alam *et al*. (2012) at Agronomy Field Laboratory, Department of Agronomy and Agricultural Extension, University of Rajshahi during the kharif season to study the effect of variety, spacing and number of seedlings hill$^{-1}$ on the yield potentials of transplant aman rice. The experiment consisted of three high yielding varieties viz. BRRI dhan32, BRRI dhan33 and BR11, four levels of spacing and four levels of number of seedlings hill$^{-1}$. They reported that variety had significant effects on plant height.

Two field experiments were conducted by Salem *et al*. (2011) at the Rice Research and Training Center (RRTC), Sakha, Kafr-El Sheikh Governorate, Egypt during summer seasons to study the effect of nitrogen fertilizer and seedling age on Giza 178, H1 and Sakha 101. The results indicated that Sakha 101 variety surpassed than other varieties in terms of plant height.

A field experiment was conducted by Khalifa (2009) at the experimental farm of Rice research and training centre (RRTC), Sakha, Kafr-El Sheikh Governorate, Egypt rice season for physiological evaluation of some hybrid rice varieties under different sowing dates. Four hybrid rice $H_1$, $H_2$, GZ 6522 and GZ 6903 were evaluated at six different sowing dates. Results indicated that $H_1$ hybrid rice variety surpassed other varieties in terms of plant height.

Masum *et al*. (2008) found that plant height of rice affected by varieties in *Aman* season where Nizershail produced the taller plant height than BRRI dhan44 at different days after transplanting (DAT).

Murthy *et al.* (2004) conducted an experiment with six varieties of rice genotypes Mangala, Madhu, J-13, Sattari, CR 666-16 and Mukti, and observed that Mukti gave the longest plant compared to the others.

Chen-Liang *et al*. (2000) showed that the cross between Peiai 64s and the new plant type lines had the longest plant height. Xu and Li (1998) observed that the maintainer lines were generally shorter than restorer line. Munoz *et al.* (1996) noted that IR8025A hybrid rice cultivar produced 16% longer plant than the commercial variety Oryzica Yacu-9.

BINA (1993) evaluated the performance of four rice varieties (IRAATOM 24, BR14, Bina dhan13 and Bina dhan19). It was found that varieties differed significantly in respect of plant height.

BRRI (1991) observed the plant height differed significantly among BR3, BR11, BR14, Pajam and Zagali varieties in the *Boro* season.

Hosain and Alam (1991) carried out an experiment and found that the plant height in modern rice varieties BR3, BR11, BR14 and Pajam were 90.4, 94.5, 81.3 and 100.7 cm, respectively.

Miah *et al*. (1990) conducted an experiment with rice cv. Nizersail and mutant lines Mutant NSI and Mutant NSS and found that plant height were greater in Mutant NSI than Nizersail.

Shamsuddin *et al*. (1988) conducted a field trial with nine different rice varieties and observed that plant height and other yield contributing characters and yield differed significantly among the varieties tested.

Sawant *et al*. (1986) conducted an experiment with the new rice lines R-73-1-1, R-711 and the traditional cv. Ratna and reported that the traditional cv. Ratna was the shortest.

**2.2.2 Tillering pattern**

Bhuiyan *et al*. (2014) conducted an experiment with aimed to determine the adaptability and performance of different hybrid rice varieties and to identify the best hybrid rice variety in terms of yield and recommend it to rice farmers. Based on the findings of the study, the different hybrid rice varieties evaluated had significant effects on number of tillers, number of productive tillers. RGBU010A × SL8R is therefore recommended as planting material among hybrid rice varieties because it produced more productive tillers.

A field experiment was conducted by Khalifa (2009) at the experimental farm of Rice research and training centre (RRTC), Sakha, Kafr-El Sheikh Governorate, Egypt for physiological evaluation of some hybrid rice varieties under different sowing dates. Four hybrid rice $H_1$, $H_2$, GZ 6522 and GZ 6903 were evaluated at six different sowing dates. Results indicated that $H_1$ hybrid rice variety surpassed other varieties in consideration of effective and total tillers hill$^{-1}$.

Masum *et al*. (2008) stated that number of total tillers hill$^{-1}$ was significantly influenced by cultivars at all stages of crop growth. Nizersail was achieved maximum (25.63) tiller at 45 DAT, then with advancement to age it declined up to maturity, whereas in the case of BRRI dhan44, maximum (18.92) tiller production was observed around panicle initiation stage at 60 DAT.

Murthy *et al.* (2004) conducted an experiment with six varieties of rice genotypes Mangala, Madhu, J-13, Sattari, CR 666-16 and Mukti, and observed that Mukti gave the highest tillers hill$^{-1}$ compared to the others.

Bhowmick and Nayak (2000) conducted an experiment with two hybrids (CNHR2 and CNHR3) and two high yielding varieties (IR36 and IR64) of rice and five levels of nitrogenous fertilizers. They observed that CNHR2 produced more number of productive tillers (413.4 $m^{-2}$) than other tested varieties.

Devaraju *et al*. (1998) in a study with two rice hybrids, Karnataka Rice Hybrid 1 (KRHI) and Karnataka Rice Hybrid-2 (KRH2), using HYV IR20 as the check, found that IR20, the tiller number was higher than that of KRH2.

Islam (1995) in an experiment with four rice cultivars *viz*. BR10, BR11, BR22 and BR23 found that the highest number of non bearing tillers $hill^{-1}$ was produced by cultivar BR11 and the lowest number by BR10.

Chowdhury *et al*. (1993) reported that the cultivar BR23 showed superior performance over Pajam in respect of yield and yield contributing characters i. e. number of productive tillers $hill^{-1}$.

BINA (1993) conducted an experiment with four varieties or advance lines (IRATOM24, BR14, BINA dhan13 and BINA dhan19) and reported significant variation in number of non-bearing tillers $hill^{-1}$.

Hosain and Alam (1991) also found that the growth characters like total tillers $hill^{-1}$ differed significantly among BR3, BR11, Pajam and Jaguli varieties in the *Boro* srason.

Idris and Matin (1990) stated that number of total tillers $hill^{-1}$ was identical among the six varieties studied.

### 2.2.3 Dry matter

In order to evaluate the response to planting date in rice hybrids Line, dry method of working was carried out by Shaloie *et al*. (2014) at the Agricultural Research Station, Agriculture and Natural Resources Research Center of Khuzestan Shavuor. Hybrid rice Hb2 and Hb1 was used in the sub plots. Results showed traits were significantly affected in terms of dry matter and mentioned trait was more in hybrid $Hb_2$ than $Hb_1$.

Masum *et al*. (2008) found that total dry matter production differed due to varieties. Total dry matter of BRRI dhan 44 Nizershail significantly varied at different sampling dates.

Xie *et al.* (2007) found that Shanyou-63 variety gave the higher yield (12 t $ha^{-1}$) compared to Xieyou46 variety (10 t $ha^{-1}$). Amin *et al.* (2006) conducted a field experiment to find out the influence of variable doses of N fertilizer on growth, tillering and yield of three traditional rice varieties (*viz.* Jharapajam, Lalmota, Bansful Chikon) which were compared with that of a modern variety (*viz.* KK-4) and reported that traditional varieties accumulated higher amount of vegetative dry matter than the modern variety.

Son *et al*. (1998) reported that dry matter production of four inbred lines of rice (low-tillering large panicle type), YR15965ACP33, YR17104ACP5, YR16510-B-B-B-9 and YR16512-B-B-B-10 and cv. Namcheonbyeo and Daesanbyeo, were evaluated at plant densities of 10 to 300 plants $m^{-2}$ and reported that dry matter production of low-tillering large panicle type rice was lower than that of Namcheonbyeo, regardless of plant density

### 2.2.4 Yield attributes

An experiment was conducted by Hosain *et al*. (2014) at the research farm of Sher-e-Bangla Agricultural University (SAU), Dhaka during *Aus* season (March to July 2010) to observe the effect of transplanting dates on the yield and yield attributes of exotic hybrid rice varieties. The experiment comprised of three rice varieties (two hybrids-Heera2, Aloron and one inbred- BRRI dhan48). Hybrid varieties Heera2 (3.03 t $ha^{-1}$) and Aloron (2.77 t $ha^{-1}$) gave the higher spikelet sterility.

Bhuiyan *et al*. (2014) conducted an experiment to determine the adaptability and performance of different hybrid rice varieties and to identify the best hybrid rice variety in terms of yield and recommend it to rice farmers. Based on the findings of the study, the different hybrid rice varieties evaluated had significant effects on number of filled and unfilled grains, length of panicle and yield. RGBU010A × SL8R is therefore recommended as planting material among hybrid rice varieties because it produced longer panicles and heavy seeds. In the absence of this variety, RGBU02A × SL8R, RGBU003A × SL8R and RGBU0132A × SL8R may also be used as planting material.

In order to evaluate the response to planting date in rice hybrids Line dry method of working, was carried out by Shaloie *et al*. (2014) at the Agricultural Research Station, Agriculture and Natural Resources Research Center of Khuzestan Shavuor. Hybrid rice Hb2 and Hb1 was used in the sub plots. Results showed traits were significantly affected in terms of panicle length, fertility percentage, and mentioned traits was more in hybrid $Hb_2$ than $Hb_1$.

An experiment was carried out by Alam *et al.* (2012) at Agronomy Field Laboratory, Department of Agronomy and Agricultural Extension, University of Rajshahi during the kharif season to study the effect of variety, spacing and number of seedlings $hill^{-1}$ on the yield potentials of transplant aman rice. The experiment consisted of three high yielding varieties viz. BRRI dhan32, BRRI dhan33 and BR11, four levels of spacing and four levels of number of seedlings $hill^{-1}$ viz. 2 seedlings $hill^{-1}$, 3 seedlings $hill^{-1}$, 4 seedlings $hill^{-1}$ and 5 seedlings $hill^{-1}$. Variety had significant effects on almost all the yield component characters. All the yield components characters except number of fertile spikelets $panicle^{-1}$ were highest in case of variety BR11.

Forty five aromatic rice genotypes were evaluated by Fatema *et al*. (2011) to assess the genetic variability and diversity on the basis of nine characters. Significant variations were observed among the genotypes for all the characters. Thousand grain weight have been found to contribute maximum towards genetic diversity in 45 genotypes of aromatic rice.

Two field experiments were conducted by Salem *et al*. (2011) at the Rice Research and Training Center (RRTC), Sakha, Kafr-El Sheikh Governorate, Egypt during summer seasons to study the effect of nitrogen fertilizer and seedling age on Giza 178, H1 and Sakha 101. The results indicated that Sakha 101 variety surpassed than other varieties in terms of 1000 seeds weight.

A field experiment was conducted by Khalifa (2009) at the experimental farm of Rice research and training centre (RRTC), Sakha, kafr- El sheikh governorate, Egypt in 2008 rice season for physiological evaluation of some hybrid rice varieties under different sowing dates. Four hybrid rice $H_1$, $H_2$, GZ 6522 and GZ 6903 were evaluated at six different sowing dates. Results indicated that $H_1$ hybrid rice variety surpassed other varieties for studied characters except for number of days to panicle initiation and heading date.

Wang *et al*. (2006) studied the effects of plant density and row spacing (equal row spacing and one seedling hill$^{-1}$, equal row spacing and 3 seedlings hill$^{-1}$, wide-narrow row spacing and one seedling hill$^{-1}$, and wide-narrow row spacing and 3 seedlings hill$^{-1}$) on the yield and yield components of hybrids and conventional cultivars of rice. Compared with conventional cultivars, the hybrids had larger panicles, heavier seeds, resulting in an average yield increase of 7.27%.

Myung (2005) worked with four different panicle types of rice varieties and observed that the primary rachis branches (PRBs) panicle$^{-1}$ and grains were more on Sindongjinbyeo and Iksan467 varieties, but secondary rachis branches (SRBs) were fewer than in Dongjin1 and Saegyehwa varieties.

Obulamma *et al.* (2004) recorded hybrid APHR 2 produced significantly higher grain yield than hybrid DRRH 1. The increased grain yield was due to increase in number of panicles $m^{-2}$ and number of filled grain $panicle^{-1}$ in hybrid APHR 2 than hybrid DRRH 1.

Guilani *et al*. (2003) studied on crop yield and yield components of rice cultivars (Anboori, Champa and LD183) in Khusestan, Iran. They observed that grain number $panicle^{-1}$ was not significantly different among cultivars. The highest grain number $panicle^{-1}$ was obtained with Anboori. Grain fertility percentages were different among cultivars. Among cultivars, LD183 had the highest grain weight.

Ahmed *et al*. (1997) conducted an experiment to compare the grain yield and yield components of seven modern rice varieties (BR4, BR5, BR10, BR11, BR22, BR23, and BR25) and a local improved variety, Nizersail. The fertilizer dose was 60-60-40 kg $ha^{-1}$ of N, $P_2O_5$ and $K_2O$, respectively for all the varieties and found that percent filled grain was the highest in Nizersail followed by BR25 and the lowest in BR11 and BR23.

BRRI (1994) studied the performance of BR14, BR5, Pajam, and Tulsimala and reported that Tulsimala produced the highest number of filled grains $panicle^{-1}$ and BR14 produced the lowest.

BINA (1993) evaluated the performance of four varieties IRATOM 24, BR14, Bina dhan13 and Bina dhan19. They found that varieties differed significantly on panicle length and sterile spikelets $panicle^{-1}$. It was also reported that varieties Bina dhan13 and Bina dhan19 each had better morphological characters like more grains $panicle^{-1}$ compared to their better parents which contributed to yield improvement in these hybrid lines of rice.

BRRI (1991) also reported that the filled grains $panicle^{-1}$ of different modern varieties were 95-100 in BR3, 125 in BR4 , 120-130 in BR22 and 110-120 in BR23 when they were cultivated in the *Aman* season.

Idris and Matin (1990) also observed that panicle length differed among the six rice varieties and it was longer in IR20 than in indigenous high yielding varieties.

Singh and Gangwer (1989) conducted an experiment with rice cultivars C-14-8, CR-10009, IET-5656 and IET-6314 and reported that grain number panicle$^{-1}$, 1000-grain weight were higher for C-14-8 than those of any other three varieties. Rafey *et al*. (1989) carried out an experiment with three different rice cultivars and reported that weight of 1000 grain differed among the cultivars studied.

Shamsuddin *et al*. (1988) also observed that panicle number hill$^{-1}$ and 1000-grain weight differed significantly among the varieties. Kamal *et al*. (1988) evaluated BR3, IR20, and Pajam2 and found that number of grain panicle$^{-1}$ were 107.6, 123.0 and 170.9 respectively, for the varieties.

Costa and Hoque (1986) studied during *kharif* season, 1985 at Tangail FSR site, Palima, Bangladesh with five different varieties of T. *Aman* BR4, BR10, BR11. Nizersail and Indrasail. Significant differences were observed in panicle length and number of unfilled grains panicle$^{-1}$ among the varieties tested.

### 2.2.5 Grain and straw yield

Kanfany *et al*. (2014) conducted an experiment at the Africa Rice Sahel Regional Station during two wet seasons with the aim of assessing the performances of introduced hybrid cultivars along with an inbred check cultivar. There were significant cultivar effects for all traits. The grain yield of rice hybrids (bred by the International Rice Research Institute) was not significantly higher than that of the check cultivar widely grown in Senegal.

An experiment was conducted by Hosain *et al*. (2014) at the research farm of Sher-e-Bangla Agricultural University (SAU), Dhaka during *Aus* season to observe the effect of transplanting dates on the yield and yield attributes of exotic hybrid rice varieties. The experiment comprised of three rice varieties (two hybrids-Heera2, Aloron and one inbred- BRRI dhan48). BRRI dhan48 produced the highest grain yield (3.51 t $ha^{-1}$).

Bhuiyan *et al*. (2014) conducted an experiment with aimed to determine the adaptability and performance of different hybrid rice varieties and to identify the best hybrid rice variety in terms of yield and recommend it to rice farmers. Based on the findings of the study, the different hybrid rice varieties evaluated had significant effects on yield. RGBU010A × SL8R is therefore recommended as planting material among hybrid rice varieties because it produced favorable yield.

An experiment was carried out by Alam *et al*. (2012) at Agronomy Field Laboratory, Department of Agronomy and Agricultural Extension, University of Rajshahi during the kharif season to study the effect of variety, spacing and number of seedlings $hill^{-1}$ on the yield potentials of transplant aman rice. The experiment consisted of three high yielding varieties viz. BRRI dhan32, BRRI dhan33 and BR11, four levels of spacing and four levels of number of seedlings $hill^{-1}$ viz. 2 seedlings $hill^{-1}$, 3 seedlings $hill^{-1}$, 4 seedlings $hill^{-1}$ and 5 seedlings $hill^{-1}$. Variety had significant effects on almost all the yield component characters and yield. Variety BR11 produced the highest grain yield (5.92 t $ha^{-1}$).

Swain *et al*. (2006) reported that the control cultivar IR64, with high translocation efficiency and 1000-grain weight and lowest spikelet sterility recorded a grain yield of 5.6 t $ha^{-1}$ that was statistically similar to the hybrid line PA6201.

Molla (2001) reported that Pro-Agro6201 (hybrid) had a significant higher yield than IET4786 (HYV), due to more mature panicles $m^{-2}$, higher number of filled grains $panicle^{-1}$ and greater seed weight.

Patel (2000) studied the varietal performance of Kranti and IR36. He observed that Kranti produced significantly higher grain and straw yield than IR36. The mean yield increased with Kranti over IR36 was 7.1% and 10.0% for grain and straw, respectively.

Julfiquar *et al*. (1998) reported that BRRI evaluated 23 hybrids along with three standard checks. It was reported that five hybrids (IR58025A × IR54056, IR54883, PMS8A × IR46R) out yielded the check varieties (BR14 and BR16) with significant yield difference. Two hybrids out yielded the check variety of same duration yielded by more than 1 t $ha^{-1}$.

BRRI (1997) reported that three modern upland rice varieties namely, BR20, BR21, BR24 were suitable for high rainfall belts of Bangladesh. Under proper management, the grain yield was 3.5 t $ha^{-1}$ for BR20, 3.0 t $ha^{-1}$ for BR21 and 3.5 t $ha^{-1}$ for BR24.

BRRI (1995) conducted an experiment to find out varietal performances of BR4, BR10, BR11, BR22, BR23 and BR25 varieties including two local check Challish and Nizersail, produced yields of 4.38, 3.18, 3.12, 3.12 and 2.70 5 t $ha^{-1}$, respectively.

Chowdhury *et al*. (1995) studied three native (Maloti, Nizersail and Chandrashail) and four improved (BR3, BR11, Pasam and Mala) variety and reported that both the grain and straw yields were higher in the improved than the native varieties. Liu (1995) conducted a field trial with new indica hybrid rice You 92 and found an average yield of 7.5 t $ha^{-1}$ which was 10% higher than that of standard hybrid Shanyou 64.

In field experiments at Gazipur rice cv. BR11 (weakly photosensitive), BR22, BR23 and Nizersail (strongly photosensitive) were sown at various intervals from July to September and transplanted from August to October. Among the cv. BR22 gave the highest grain yield from most of the sowing dates for both of the years (Ali *et al*., 1993). Chowdhury *et al*. (1993) reported that the cultivar BR23 showed superior performance over Pajam in respect of yield and yield contributing characters i.e. grain yield, straw yield.

Suprihatno and Sutaryo (1992) conducted an experiment with seven IRRI hybrids and 13 Indonesian hybrids using IR64 and way-seputih. They observed that TR64 was the highest yielding, significantly out yielding IR64616H, IR64618, IR64610H and IR62829A × IR54 which in turn out yielded way-seputih. Chandra *et al*. (1992) reported that hybrid IR58025A out yielded the IR62829A hybrids and the three control varieties Jaya, IR36 and hybrids IR58025A × 9761-191R and IR58025A IR58025A × 1R35366-62-1-2-2-3R.

Hosain and Alam (1991) studied farmers production technology in haor area and found that the grain yield of modern varieties of *Boro* rice were 2.12, 2.18, 3.17, 2.27 and 3.05 t $ha^{-1}$, with BR14, BR11, BR9, IR8 and BR3, respectively. In evaluation of performance of four HYV and local varieties-BR4, BR16, Rajasail and Kajalsail in *Aman* season, BR4 and BR16 were found to produce more grain yield among four varieties (BRRI, 1985).

From the above literature, it is evident that seedlings number $hill^{-1}$ and varieties have a significant influence on yield and yield components of rice. The literature suggests that optimum seedlings number $hill^{-1}$ and suitable variety increases the grain yield of rice. Increased grain yield is mainly attributed by the increases of number of tiller $hill^{-1}$, grains $panicle^{-1,}$ panicle length and thousand grain weight due to suitable condition of development of these parameters for the effect of number of seedlings and variety itself.

# CHAPTER III

# MATERIALS AND METHODS

The experiment was conducted to find out the effect of seedlings hill$^{-1}$ on yield and yield components of hybrid and inbred rice varieties. The details of the materials and methods i.e. experimental period, location, soil and climatic condition of the experimental area, materials used, treatment and design of the experiment, growing of crops, data collection and data analysis procedure that followed in this experiment has been presented under the following headings:

## 3.1 Description of the experimental site

### 3.1.1 Experimental period

The experiment was conducted during the period of July to November, 2014.

### 3.1.2 Experimental location

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

### 3.1.3 Soil characteristics

The soil belonged to “The Modhupur Tract”, AEZ-28 (FAO, 1988). Top soil was Silty Clay in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. Soil pH was 5.6 and had organic carbon 0.45%. The experimental area was flat having available irrigation and drainage system and above flood level. The details have been presented in Appendix II.

### 3.1.4 Climatic condition

The geographical location of the experimental site was under the subtropical climate and its climatic conditions is characterized by three distinct seasons, namely winter season from the month of November to February, the pre-monsoon period or hot season from the month of March to April and monsoon period from the month of May to October (Edris *et al*., 1979). Details of the meteorological data of air temperature, relative humidity, rainfall and sunshine hour during the period of the experiment has been presented in Appendix III.

## 3.2 Experimental details

### 3.2.1 Planting material

Chamak and BRRI dhan62 were used as the study materials in this experiment.

### 3.2.2 Treatment of the experiment

The experiment comprised of two factors.

Factor A: Rice variety (2)

i. $V_1$: Hybrid (Chamak)
ii. $V_2$: Inbred (BRRI dhan62)

Factor B: Number of seedlings hill$^{-1}$ (5 levels)

i. $S_1$: 1 seedling hill$^{-1}$
ii. $S_2$: 2 seedlings hill$^{-1}$
iii. $S_3$: 3 seedlings hill$^{-1}$
iv. $S_4$: 4 seedlings hill$^{-1}$
v. $S_5$: 5 seedlings hill$^{-1}$

As such there were 10 (2×5) treatment combinations viz. $V_1S_1$, $V_1S_2$, $V_1S_3$, $V_1S_4$, $V_1S_5$, $V_2S_1$, $V_2S_2$, $V_2S_3$, $V_2S_4$ and $V_2S_5$.

### 3.2.3 Experimental design and layout

The two factors experiment was laid out in Split-plot design with three replications. An area of 16.5 m × 13.5 m was divided into 3 blocks. The two varieties were assigned in the main plot and number of seedlings hill$^{-1}$ in sub-plot. The size of the each unit plot was 2.0 m × 2.0 m. The space between two blocks and two plots were 0.75 m and 0.5 m, respectively. The layout of the experiment is shown in Figure 1.

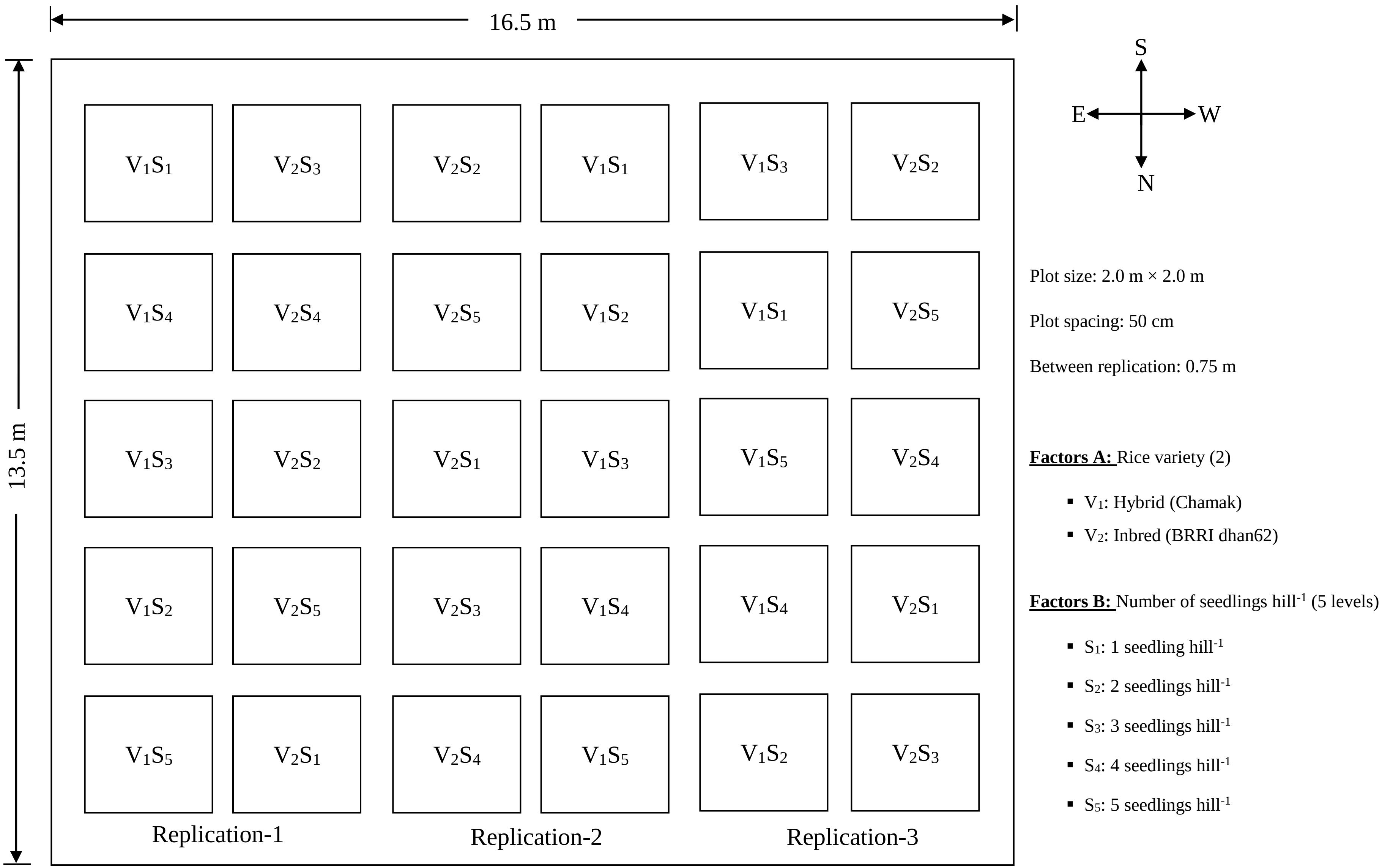



Figure 1. Field layout of the experiment plot

### 3.3 Growing of crops

#### 3.3.1 Seed collection and sprouting

Seeds were collected from BRRI (Bangladesh Rice Research Institute), Gazipur and local market just 20 days ahead of the sowing of seeds in seed bed. For seedling raising, clean seeds were immersed in water in a bucket for 24 hours. The imbibed seeds were then taken out of water and kept in gunny bags. The seeds started sprouting after 48 hours which were suitable for sowing in 72 hours.

#### 3.3.2 Raising of seedlings

The nursery bed was prepared by puddling with repeated ploughing followed by laddering. The sprouted seeds were sown on beds on 1$^{st}$ July, 2014 as uniformly as possible. Irrigation was gently provided to the bed as and when needed. No fertilizer was used in the nursery bed.

#### 3.3.3 Land preparation

The plot selected for conducting the experiment was opened in the 15$^{th}$ July 2014 with a power tiller, and left exposed to the sun for a week. After one week the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain good puddle condition. Weeds and stubbles were removed. The experimental plot was partitioned into unit plots in accordance with the experimental design. Organic and inorganic manures as indicated below were mixed with the soil of each unit plot.

#### 3.3.4 Fertilizers and manure application

The fertilizers N, P, K, S, Zn and B in the form of urea, TSP, MoP, Gypsum, zinc sulphate and borax, respectively were applied @ 80 kg, 60 kg, 90 kg, 12 kg, 2.0 kg and 10 kg ha$^{-1}$ (BRRI, 2013). The entire amount of TSP, MoP, gypsum, zinc sulphate and borax were applied during the final preparation of experimental plot. Urea was applied in two equal installments as top dressing at tillering and panicle initiation stages.

### 3.3.5 Transplanting of seedling

Twenty five days old seedlings were carefully uprooted from the seedling nursery and transplanted on 25 July, 2014 in well puddled plot. Number of seedlings $hill^{-1}$ was used as per treatment. After one week of transplanting all plots were checked for any missing hill, which was filled up with extra seedlings of the same source whenever required followed by the treatment of number of seedlings $hill^{-1}$.

### 3.3.6 Intercultural operations

Intercultural operations were done to ensure normal growth of the crop. Plant protection measures were followed as and when necessary. The following intercultural operations were done:

#### 3.3.6.1 Irrigation and drainage

In the early stages to establishment of the seedlings, irrigation was provided to maintain a constant level of standing water upto 6 cm and then maintained the amount drying and wetting system throughout the entire vegetative phase. No water stress was encountered in reproductive and ripening phase. The plot was finally dried out at 15 days before harvesting.

#### 3.3.6.2 Weeding

Weeding were done to keep the plots free from weeds, which ultimately ensured better growth and development. The newly emerged weeds were uprooted carefully at 25 DAT and 45 DAT by sickles.

#### 3.3.6.3 Insect and pest control

There was no infection of diseases in the field but leaf roller (*Chaphalocrosis medinalis*) was found in the field and used Malathion @ 1.12 L $ha^{-1}$ at 30 DAT with using a hand sprayer.

### 3.4 Harvesting, threshing and cleaning

The crop was harvested at full maturity at 07 November, 2014 when 80-90% of the grains were turned into straw colored. The harvested crop was bundled separately, properly tagged and brought to threshing floor. Enough care was taken during threshing and cleaning period of rice grain. Fresh weight of rice grain and straw were recorded plot wise from 1 $m^2$ area. The grains were dried up to moisture content 14%, then cleaned and weighed for individual plot. Yields of rice grain and straw 1 $m^{-2}$ were recorded from each plot and converted to hectare yield and expressed in t $ha^{-1}$.

## 3.5 Data recording

### 3.5.1 Plant height

The height of plant was recorded in centimeter (cm) at 25, 35, 45, 55 DAT (days after transplanting) and at harvesting stage. Data were recorded as the average of 5 plants selected at random from the inner rows of each plot. The height was measured from the ground level to the tip of the panicle or flag leaf.

### 3.5.2 Number of tillers hill$^{-1}$

Number of tillers hill$^1$ was recorded at 25, 35, 45, 55 DAT. Data were recorded as the average of 5 plants selected at random from the inner rows of each plot.

### 3.5.3 Total dry matter hill$^{-1}$

Total dry matter hill$^{-1}$ was recorded at 25, 35, 45 and 55 DAT by drying plant sample. Data were recorded as the average of 5 sample hill$^{-1}$ collected at random from the inner rows of each plot and expressed in gram (g).

### 3.5.4 Effective tillers hill$^{-1}$

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

### 3.5.5 Non-effective tillers hill$^{-1}$

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

### 3.5.6 Total tillers hill$^{-1}$

The total number of tiller hill$^{-1}$ was counted by adding the number of effective tillers hill$^{-1}$ and non-effective tillers hill$^{-1}$. Data on total tillers hill$^{-1}$ were recorded from 5 selected hills and average value was calculated.

### 3.5.7 Panicle length

The length of panicle was measured with a meter scale from 5 selected plants of a plot and the average length was recorded as per panicle in cm.

### 3.5.8 Filled grains panicle$^{-1}$

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

### 3.5.9 Unfilled grains panicle$^{-1}$

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

### 3.5.10 Total grains panicle$^{-1}$

The total numbers of grain was collected from randomly selected 5 plants of a plot by adding filled and unfilled grain and then average numbers of grains panicle$^{-1}$ was recorded.

### 3.5.11 Weight of 1000-grain

One thousand grains were counted randomly from the total cleaned harvested grains and then weighed in grams and recorded.

### 3.5.12 Grain yield

Grains obtained from each unit plot were sun-dried and weighed carefully. The dry weight of grains of central 1 m$^2$ area in each plot were taken the final grain yield plot$^{-1}$ and finally converted to ton hectare$^{-1}$ (t ha$^{-1}$).

### 3.5.13 Straw yield

Straw obtained from each unit plot were sun-dried and weighed carefully. The dry weight of straw of central 1 $m^2$ area was taken from each plot and finally converted to ton hectare$^{-1}$ (t ha$^{-1}$).

### 3.5.14 Biological yield

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

Biological yield = Grain yield + Straw yield.

### 3.5.15 Harvest index

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

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

## 3.6 Statistical Analysis

The data obtained for different characters were statistically analyzed to observe the significant difference among different variety and number of seedlings hill$^{-1}$. The mean values of all the characters were calculated and analysis of variance was performed using MSTAT-C software programme. The significance of the difference among the treatments means was estimated by the Least Significant Difference (LSD) test at 5% level of probability (Gomez and Gomez, 1984).

# CHAPTER IV

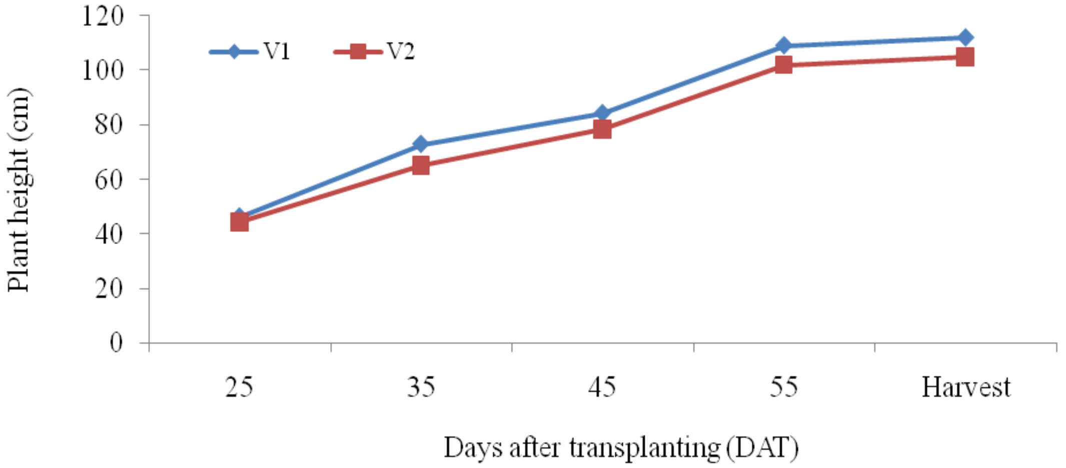
# RESULTS AND DISCUSSION

The experiment was conducted to find out the effect of seedlings hill$^{-1}$ on yield and yield components of hybrid and inbred rice varieties. Data on different growth characters, yield components and yield were recorded. The analyses of variance (ANOVA) of the data on different parameters are presented in Appendix IV-VIII. The results have been presented on tables and graphs and possible interpretations given under the following headings:

## 4.1 Crop growth characters

### 4.1.1 Plant height (cm)

Plant height at 25, 35, 45, 55 days after transplanting (DAT) and at harvest varied significantly due to rice varieties (Figure 2). At 25, 35, 45, 55 DAT and at harvest, the taller plants (46.25, 72.97, 84.29, 109.29 and 112.17 cm, respectively) were recorded from $V_1$ (Chamak), while the shorter plants (44.31, 65.10, 78.32, 101.96 and 104.96 cm, respectively) from $V_2$ (BRRI dhan62). Varieties showed different plant height on the basis of their varietal characters. Growth and yield of rice are strongly influenced by genotype as well as environmental factors (BRRI, 2003). Variety is the key component to produce plant height of rice depending upon their differences in genotypic characters, input requirements and response, growth process and off course the prevailing environmental conditions during the growing season. Bhuiyan *et al*. (2014) reported that the different hybrid rice varieties had significant effects on plant height at maturity. Khalifa (2009) reported that $H_1$ hybrid rice variety surpassed other varieties in terms of plant height. Munoz *et al.* (1996) noted that IR8025A hybrid rice cultivar produced 16% longer plant than the commercial variety Oryzica Yacu-9. Miah *et al*. (1990) reported that mutant NSI and Mutant NSS were planted and found that plant height were greater in Mutant NSI than Nizersail.




$V_1$: Hybrid (Chamak) $V_2$: Inbred (BRRI dhan62)

Figure 2. Effect of varieties on plant height of rice ($LSD_{0.05}$ = 1.941, 7.466, 5.595, 6.017 and 6.017 at 25, 35, 45, 55 DAT and harvest)

Number of seedlings hill$^{-1}$ showed significant differences on plant height at 25, 35, 45, 55 DAT and at harvest (Table 1). At 25 DAT the tallest plant (47.55cm) was found from $S_2$ (2 seedlings hill$^{-1}$) which was statistically similar (45.91cm) to $S_1$ (1 seedling hill$^{-1}$) and also (45.69 cm) to $S_3$ (3 seedlings hill$^{-1}$), whereas the shortest plant (43.26 cm) from $S_5$ (5 seedlings hill$^{-1}$) which was statistically similar (43.99 cm) to $S_4$ (4 seedlings hill$^{-1}$). At 35, 45, 55 DAT and at harvest, the tallest plant (72.06, 85.20, 109.49 and 112.43 cm, respectively) were found from $S_2$ (2 seedlings hill$^{-1}$), which was statistically similar (70.67, 83.03, 108.15 and 111.09 cm, respectively) to $S_1$ (1 seedling hill$^{-1}$), also (69.30, 81.49, 107.05 and 109.99 cm, respectively) to $S_3$ (3 seedlings hill$^{-1}$), and also (68.80, 80.98, 105.07 and 108.01 cm, respectively) to $S_4$ (4 seedlings hill$^{-1}$), whereas the shortest plant (64.36, 75.81, 98.32 and 101.32 cm, respectively) from $S_5$ (5 seedlings hill$^{-1}$). Optimum number of seedlings hill$^{-1}$ may facilitate the rice plant to grow properly both in its aerial and underground parts by utilizing maximum radiant energy, nutrient, space and water. Alam *et al*. (2012) recorded the highest plant height when 2 seedlings were transplanted hill$^{-1}$.

**Table 1. Effect of number of seedlings hill$^{-1}$ on plant height (cm) at different days after transplanting (DAT) and at harvest**

| Treatments | Plant height (cm) at different DAT | | | | |
|---|---|---|---|---|---|
| | 25 DAT | 35 DAT | 45 DAT | 55 DAT | Harvest |
| $S_1$ | 45.91 ab | 70.67 a | 83.03 a | 108.15 a | 111.09 a |
| $S_2$ | 47.55 a | 72.06 a | 85.20 a | 109.49 a | 112.43 a |
| $S_3$ | 45.69 ab | 69.30 a | 81.49 a | 107.05 a | 109.99 a |
| $S_4$ | 43.99 bc | 68.80 a | 80.98 a | 105.07 a | 108.01 a |
| $S_5$ | 43.26 c | 64.36 b | 75.81b | 98.38 b | 101.32 b |
| **$LSD_{(0.05)}$** | **2.307** | **3.252** | **4.055** | **5.820** | **5.820** |
| **Level of significance** | **0.05** | **0.01** | **0.01** | **0.05** | **0.05** |
| **CV(%)** | **5.10** | **4.71** | **4.99** | **5.51** | **5.27** |

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly at 0.05 level of probability

$S_1$: 1 seedling hill$^{-1}$
$S_2$: 2 seedlings hill$^{-1}$
$S_3$: 3 seedlings hill$^{-1}$
$S_4$: 4 seedlings hill$^{-1}$
$S_5$: 5 seedlings hill$^{-1}$

Due to the interaction effect of varieties and number of seedlings hill$^{-1}$, significant variation was recorded on plant height at 25, 35, 45, 55 DAT and at harvest (Table 2). At 25, 35, 45, 55 DAT and at harvest, the tallest plant (49.61, 78.91, 90.68, 119.48 and 121.93 cm, respectively) were recorded from the combination of $V_1S_2$ (Chamak and 2 seedlings hill$^{-1}$) and at 25 and 45 DAT the shortest plant (42.08 cm and 73.20 cm) were found from the combination of $V_2S_3$ (BRRI dhan62 and 3 seedlings hill$^{-1}$), whereas at 35, 55 DAT and at harvest the shortest plants (61.17, 97.70 and 100.70 cm, respectively) were found from the combination of $V_2S_5$ (BRRI dhan62 and 5 seedlings hill$^{-1}$).

**Table 2. Interaction effect of varieties with number of seedlings $hill^{-1}$ on plant height (cm) at different days after transplanting (DAT) and at harvest**

| Combination of treatments | Plant height (cm) at different DAT | | | | |
|---|---|---|---|---|---|
| | 25 DAT | 35 DAT | 45 DAT | 55 DAT | Harvest |
| $V_1S_1$ | 45.29 ab | 71.47 bc | 85.58 ab | 111.60 ab | 114.48 ab |
| $V_1S_2$ | 49.61 a | 78.91 a | 90.68 a | 119.05 a | 121.93 a |
| $V_1S_3$ | 49.29 a | 76.39 ab | 89.77 a | 112.48 ab | 115.36 ab |
| $V_1S_4$ | 43.54 b | 70.56 bc | 78.80 b-d | 104.27 bc | 107.15 bc |
| $V_1S_5$ | 43.54 b | 67.55 cd | 76.63 cd | 99.06 c | 101.94 c |
| $V_2S_1$ | 46.53 ab | 69.86 c | 80.49 b-d | 104.70 bc | 107.70 bc |
| $V_2S_2$ | 45.50 ab | 65.21 c-e | 79.73 b-d | 99.92 c | 102.92 c |
| $V_2S_3$ | 42.08 b | 62.20 de | 73.20 d | 101.61 bc | 104.61 bc |
| $V_2S_4$ | 44.44 b | 67.04 c-e | 83.17 a-c | 105.88 bc | 108.88 bc |
| $V_2S_5$ | 42.98 b | 61.17 e | 74.99 d | 97.70 c | 100.70 c |
| **$LSD_{(0.05)}$** | **3.996** | **5.632** | **7.023** | **10.08** | **10.08** |
| **Level of significance** | **0.05** | **0.01** | **0.01** | **0.05** | **0.05** |
| **CV(%)** | **5.10** | **4.71** | **4.99** | **5.51** | **5.27** |

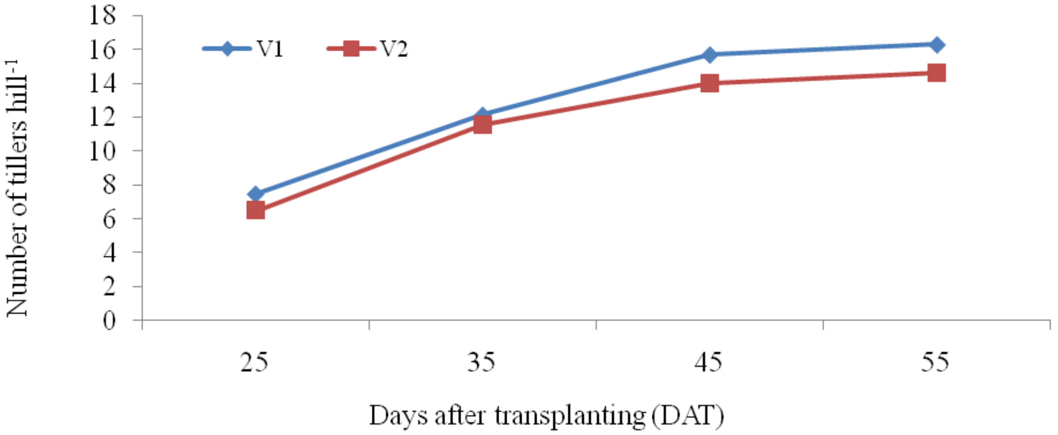
In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly at 0.05 level of probability

$V_1$: Hybrid (Chamak)
$V_2$: Inbred (BRRI dhan62)

$S_1$: 1 seedling $hill^{-1}$
$S_2$: 2 seedlings $hill^{-1}$
$S_3$: 3 seedlings $hill^{-1}$
$S_4$: 4 seedlings $hill^{-1}$
$S_5$: 5 seedlings $hill^{-1}$

### 4.1.2 Number of tillers hill$^{-1}$

Rice varieties varied significantly on number of total tillers hill$^{-1}$ at 25, 35, 45 and 55 DAT (Figure 3). Data revealed that at 25, 35, 45 and 55 DAT, the maximum number of tillers hill$^{-1}$ were found from $V_1$ (7.44, 12.12, 15.69 and 16.29, respectively) and the minimum number from $V_2$ (6.48, 11.53, 13.99 and 14.61, respectively). Masum *et al*. (2008) reported that maximum (25.63) tiller was found at 45 DAT, then with advancement of age it declined up to maturity, whereas in the case of BRRI dhan44, maximum (18.92) tiller production was observed around panicle initiation stage at 60 DAT .




$V_1$: Hybrid (Chamak) $V_2$: Inbred (BRRI dhan62)

Figure 3. Effect of varieties on number of tillers hill$^{-1}$of rice ($LSD_{0.05}$ = 0.596, 0.228, 1.437 and 1.146 at 25, 35, 45 and 55 DAT)

Number of seedlings hill$^{-1}$ showed significant differences on number of tillers hill$^{-1}$ at 25, 35, 45 and 55 DAT (Table 3). At 25 DAT, the maximum number of tillers hill$^{-1}$ was recorded from $S_2$ (7.40) which was statistically similar to $S_1$ (7.20) and also $S_3$ (7.00). At 35 DAT, the maximum number of tillers hill$^{-1}$ was recorded from $S_2$ (12.13) which was statistically similar to $S_1$ (12.00), $S_3$ (11.93) and $S_4$ (11.87). At 45 DAT, the maximum number of tillers hill$^{-1}$ was recorded from $S_2$ (16.43) which was statistically similar to $S_1$ (15.87). At 55 DAT, the maximum number of tillers hill$^{-1}$ was found from $S_2$ (16.73) which was statistically different from others, while at 25, 35, 45 and 55 DAT the minimum number were recorded from $S_5$ (6.40, 11.20, 12.40 and 13.67, respectively).

**Table 3. Effect of number of seedlings hill$^{-1}$ on number of tillers hill$^{-1}$ of rice at different days after transplanting (DAT)**

| Treatments | Number of tillers hill$^{-1}$ at different DAT | | | |
|---|---|---|---|---|
| | 25 DAT | 35 DAT | 45 DAT | 55 DAT |
| $S_1$ | 7.20 ab | 12.00 a | 15.87 a | 15.90 b |
| $S_2$ | 7.40 a | 12.13 a | 16.43 a | 16.73 a |
| $S_3$ | 7.00 ab | 11.93 a | 14.90 b | 15.53 b |
| $S_4$ | 6.80 b | 11.87 a | 14.60 b | 15.43 b |
| $S_5$ | 6.40 c | 11.20 b | 12.40 c | 13.67 c |
| **$LSD_{(0.05)}$** | **0.395** | **0.249** | **0.705** | **0.813** |
| **Level of significance** | **0.01** | **0.01** | **0.01** | **0.01** |
| **CV(%)** | **5.67** | **2.10** | **4.75** | **5.26** |

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly at 0.05 level of probability

$S_1$: 1 seedling hill$^{-1}$
$S_2$: 2 seedlings hill$^{-1}$
$S_3$: 3 seedlings hill$^{-1}$
$S_4$: 4 seedlings hill$^{-1}$
$S_5$: 5 seedlings hill$^{-1}$

Interaction effect of rice varieties and number of seedlings hill$^{-1}$ showed significant variation on number of tillers hill$^{-1}$ at 25, 35, 45 and 55 DAT (Table 4). At 25, 45 and 55 DAT, the maximum number of tillers hill$^{-1}$ was found from the combination of $V_1S_2$ (7.80, 18.07 and 17.80, respectively) but at 35 DAT the maximum number of tillers hill$^{-1}$ was found from the combination of $V_1S_3$ (12.47) and the minimum number of tillers hill$^{-1}$ was obtained from the combination of $V_2S_5$ (6.00, 10.80, 11.87 and 13.33, respectively).

**Table 4. Interaction effect of varieties and number of seedlings hill$^{-1}$ on number of tillers hill$^{-1}$ at different days after transplanting (DAT)**

| Combination of treatments | Number of tillers hill$^{-1}$ at different DAT | | | |
|---|---|---|---|---|
| | 25 DAT | 35 DAT | 45 DAT | 55 DAT |
| $V_1S_1$ | 7.60 ab | 12.20 ab | 16.73 b | 16.80 ab |
| $V_1S_2$ | 7.80 a | 12.40 a | 18.07 a | 17.80 a |
| $V_1S_3$ | 7.60 ab | 12.47 a | 15.33 c | 17.07 ab |
| $V_1S_4$ | 7.40 a-c | 11.93 bc | 15.40 c | 15.80 bc |
| $V_1S_5$ | 6.80 c-e | 11.60 cd | 12.93 ef | 14.00 de |
| $V_2S_1$ | 6.80 c-e | 11.80 b-d | 15.00 cd | 15.00 cd |
| $V_2S_2$ | 7.00 b-d | 11.87 b-d | 14.80 cd | 15.67 bc |
| $V_2S_3$ | 6.40 d-f | 11.40 d | 14.47 cd | 14.00 de |
| $V_2S_4$ | 6.20 ef | 11.80 b-d | 13.80 de | 15.07 cd |
| $V_2S_5$ | 6.00 f | 10.80 e | 11.87 f | 13.33 e |
| **$LSD_{(0.05)}$** | **0.684** | **0.431** | **1.220** | **1.407** |
| **Level of significance** | **0.05** | **0.05** | **0.05** | **0.05** |
| **CV(%)** | **5.67** | **2.10** | **4.75** | **5.26** |

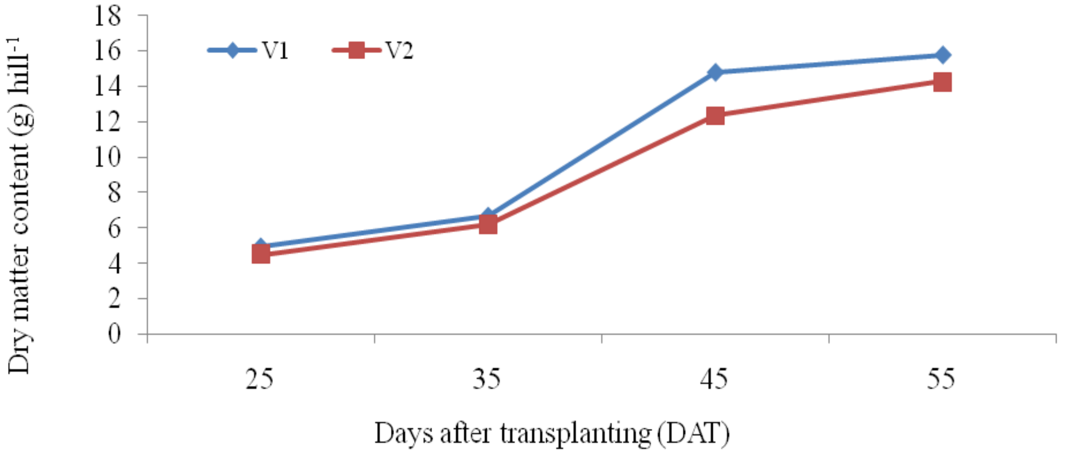
In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly at 0.05 level of probability

$V_1$: Hybrid (Chamak)
$V_2$: Inbred (BRRI dhan62)

$S_1$: 1 seedling hill$^{-1}$
$S_2$: 2 seedlings hill$^{-1}$
$S_3$: 3 seedlings hill$^{-1}$
$S_4$: 4 seedlings hill$^{-1}$
$S_5$: 5 seedlings hill$^{-1}$

### 4.1.3 Dry matter content hill$^{-1}$ (g)

Dry matter content hill$^{-1}$ at 25, 35, 45 and 55 DAT varied significantly due to varieties (Figure 4). At 25, 35, 45 and 55 DAT, the maximum dry matter content hill$^{-1}$ were observed from $V_1$ (4.93, 6.67, 14.80 and 15.78 g, respectively), whereas the minimum dry matter content hill$^{-1}$ were recorded from $V_2$ (4.49, 6.19, 12.35 and 14.27 g, respectively).




$V_1$: Hybrid (Chamak) $V_2$: Inbred (BRRI dhan62)

Figure 4. Effect of varieties on dry matter content hill$^{-1}$of rice ($LSD_{0.05}$ = 0.337, 0.285, 2.225 and 1.297 at 25, 35, 45 and 55 DAT)

Number of seedlings hill$^{-1}$ showed significant differences on dry matter content hill$^{-1}$ at 25, 35, 45 and 55 DAT (Table 5). At 25, 35 and 45 DAT, the maximum dry matter content hill$^{-1}$ were observed from $S_2$ (5.71, 7.14 and 15.14 g, respectively) which was statistically similar to $S_1$ (5.51, 6.96 and 14.57 g, respectively) and at 55 DAT the maximum dry matter content hill$^{-1}$ was observed from $S_2$ (17.10 g) and it was statistically different from others while the minimum dry matter content hill$^{-1}$ were observed from $S_5$ (3.02, 5.11, 10.79 and 11.97 g, respectively).

**Table 5. Effect of number of seedlings hill$^{-1}$ on dry matter content (g) hill$^{-1}$ at different days after transplanting (DAT)**

| Treatments | Dry matter content (g) hill$^{-1}$ at different DAT | | | |
|---|---|---|---|---|
| | **25 DAT** | **35 DAT** | **45 DAT** | **55 DAT** |
| $S_1$ | 5.51 a | 6.96 a | 14.57 ab | 16.07 b |
| $S_2$ | 5.71 a | 7.14 a | 15.14 a | 17.10 a |
| $S_3$ | 4.88 b | 6.70 b | 13.76 b | 15.22 bc |
| $S_4$ | 4.44 c | 6.24 c | 13.63 b | 14.79 c |
| $S_5$ | 3.02 d | 5.11 d | 10.79 c | 11.97 d |
| **$LSD_{(0.05)}$** | **0.230** | **0.247** | **0.935** | **0.902** |
| **Level of significance** | **0.01** | **0.01** | **0.01** | **0.01** |
| **CV(%)** | **4.87** | **3.85** | **6.89** | **6.00** |

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly at 0.05 level of probability

$S_1$: 1 seedling hill$^{-1}$ $S_2$: 2 seedlings hill$^{-1}$
$S_3$: 3 seedlings hill$^{-1}$ $S_4$: 4 seedlings hill$^{-1}$
$S_5$: 5 seedlings hill$^{-1}$

Significant variation was recorded due to the interaction effect of varieties and number of seedlings hill$^{-1}$ on dry matter content hill$^{-1}$ at 25, 35, 45 and 55 DAT (Table 6). At 25, 35, 45 and 55 DAT, the maximum dry matter content hill$^{-1}$ were recorded from the combination of $V_1S_2$ (6.18, 7.39, 16.55 and 18.51 g, respectively), whereas the minimum dry matter content hill$^{-1}$ were found from the combination of $V_2S_5$ (2.91, 4.87, 10.13 and 11.54 g, respectively).

**Table 6. Interaction effect of varieties and number of seedlings hill$^{-1}$ on dry matter content (g) hill$^{-1}$ at different days after transplanting (DAT)**

| Combination of treatments | Dry matter content (g) hill$^{-1}$ at different DAT | | | |
|---|---|---|---|---|
| | 25 DAT | 35 DAT | 45 DAT | 55 DAT |
| $V_1S_1$ | 5.74 b | 7.17 ab | 15.87 a | 18.06 a |
| $V_1S_2$ | 6.18 a | 7.39 a | 16.55 a | 18.51 a |
| $V_1S_3$ | 5.01 cd | 7.10 ab | 16.18 a | 14.95 b |
| $V_1S_4$ | 4.62 de | 6.32 cd | 13.98 b | 15.01 b |
| $V_1S_5$ | 3.13 f | 5.35 e | 11.44 c | 12.39 c |
| $V_2S_1$ | 5.28 c | 6.74 bc | 13.26 b | 14.08 b |
| $V_2S_2$ | 5.23 c | 6.89 b | 13.73 b | 15.69 b |
| $V_2S_3$ | 4.76 d | 6.31 cd | 11.33 c | 15.48 b |
| $V_2S_4$ | 4.26 e | 6.15 d | 13.29 b | 14.57 b |
| $V_2S_5$ | 2.91 f | 4.87 f | 10.13 c | 11.54 c |
| **$LSD_{(0.05)}$** | **0.399** | **0.428** | **1.620** | **1.562** |
| **Level of significance** | **0.05** | **0.05** | **0.05** | **0.01** |
| **CV(%)** | **4.87** | **3.85** | **6.89** | **6.00** |

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly at 0.05 level of probability

$V_1$: Hybrid (Chamak)

$V_2$: Inbred (BRRI dhan62)

$S_1$: 1 seedling hill$^{-1}$

$S_2$: 2 seedlings hill$^{-1}$

$S_3$: 3 seedlings hill$^{-1}$

$S_4$: 4 seedlings hill$^{-1}$

$S_5$: 5 seedlings hill$^{-1}$

## 4.2 Yield contributing characters

### 4.2.1 Total tillers hill$^{-1}$ (No.)

Total tillers hill$^{-1}$ varied significantly due to rice varieties (Table 7). The maximum number of total tillers hill$^{-1}$ was observed from $V_1$ (14.92) and the minimum number of total tillers hill$^{-1}$ from $V_2$ (13.15). Khalifa (2009) reported that $H_1$ hybrid rice variety surpassed other varieties in consideration of total tillers hill$^{-1}$.

Number of seedlings hill$^{-1}$ showed significant differences on total tillers hill$^{-1}$ (Table 7). The maximum number of total tillers hill$^{-1}$ was found from $S_2$ (15.27) which was closely followed by $S_1$ (14.57) and also $S_3$ (14.27) and they were statistically similar. On the other hand, the minimum number of total tillers hill$^{-1}$ from $S_5$ (12.33). Alam (2006) reported that the highest number of total tillers were obtained from 2 seedlings hill$^{-1}$.

Significant variation was recorded due to the interaction effect of varieties and number of seedlings hill$^{-1}$ on total tillers hill$^{-1}$ of rice (Table 8). The maximum number of total tillers hill$^{-1}$ was recorded from the combination of $V_1S_2$ (16.80) and it was statistically different from others and the minimum number of total tillers hill$^{-1}$ was found from $V_2S_5$ (12.33) which was statistically similar to $V_1S_{5,}$ $V_2S_4$ and $V_2S_{3.}$

### 4.2.2 Effective tillers hill$^{-1}$ (No.)

Significant variation was recorded on effective tillers hill$^{-1}$ due to rice varieties (Table 7). The maximum number of effective tillers hill$^{-1}$ was found from $V_1$ (12.73) and the minimum number of effective tillers hill$^{-1}$ from $V_2$ (10.37). Khalifa (2009) reported that $H_1$ hybrid rice variety surpassed other varieties in consideration of effective tillers hill$^{-1}$.

Effective tillers hill$^{-1}$ also showed significant differences due to number of seedlings hill$^{-1}$ (Table 7). The highest number of effective tillers hill$^{-1}$ was recorded from $S_2$ (12.20) which was statistically similar to $S_1$ (11.97) and also to $S_3$ (11.90). On the other hand, the minimum number of effective tillers hill$^{-1}$ was found from $S_5$ (10.27). This result is in agreement with Alam (2006) who found the highest number of effective tillers hill$^{-1}$ from 2 seedlings hill$^{-1}$.

Interaction effect of rice varieties and number of seedlings hill$^{-1}$ varied significantly on effective tillers hill$^{-1}$ (Table 8). The maximum number of effective tillers hill$^{-1}$ was recorded from the combination of $V_1S_2$ (13.87) which was statistically similar to $V_1S_3$ and $V_1S_1$ while the minimum number of effective tillers hill$^{-1}$ was found from the combination of $V_2S_5$ (10.07).

### 4.2.3 Non-effective tillers hill$^{-1}$ (No.)

Different rice varieties showed significant variation on non-effective tillers hill$^{-1}$ (Table 7). The maximum number of non-effective tillers hill$^{-1}$ was obtained from $V_2$ (2.77), whereas the minimum number of non-effective tillers hill$^{-1}$ was found from $V_1$ (2.19).

Significant variation was recorded due to the number of seedlings hill$^{-1}$ on non-effective tillers hill$^{-1}$ (Table 7). The maximum number of non-effective tillers hill$^{-1}$ was recorded from $S_2$ (3.07) which was followed by $S_1$ (2.60) while the minimum number from $S_5$ (2.07). Islam *et al.* (2012) reported that the highest and the lowest number of non-effective tillers hill$^{-1}$ were found due to 2-seedilings and 4-seeedlings hill$^{-1}$, respectively.

Interaction effect of varieties and number of seedlings hill$^{-1}$ varied significantly on non-effective tillers hill$^{-1}$ (Table 8). The maximum number of non-effective tillers hill$^{-1}$ was found from the combination of $V_2S_1$ (3.20) which was statistically similar to $V_2S_2$ (3.20) and $V_1S_2$ (2.93) and the minimum number of non-effective tillers hill$^{-1}$ was observed from the combination of $V_1S_5$ (1.87).

### 4.2.4 Panicle length (cm)

Panicle length showed significant variation due to varieties (Table 7). The longer panicle was recorded from $V_1$ (24.81 cm) and the shorter panicle was found from $V_2$ (23.59 cm). This findings was supported by Wang *et al*. (2006) who found that the hybrids had larger panicles.

Significant differences were recorded for number of seedlings hill$^{-1}$ on panicle length (Table 7). The longest panicle was observed from $S_2$ (25.83 cm), which was statistically similar to $S_1$ (24.81 cm), whereas, the shortest panicle from $S_4$ (21.54 cm). Alam *et al*. (2012) recorded the highest panicle length when 2 seedlings were transplanted hill$^{-1}$. Sarkar *et al*. (2011) observed the highest panicle length when 2 tiller seedlings were transplanted hill$^{-1}$.

Panicle length varied significantly due to the interaction effect of varieties and number of seedlings hill$^{-1}$ (Table 8). The longest panicle was found from the combination of $V_1S_2$ (26.58 cm) and the shortest panicle was recorded from $V_2S_5$ (21.15 cm) which was statistically similar to $V_1S_5$ (21.93).

### 4.2.5 Filled grains panicle$^{-1}$ (No.)

Filled grains panicle$^{-1}$varied significantly due to rice varieties (Table 7). The maximum number of filled grains panicle$^{-1}$ was found from $V_1$ (80.95) and the minimum number of filled grains panicle$^{-1}$ was observed from $V_2$ (74.49). Obulamma *et al.* (2004) recorded the highest number of filled grain panicle$^{-1}$ in hybrid APHR 2 than hybrid DRRH 1.

Number of seedlings hill$^{-1}$ showed significant differences on filled grains panicle$^{-1}$ (Table 7). The maximum number of filled grains panicle$^{-1}$ was recorded from $S_2$ (83.47) which was statistically similar to $S_1$ (82.00) and also to $S_3$ (80.70), whereas, the minimum number of filled grains panicle$^{-1}$ from $S_5$ (63.20). Ali (2008) reported that number of seedlings hill$^{-1}$ had significant influence on number of filled grains panicle$^{-1}$.

Significant variation was recorded due to the interaction effect of varieties and number of seedlings $hill^{-1}$ on filled grains $panicle^{-1}$ (Table 8). The maximum number of filled grains $panicle^{-1}$ was found from the combination of $V_1S_2$ (90.53) which was statistically similar to $V_1S_1$ (85.27) and the minimum number of filled grains $panicle^{-1}$ was found from the combination of $V_2S_5$ (61.53) which was statistically similar to $V_1S_5$ (64.87).

### 4.2.6 Unfilled grains $panicle^{-1}$ (No.)

Significant variation was recorded on unfilled grains $panicle^{-1}$ due to rice varieties (Table 7). The maximum number of unfilled grains $panicle^{-1}$ was recorded from $V_1$ (7.01), whereas the minimum number was recorded from $V_2$ (6.24). Hosain *et al*. (2014) reported that hybrid varieties Heera2 and Aloron gave the higher spikelet sterility.

Number of seedlings $hill^{-1}$ showed significant differences on unfilled grains $panicle^{-1}$ (Table 7). The maximum number of unfilled grains $panicle^{-1}$ was observed from $S_5$ (8.87) which was followed by $S_2$ (6.60) while the minimum number of unfilled grains $panicle^{-1}$ from $S_3$ (5.47). Ali (2008) reported that number of seedlings $hill^{-1}$ had significant influence on number of unfilled grains $panicle^{-1}$.

Interaction effect of rice varieties and number of seedlings $hill^{-1}$ showed significant differences on unfilled grains $panicle^{-1}$ (Table 8). The maximum number of unfilled grains $panicle^{-1}$ was found from the combination of $V_1S_5$ (9.27) which was statistically different from others while the minimum number of unfilled grains $panicle^{-1}$ was observed from $V_2S_3$ (4.87).

**Table 7. Effect of varieties and number of seedlings $hill^{-1}$ on yield contributing characters of rice**

| Treatments | Total tillers $hill^{-1}$ (No.) | Effective tillers $hill^{-1}$ (No.) | Non-effective tillers $hill^{-1}$ (No.) | Panicle length (cm) | Filled grains $panicle^{-1}$ (No.) | Unfilled grains $panicle^{-1}$ (No.) |
|---|---|---|---|---|---|---|
| **Rice varieties** | | | | | | |
| $V_1$ | 14.92 a | 12.73 a | 2.19 b | 24.81 a | 80.95 a | 7.01 a |
| $V_2$ | 13.15 b | 10.37 b | 2.77 a | 23.59 b | 74.49 b | 6.24 b |
| **$LSD_{(0.05)}$** | **1.527** | **1.543** | **0.564** | **0.901** | **5.415** | **0.489** |
| **Level of significance** | **0.05** | **0.05** | **0.05** | **0.05** | **0.05** | **0.05** |
| **CV(%)** | **6.93** | **8.50** | **14.48** | **2.38** | **4.45** | **4.70** |
| **Number of seedlings $hill^{-1}$** | | | | | | |
| $S_1$ | 14.57 b | 11.97 ab | 2.60 b | 24.81 ab | 82.00 ab | 6.13 c |
| $S_2$ | 15.27 a | 12.20 a | 3.07 a | 25.83 a | 83.47 a | 6.60 b |
| $S_3$ | 14.27 bc | 11.90 ab | 2.37 c | 24.29 b | 80.70 ab | 5.47 d |
| $S_4$ | 13.73 c | 11.43 b | 2.30 c | 24.54 b | 79.23 b | 6.07 c |
| $S_5$ | 12.33 d | 10.27 c | 2.07 d | 21.54 c | 63.20 c | 8.87 a |
| **$LSD_{(0.05)}$** | **0.549** | **0.531** | **0.176** | **1.052** | **3.240** | **0.439** |
| **Level of significance** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** |
| **CV(%)** | **3.92** | **4.60** | **7.10** | **4.35** | **4.17** | **6.64** |

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly at 0.05 level of probability

$V_1$: Hybrid (Chamak)
$V_2$: Inbred (BRRI dhan62)

$S_1$: 1 seedling $hill^{-1}$
$S_2$: 2 seedlings $hill^{-1}$
$S_3$: 3 seedlings $hill^{-1}$
$S_4$: 4 seedlings $hill^{-1}$
$S_5$: 5 seedlings $hill^{-1}$

**Table 8. Interaction effect of varieties and number of seedlings hill$^{-1}$ on yield contributing characters of rice**

| Combination of treatments | Total tillers hill$^{-1}$ (No.) | Effective tillers hill$^{-1}$ (No.) | Non-effective tillers hill$^{-1}$ (No.) | Panicle length (cm) | Filled grains panicle$^{-1}$ (No.) | Unfilled grains panicle$^{-1}$ (No.) |
|---|---|---|---|---|---|---|
| $V_1S_1$ | 15.20 b | 13.20 ab | 2.00 d-f | 25.34 ab | 85.27 ab | 6.47 cd |
| $V_1S_2$ | 16.80 a | 13.87 a | 2.93 ab | 26.58 a | 90.53 a | 7.00 c |
| $V_1S_3$ | 15.53 b | 13.60 a | 1.93 ef | 25.88 ab | 81.87 bc | 6.07 d |
| $V_1S_4$ | 14.73 bc | 12.53 b | 2.20 c-e | 24.31 bc | 82.20 bc | 6.27 cd |
| $V_1S_5$ | 12.33 e | 10.47 c | 1.87 f | 21.93 d | 64.87 d | 9.27 a |
| $V_2S_1$ | 13.93 cd | 10.73 c | 3.20 a | 24.27 bc | 78.73 c | 5.80 d |
| $V_2S_2$ | 13.73 d | 10.53 c | 3.20 a | 25.08 ab | 76.40 c | 6.20 cd |
| $V_2S_3$ | 13.00 de | 10.20 c | 2.80 b | 22.70 cd | 79.53 bc | 4.87 e |
| $V_2S_4$ | 12.73 e | 10.33 c | 2.40 c | 24.77 ab | 76.27 c | 5.87 d |
| $V_2S_5$ | 12.33 e | 10.07 c | 2.27 cd | 21.15 d | 61.53 d | 8.47 b |
| **$LSD_{(0.05)}$** | **0.951** | **0.919** | **0.305** | **1.822** | **5.611** | **0.760** |
| **Level of significance** | **0.01** | **0.01** | **0.01** | **0.05** | **0.05** | **0.05** |
| **CV(%)** | **3.92** | **4.60** | **7.10** | **4.35** | **4.17** | **6.64** |

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly at 0.05 level of probability

$V_1$: Hybrid (Chamak)
$V_2$: Inbred (BRRI dhan62)

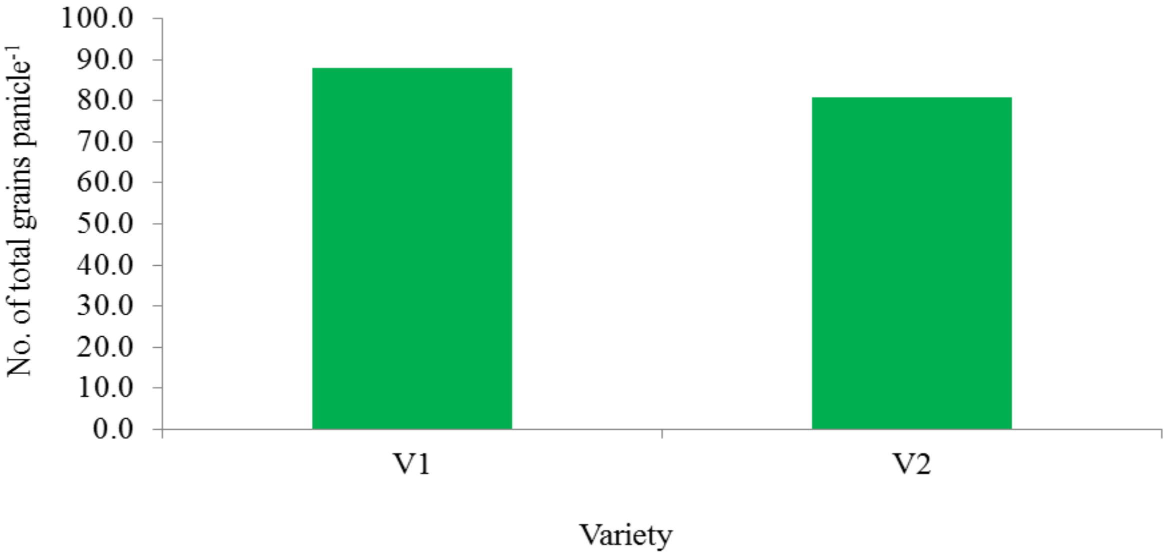
$S_1$: 1 seedling hill$^{-1}$
$S_2$: 2 seedlings hill$^{-1}$
$S_3$: 3 seedlings hill$^{-1}$
$S_4$: 4 seedlings hill$^{-1}$
$S_5$: 5 seedlings hill$^{-1}$

### 4.2.7 Total grains panicle$^{-1}$ (No.)

Total grains panicle$^{-1}$ varied significantly due to rice varieties (Figure 5). The maximum number of total grains panicle$^{-1}$ was observed from $V_1$ (87.96) and the minimum number of total grains panicle$^{-1}$ was recorded from $V_2$ (80.73). Guilani *et al*. (2003) observed that grain number panicle$^{-1}$ was not significantly different among cultivars.

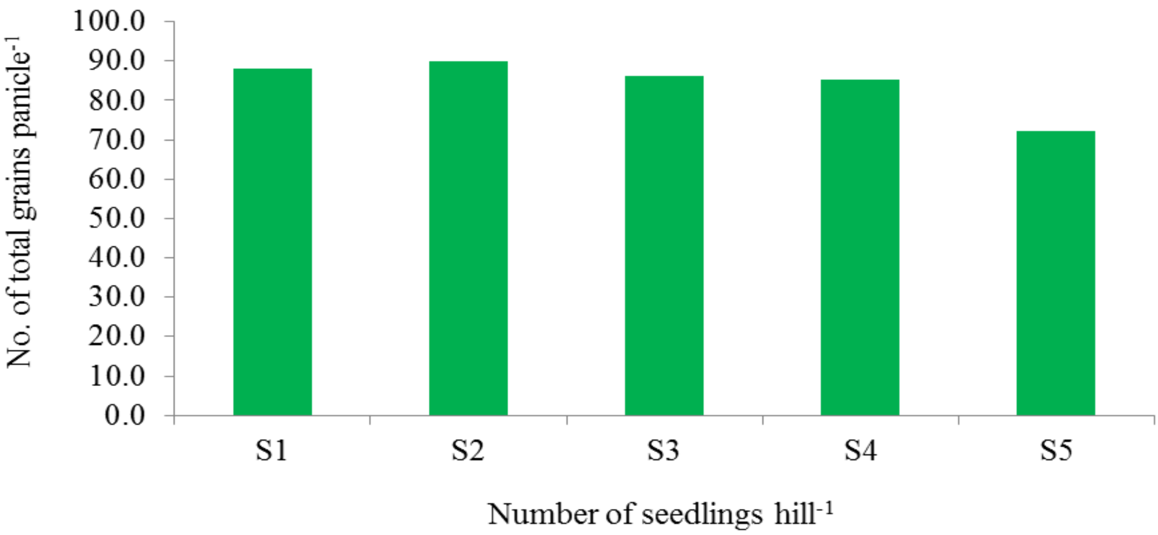
Number of seedlings hill$^{-1}$ showed significant variation on total grains panicle$^{-1}$ (Figure 6). The maximum number of total grains panicle$^{-1}$ was found from $S_2$ (90.07) which was statistically similar to $S_1$ (88.13), whereas the minimum number of total grains panicle$^{-1}$ from $S_5$ (72.07).

Significant variation was recorded due to the interaction effect of rice varieties and number of seedlings hill$^{-1}$ on total grains panicle$^{-1}$ (Figure 7). The maximum number of total grains panicle$^{-1}$ was recorded from the combination of $V_1S_2$ (97.53) and the minimum number of total grains panicle$^{-1}$ was found from $V_2S_5$ (70.00) which was statistically similar to $V_1S_5$ (74.13).



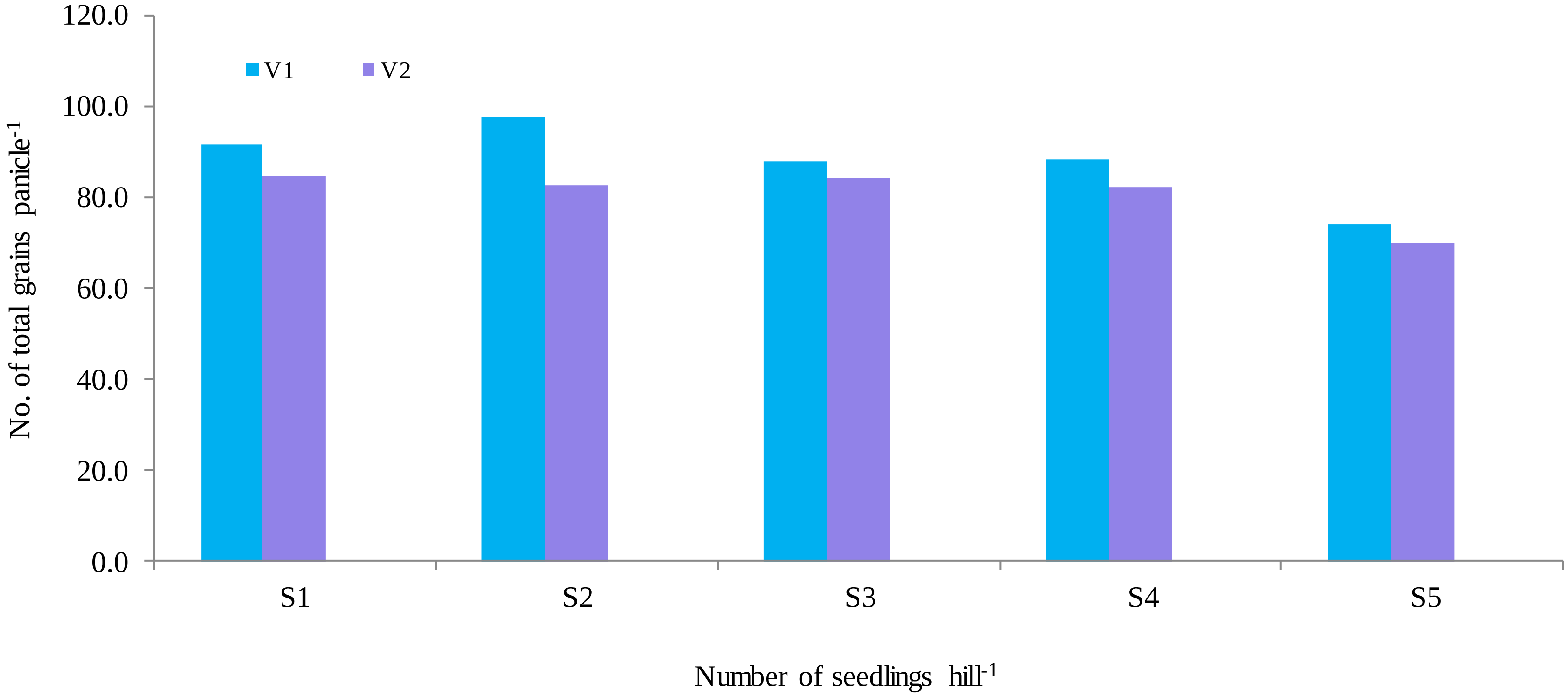

$V_1$: Hybrid (Chamak) $V_2$: Inbred (BRRI dhan62)

Figure 5. Effect of varieties on total grains $panicle^{-1}$ of rice ($LSD_{0.05}$ = 5.661)




$S_1$: 1 seedling $hill^{-1}$ $S_2$: 2 seedlings $hill^{-1}$
$S_3$: 3 seedlings $hill^{-1}$ $S_4$: 4 seedlings $hill^{-1}$
$S_5$: 5 seedlings $hill^{-1}$

Figure 6. Effect of number of seedlings $hill^{-1}$ on total grains $panicle^{-1}$ of rice ($LSD_{0.05}$ = 3.326)




$V_1$: Hybrid (Chamak)

$V_2$: Inbred (BRRI dhan62)

$S_1$: 1 seedling hill$^{-1}$ $S_2$: 2 seedlings hill$^{-1}$

$S_3$: 3 seedlings hill$^{-1}$ $S_4$: 4 seedlings hill$^{-1}$

$S_5$: 5 seedlings hill$^{-1}$

Figure 7. Interaction effect of varieties and number of seedlings hill$^{-1}$ on total grains panicle$^{-1}$ of rice ($LSD_{0.05}$ = 5.760)

### 4.2.8 Weight of 1000 seeds (g)

Rice varieties showed significant variation on weight of 1000 seeds (Figure 8). The maximum weight of 1000 seeds was found from $V_1$ (24.49 g) and the minimum weight of 1000 seeds was observed from $V_2$ (23.21 g). Wang *et al*. (2006) reported that compared with conventional cultivars, the hybrids had heavier seeds.

Significant variation was recorded due to the number of seedlings hill$^{-1}$ on weight of 1000 seeds (Figure 9). The maximum weight of 1000 seeds was attained from $S_2$ (25.66 g) which was closely followed by $S_1$ (24.41 g) and $S_3$ (24.07 g) and they were statistically similar, whereas, the minimum weight from $S_5$ (22.00 g).

Weight of 1000 seeds showed significant difference due to the interaction effect of rice varieties and number of seedlings hill$^{-1}$ (Figure 10). The maximum weight of 1000 seeds was found from the combination of $V_1S_2$ (26.39 g) and the minimum weight of 1000 seeds was found from $V_2S_5$ (21.58 g).

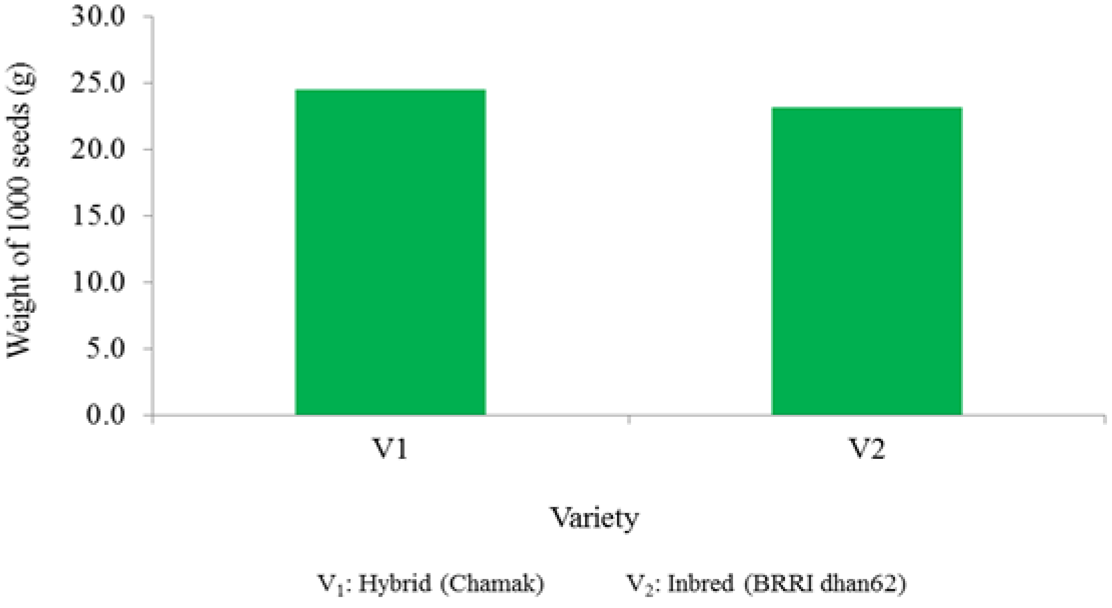



Figure 8. Effect of varieties on weight of 1000 seeds of rice ($LSD_{0.05}$ = 1.0)

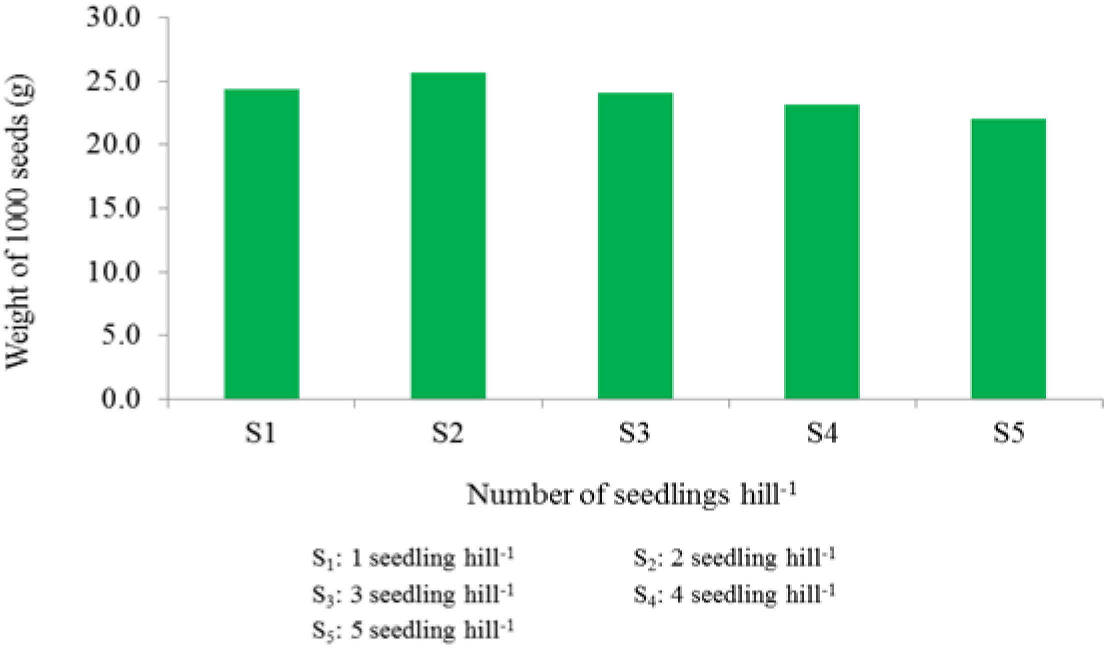
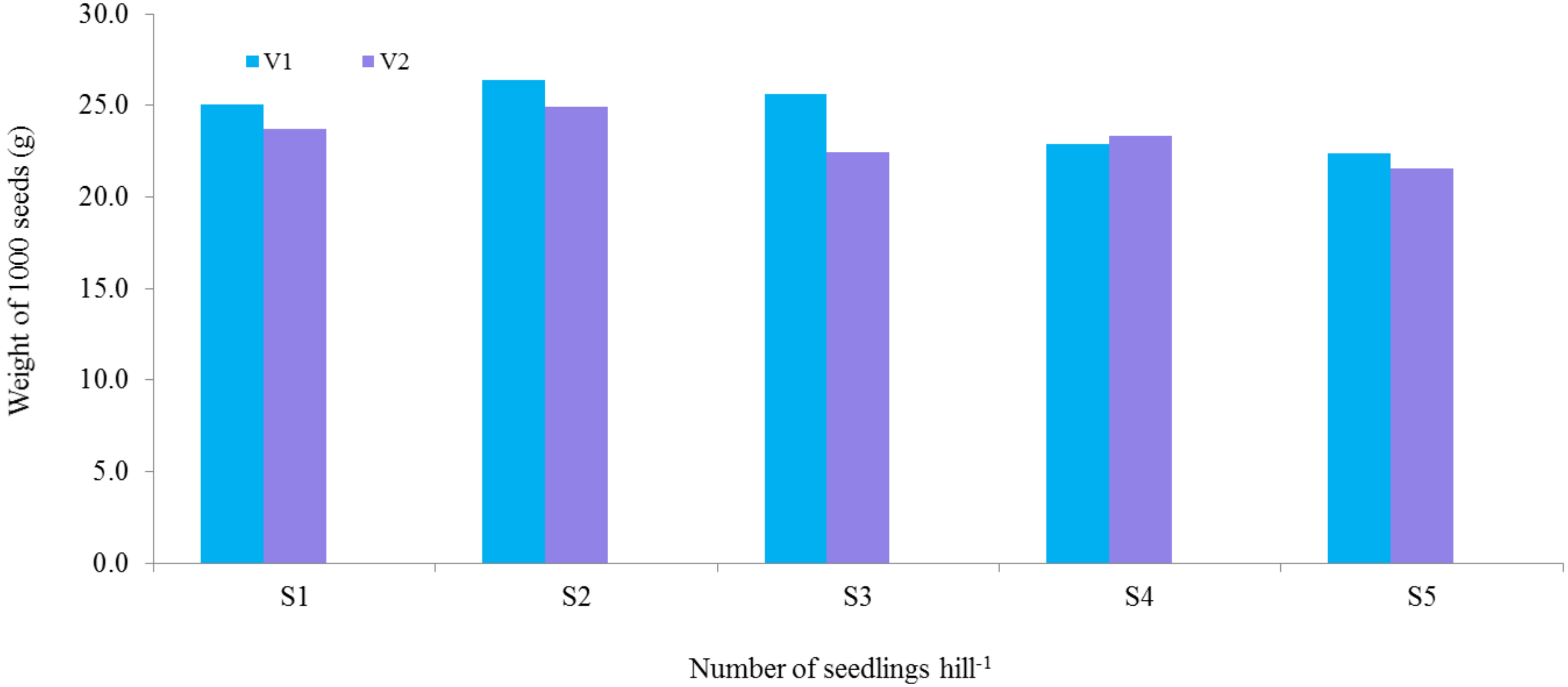



Figure 9. Effect of number of seedlings $hill^{-1}$ on weight of 1000 seeds of rice ($LSD_{0.05}$ = 1.643)




$V_1$: Hybrid (Chamak)

$V_2$: Inbred (BRRI dhan62)

$S_1$: 1 seedling hill$^{-1}$ $S_2$: 2 seedlings hill$^{-1}$

$S_3$: 3 seedlings hill$^{-1}$ $S_4$: 4 seedlings hill$^{-1}$

$S_5$: 5 seedlings hill$^{-1}$

Figure 10. Interaction effect of varieties and number of seedlings hill$^{-1}$ on weight of 1000 seeds of rice ($LSD_{0.05}$ = 1.643)

### 4.3 Yield (t $ha^{-1}$)

#### 4.3.1 Grain yield (t $ha^{-1}$)

Grain yield varied significantly due to rice varieties (Table 9). The higher grain yield was observed from $V_1$ (4.06 t $ha^{-1}$) while the lower grain yield was recorded from $V_2$ (3.04 t $ha^{-1}$). Wang *et al*. (2006) reported that compared with conventional cultivars, the hybrids had larger panicles, heavier seeds, resulting in an average yield increase of 7.27%. Kanfany *et al*. (2014) reported that grain yield of rice hybrids (bred by the International Rice Research Institute) was not significantly higher than that of the check cultivar.

Number of seedlings $hill^{-1}$ showed significant differences on grain yield (Table 9). Data revealed that the highest grain yield was found from $S_2$ (4.10 t $ha^{-1}$) which was statistically similar to $S_1$ (3.93 t $ha^{-1}$). On the other hand, the lowest grain yield was recorded from $S_5$ (2.93 t $ha^{-1}$). Sarkar *et al*. (2011) reported that the highest grain yield was found when 2 tiller seedlings were transplanted $hill^{-1}$. Faruk *et al*. (2009) reported that different levels of number of seedlings $hill^{-1}$ significantly influenced grain yields and higher grain yield was achieved from two than one or three seedlings $hill^{-1}$.

Significant variation was recorded due to the interaction effect of rice varieties and number of seedlings $hill^{-1}$ on grain yield of rice (Table 10). The highest grain yield was recorded from the combination of $V_1S_2$ (4.74 t $ha^{-1}$) which was statistically different from others and the lowest grain yield was found from $V_2S_5$ (2.55 t $ha^{-1}$).

#### 4.3.2 Straw yield (t $ha^{-1}$)

Significant variation was recorded due to rice varieties on straw yield (Table 9). The higher straw yield was recorded from $V_1$ (4.67 t $ha^{-1}$) and the lower straw yield was found from $V_2$ (4.21 t $ha^{-1}$). Patel (2000) observed significantly higher grain and straw yield from Kranti than IR36.

Straw yield varied significantly due to number of seedlings hill$^{-1}$ under the present trial (Table 9). The highest straw yield was found from $S_2$ (4.80 t ha$^{-1}$) which was statistically similar to $S_1$ (4.67 t ha$^{-1}$) while the lowest straw yield was recorded from $S_5$ (4.14 t ha$^{-1}$) which was statistically similar to $S_4$ (4.21 t ha$^{-1}$). Faruk *et al*. (2009) reported that different levels of number of seedlings hill$^{-1}$ significantly influenced straw yields.

Interaction effect of rice varieties and number of seedlings hill$^{-1}$ showed significant variation on straw yield of rice (Table 10). The highest straw yield was found from the combination of $V_1S_2$ (4.99 t ha$^{-1}$) which was statistically similar to $V_1S_3$ (4.98 t ha$^{-1}$) and also $V_1S_1$ (4.85 t ha$^{-1}$), whereas the lowest straw yield was found from $V_2S_5$ (4.02 t ha$^{-1}$).

### 4.3.3 Biological yield (t ha$^{-1}$)

Biological yield varied significantly due to rice varieties (Table 9). The higher biological yield was recorded from $V_1$ (8.74 t ha$^{-1}$), whereas the lower biological yield was observed from $V_2$ (7.25 t ha$^{-1}$).

Number of seedlings hill$^{-1}$ showed significant differences in terms of biological yield (Table 9). The highest biological yield was obtained from $S_2$ (8.90 t ha$^{-1}$) which was followed by $S_1$ (8.60 t ha$^{-1}$) while the lowest biological yield from $S_5$ (7.07 t ha$^{-1}$).

Significant variation was recorded due to the interaction effect of rice varieties and number of seedlings hill$^{-1}$ on biological yield of rice (Table 10). The highest biological yield was found from the combination of $V_1S_2$ (9.72 t ha$^{-1}$), whereas the lowest biological yield was found from $V_2S_3$ (6.52 t ha$^{-1}$) which was statistically similar to $V_2S_5$ (6.57 t ha$^{-1}$).

### 4.3.4 Harvest index (%)

Harvest index varied significantly due to rice varieties (Table 9). The highest harvest index was observed from $V_1$ (46.38%) and the lowest harvest index was recorded from $V_2$ (41.79%).

Number of seedlings hill$^{-1}$ showed significant differences in terms of harvest index (Table 9). Data revealed that the higher harvest index was found from $S_2$ (45.83%), which was statistically similar to $S_1$ (45.59%) and also $S_3$ (44.07%), whereas the lowest harvest index was obtained from $S_5$ (41.27%). Sarkar *et al*. (2011) reported that the highest harvest index was found when 2 tiller seedlings were transplanted hill$^{-1}$.

Interaction effect of different rice varieties and number of seedlings hill$^{-1}$ showed significant variation on harvest index (Table 10). The highest harvest index was recorded from treatment combination of $V_1S_2$ (48.69%) which was statistically similar to $V_1S_1$ (47.21%), $V_1S_3$ (46.20%) and $V_1S_4$ (46.08%) and the lowest harvest index was found from $V_2S_5$ (38.83%).

**Table 9. Effect of varieties and number of seedlings hill$^{-1}$ on yield of rice**

| Treatments | Grain yield (t ha$^{-1}$) | Straw yield (t ha$^{-1}$) | Biological yield (t ha$^{-1}$) | Harvest index (%) |
|---|---|---|---|---|
| **Rice varieties** | | | | |
| $V_1$ | 4.06 a | 4.67 a | 8.74 a | 46.38 a |
| $V_2$ | 3.04 b | 4.21 b | 7.25 b | 41.79 b |
| **$LSD_{(0.05)}$** | **0.523** | **0.447** | **0.665** | **4.452** |
| **Level of significance** | **0.01** | **0.05** | **0.01** | **0.05** |
| **CV(%)** | **9.38** | **6.41** | **5.30** | **6.43** |
| **Number of seedlings hill$^{-1}$** | | | | |
| $S_1$ | 3.93 a | 4.67 a | 8.60 b | 45.59 ab |
| $S_2$ | 4.10 a | 4.80 a | 8.90 a | 45.83 a |
| $S_3$ | 3.51 b | 4.38 b | 7.89 c | 44.07 ab |
| $S_4$ | 3.28 c | 4.21 bc | 7.49 d | 43.67 b |
| $S_5$ | 2.93 d | 4.14 c | 7.07 e | 41.27 c |
| **$LSD_{(0.05)}$** | **0.190** | **0.197** | **0.241** | **1.906** |
| **Level of significance** | **0.01** | **0.01** | **0.01** | **0.01** |
| **CV(%)** | **5.31** | **4.42** | **3.01** | **4.33** |

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly at 0.05 level of probability

$V_1$: Hybrid (Chamak)
$V_2$: Inbred (BRRI dhan62)

$S_1$: 1 seedling hill$^{-1}$
$S_2$: 2 seedlings hill$^{-1}$
$S_3$: 3 seedlings hill$^{-1}$
$S_4$: 4 seedlings hill$^{-1}$
$S_5$: 5 seedlings hill$^{-1}$

**Table 10. Interaction effect of varieties and number of seedlings hill$^{-1}$ on yield of rice**

| Combination of treatments | Grain yield (t ha$^{-1}$) | Straw yield (t ha$^{-1}$) | Biological yield (t ha$^{-1}$) | Harvest index (%) |
|---|---|---|---|---|
| $V_1S_1$ | 4.34 b | 4.85 ab | 9.19 b | 47.21 ab |
| $V_1S_2$ | 4.74 a | 4.99 a | 9.72 a | 48.69 a |
| $V_1S_3$ | 4.28 b | 4.98 a | 9.26 b | 46.20 a-c |
| $V_1S_4$ | 3.65 c | 4.27 c-e | 7.93 cd | 46.08 a-c |
| $V_1S_5$ | 3.31 c | 4.27 c-e | 7.58 d | 43.71 b-d |
| $V_2S_1$ | 3.52 c | 4.48 cd | 8.00 cd | 43.97 b-d |
| $V_2S_2$ | 3.47 c | 4.61 bc | 8.08 c | 42.96 cd |
| $V_2S_3$ | 2.74 de | 3.79 f | 6.52 f | 41.95 de |
| $V_2S_4$ | 2.91 d | 4.15 de | 7.06 e | 41.26 de |
| $V_2S_5$ | 2.55 e | 4.02 ef | 6.57 f | 38.83 e |
| **$LSD_{(0.05)}$** | **0.328** | **0.342** | **0.417** | **3.302** |
| **Level of significance** | **0.01** | **0.01** | **0.01** | **0.05** |
| **CV(%)** | **5.31** | **4.42** | **3.01** | **4.33** |

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly at 0.05 level of probability

$V_1$: Hybrid (Chamak)
$V_2$: Inbred (BRRI dhan62)

$S_1$: 1 seedling hill$^{-1}$
$S_2$: 2 seedlings hill$^{-1}$
$S_3$: 3 seedlings hill$^{-1}$
$S_4$: 4 seedlings hill$^{-1}$
$S_5$: 5 seedlings hill$^{-1}$

# CHAPTER V

# SUMMARY AND CONCLUSION

The experiment was conducted at the farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period of July to November 2014 to find out the effect of seedlings hill$^{-1}$ on yield and yield components of hybrid and inbred rice varieties. The experiment comprised of two factors. Factor A: Rice variety (2) -$V_1$: Hybrid (Chamak), $V_2$: Inbred (BRRI dhan62) and Factor B: Number of seedlings hill$^{-1}$(5 levels) -$S_1$: 1 seedling hill$^{-1}$, $S_2$: 2 seedling hill$^{-1}$, $S_3$: 3 seedlings hill$^{-1}$, $S_4$: 4 seedlings hill$^{-1}$ and $S_5$: 5 seedlings hill$^{-1}$. The experiment was laid out in split-plot design with three replications. Data on different growth characters, yield and yield components were recorded and analyzed.

Results of the experiment showed that variety had a significant influence on all the selected parameters. At harvest, the taller plant (112.17 cm) was recorded from $V_1$ (hybrid) while the shorter plant (104.96 cm) from $V_2$ (inbred). At 55 DAT, the highest number of tillers hill$^{-1}$(16.29) and the maximum dry matter content hill$^{-1}$ (15.78 g) was recorded from $V_1$ while the lowest number of tillers hill$^{-1}$(14.61) and the minimum dry matter content hill$^{-1}$(14.27g) was recorded from $V_2$ . In case of number of effective tillers hill$^{-1}$, number of total tillers hill$^{-1}$, panicle length (cm), number of filled grains panicle$^{-1}$, number of unfilled grains panicle$^{-1}$, number of total grains panicle$^{-1}$, weight of 1000 seeds (g), the highest value (12.73, 14.92, 24.81cm, 80.95, 87.96 and 24.49 g, respectively ) were observed from $V_1$ , whereas the lowest value ( 10.37, 13.15, 23.59 cm, 74.49, 80.73 and 23.21 g, respectively) from $V_2$ . The highest grain yield was observed from $V_1$ (4.06 t ha$^{-1}$) and the lowest grain yield was recorded from $V_2$ (3.04 t ha$^{-1}$). The highest straw yield was observed from $V_1$ (4.67 t ha$^{-1}$) and the lowest straw yield was recorded from $V_2$ (4.21 t ha$^{-1}$). The highest biological yield was observed from $V_1$ (8.74 t ha$^{-1}$) and the low  est biological yield was recorded from $V_2$ (7.25 t $ha^{-1}$). The highest harvest index was observed from $V_1$ (46.38%) while the lowest harvest index was recorded from $V_2$ (41.79%).

For number of seedlings $hill^{-1}$, at harves t, the highest plant height (111.09 cm) was found from $S_2$ that was statistically similar to $S_1$, $S_3$ and $S_4$, whereas, the shortest plant (101.32 cm) was found from $S_5$. At 55 DAT, the maximum number of tillers $hill^{-1}$ was found from $S_2$ (16.73), whereas the minimum number of tillers $hill^{-1}$ from $S_5$ (13.67). At 55 DAT, the maximum dry matter content $hill^{-1}$ was found from $S_2$ (17.10 g), whereas the minimum dry matter content $hill^{-1}$ from $S_5$ (11.97 g). The maximum number of effective tillers $hill^{-1}$ was found from $S_2$ (12.20) which was statistically similar to $S_1$ and $S_3$, whereas the minimum number of effective tillers $hill^{-1}$ from $S_5$ (10.27). The maximum number of non-effective tillers $hill^{-1}$ was found from $S_2$ (3.07), whereas the minimum number of non-effective tillers $hill^{-1}$ from $S_5$ (2.07). The highest number of total tillers $hill^{-1}$ was found from $S_2$ (15.27), whereas the minimum number of total tillers $hill^{-1}$ from $S_5$ (12.33). The longest panicle was found from $S_2$ (25.83 cm) which was statistically similar to $S_1$ (24.81), whereas the shortest panicle from $S_4$ (21.54 cm). The maximum number of filled grains $panicle^{-1}$ was found from $S_2$ (83.47) which was statistically similar to $S_1$ (82.00) and $S_3$ (80.70), whereas the minimum number of filled grains $panicle^{-1}$ from $S_5$ (63.20). The maximum number of unfilled grains $panicle^{-1}$ was found from $S_5$ (8.87), whereas the minimum number of unfilled grains $panicle^{-1}$ from $S_3$ (5.47). The maximum number of total grains $panicle^{-1}$ was found from $S_2$ (90.07) which was statistically similar to $S_1$ (88.13), whereas the minimum number of total grains $panicle^{-1}$ from $S_5$ (72.07). The maximum weight of 1000 seeds was found from $S_2$ (25.66 g) which was followed by $S_1$ (24.41 g) and $S_3$ (24.07 g), whereas the minimum weight of 1000 seeds from $S_5$ (22.00 g). The highest grain yield was found from $S_2$ (4.10 t $ha^{-1}$), whereas the lowest grain yield from $S_5$ (2.93 t $ha^{-1}$). The highest straw yield was found from $S_2$ (4.80 t $ha^{-1}$), whereas the lowest straw yield from $S_5$ (4.14 t $ha^{-1}$) which was statistically similar to $S_4$ (4.21 t $ha^{-1}$). The highest biological yield was found from $S_2$ (8.90 t $ha^{-1}$) which was statistically similar to $S_1$ (45.51 t ha$^{-1}$) and $S_3$ (44.07 t ha$^{-1}$), whereas the lowest biological yield was observed from $S_5$ (7.07 t ha$^{-1}$). The highest harvest index was found from $S_2$ (45.83%), whereas the lowest harvest index from $S_5$ (41.27%).

Interaction effect of varieties and number of seedlings hill$^{-1}$ was found significant for all the studied parameters. The highest plant height (117.05 cm) at harvest was found in $V_1S_2$ that was statistically similar to $V_1S_3$ and $V_1S_1$. At 55 DAT, the maximum number of tillers hill$^{-1}$ was recorded from the combination of $V_1S_2$ (17.80) and the minimum number of tillers hill$^{-1}$ was found from $V_2S_5$ (13.33). At 55 DAT, the maximum dry matter content hill$^{-1}$ was recorded from the combination of $V_1S_2$ (18.51 g) and the minimum dry matter content hill$^{-1}$ was found from $V_2S_5$ (11.54 g). The maximum number of effective tillers hill$^{-1}$ was recorded from the combination of $V_1S_2$ (13.87) and the minimum number of effective tillers hill$^{-1}$ from $V_2S_5$ (10.07). The maximum number of non-effective tillers hill$^{-1}$ was recorded from the combination of $V_2S_1$ (3.20) and the minimum number of non-effective tillers hill$^{-1}$ was found from $V_1S_5$ (1.87). The maximum number of total tillers hill$^{-1}$ was recorded from the combination of $V_1S_2$ (16.80) and the minimum number of total tillers hill$^{-1}$ was found from $V_2S_5$ (12.33). The longest panicle was recorded from the combination of $V_1S_2$ (26.58 cm) and the shortest panicle was found from $V_2S_5$ (21.15 cm). The maximum number of filled grains panicle$^{-1}$ was recorded from the combination of $V_1S_2$ (90.53) and the minimum number of filled grains panicle$^{-1}$ was found from $V_2S_5$ (61.53). The maximum number of unfilled grains panicle$^{-1}$ was recorded from the combination of $V_1S_5$ (9.27) and the minimum number of unfilled grains panicle$^{-1}$ was found from $V_2S_3$ (4.87). The maximum number of total grains panicle$^{-1}$ was recorded from the combination of $V_1S_2$ (97.53) and the minimum number of total grains panicle$^{-1}$ was found from $V_2S_5$ (70.00). The maximum weight of 1000 seeds was recorded from the combination of $V_1S_2$ (26.39 g) and the minimum weight of 1000 seeds was found from treatment combination of $V_2S_5$ (21.58 g). The highest grain yield was recorded from the combination of $V_1S_2$ (4.74 t ha$^{-1}$) and the lowest grain yield was found from $V_2S_5$ (2.55 t ha$^{-1}$) which was statistically similar to $V_2S_3$ (3.79 t $ha^{-1}$). The highest straw yield was recorded from the combination of $V_1S_2$ (4.99 t $ha^{-1}$) which was statistically similar to $V_1S_3$ (4.98 t $ha^{-1}$) and $V_1S_1$ (4.85 t $ha^{-1}$), whereas the lowest straw yield was found from $V_2S_3$ (3.79 t $ha^{-1}$) which was statistically similar to $V_2S_5$ (4.02 t $ha^{-1}$). The highest biological yield was recorded from the combination of $V_1S_2$ (9.72 t $ha^{-1}$) and the lowest biological yield was found from $V_2S_3$ (6.52 t $ha^{-1}$) which was statistically similar to $V_2S_5$ (6.57 t $ha^{-1}$). The highest harvest index was recorded from the combination of $V_1S_2$ (48.69%) and the lowest harvest index was found from $V_2S_5$ (38.83%).

From the above results it can be concluded that Hybrid (Chamak) variety provided the best yield with 2 seedlings $hill^{-1}$. The inbred variety with one to two seedlings per hill showed the higher yield. Considering the results obtained from the present experiment, further studies in the following areas might be suggested:

- Other variety (s) with different management practices might be included for future study,
- Such types of study is needed in different agro-ecological zones (AEZ) of Bangladesh for testing the regional compliance and other quality attributes.

## REFERENCES


Ahmed, M.R., Rashid, M.A., Alam, M.S., Billah, K.A. and Jameel, F. (1997). Performance of Eight Transplant Aman Rice Varieties under Irrigated Conditions. *Bangladesh Rice J.*, **8**(1&2): 43-44.

Akbar, M.K. (2004). Response of hybrid and inbred rice varieties to different seedlings ages under system of rice intensification in transplant aman season. M.S. (Ag.) Thesis, Dept. Agron. B.A.U., Mymensingh.

Alam, F. (2006). Effect of spacing, number of seedlings hill$^{-1}$ and fertilizer management on the performance of *Boro* rice cv. BRRI dhan29. M. S. Thesis, Dept. Agron., Bangladesh Agril. Univ., Mymensingh. pp. 24-27.

Alam, M.S., Baki, M.A., Sultana, M.S., Ali, K.J. and Islam, M.S. (2012). Effect of variety, spacing and number of seedlings per hill on the yield potentials of transplant aman rice. *Intl. J. Agron. Agril. Res. (IJAAR)*. **2**(12): 10-15.

Ali, H. (2008). Effect of spacing and number of seedling per hill on the performance of BRRI dhan41. Department of Agronomy, Bangladesh Agricultural University, Mymensingh.

Ali, M.G., Mannan, M.A., Halder, K.P. and Siddique, S.B. (1993). Effect of planting dates on the growth and yield of modern transplanted *aman* rice. *Annals Bangladesh Agric*., **3**(2): 103-108.

Amin, M.R., Hamid, A., Choudhury, R.U., Raquibullah, S.M. and Asaduzzaman M. (2006). Nitrogen Fertilizer Effect on Tillering, Dry Matter Production and Yield of Traditional Varieties of Rice. *Intl. J. Suatain. Crop Prod.*, **1**(1): 17-20.

Asbur, Y. (2013). Effect of seedling number per hill and seedling age on plant growth and grain yield ciherang rice. The 2nd International Conference on Multidisciplinary Research (ICMR). October 2-4, 2013, Banda Aceh, Indonesia. pp. 9-15.

Asif, M., Chudhury, F.M. and Saeed, M. (1998). Panicle structure, kernel quality and yield of fine rice as influenced by different NPK levels and per hill seedlings density. *Pakistan J. Agril. Sci*., **34**(1-40):73-77.

Banik, P., Sarkar, B., Sasmel, T., Ghosol, P.K. and Bagohi, D.K. (1997). Effect of different numbers and age of seedlings on rice cultivars in low land plateau region of Bihar. *Indian J. Agron*., **42**(2): 265-268.

BBS. (2014). Statistical Yearbook of Bangladesh. Bangladesh Bureau of Statistics. Statistics Division, Ministry of Planning, Govt. of Peoples Republic of Bangladesh. Dhaka. Bangladesh. p. 64.

Bhowmick, M.K., Nayar, R. and Ray, D. (2002). Herbicides status on weed management, crop phytotoxicity, growth and yield of dry season rice. *Ann. Agril. Res.*, **23**(1): 116-122.

Bhowmick, N. and Nayak, R.L. (2000). Response of hybrid rice (*Oryza sativa*) varieties to nitrogen, phosphorus and potassium fertilizers during dry (boro) season in West Bengal. *Indian J. Agron.*, **45**(2): 323-326.

Bhowmik, S.K., Sarkar, M.A.R. and Zaman, F. (2012). Effect of spacing and number of seedlings per hill on the performance of *aus* rice cv. NERICA 1 under dry direct seeded rice (DDSR) system of cultivation. *J. Bangladesh Agril. Univ*., **10**(2): 191-195.

Bhuiyan, M.S.H., Zahan, A., Khatun, H., Iqbal, M., Alam, F. and Manir, M.R. (2014). Yield performance of newly developed test crossed hybrid rice variety. *Intl. J. Agron. Agril. Res*., **5**(4): 48-54.

Bhuiyan, N.I. (2004). The Hybrid Rice Program for Bangladesh. **In**: 'Hybrid Rice in Bangladesh: Progress and Future Strategies'. pp. 3-5. Bangladesh Rice Res. Inst. Publication No. 138.

BINA. (1993). Annual Report (1992-93). Bangladesh Inst. Nucl. Agric. P.O. Box No. 4. Mymensingh. pp. 143-147.

Biswas, K.K., Hussain, I.A.S.M., Abuyusuf, M., Hassan, M.Z. and Noor-A-Jannat. (2015). Hill spacing and number of seedlings per hill on the yield of T. *aman* rice (var. BRRI dhan52) in the tidal ecosystem. *American Res. Thoughts*. **1**(11): 2727-2744.

BRRI (Bangladesh Rice Research Institute). (1991). Annual Report for 1988. BRRI Pub. No. 98. Joydebpur, Gazipur, Bangladesh. pp. 7-300.

BRRI (Bangladesh Rice Research Institute). (1999). Annual Report for January 1998- June 1999. Bangladesh Rice Res. Inst. Gazipur, Pub. 135. pp. 9-243.

BRRI (Bangladesh Rice Research Institute). (2013). Adhunik Dhaner Chash. Joydebpur, Dhaka. p. 80.

BRRI. (1985). Annual report for 1982. Bangladesh Rice Research Institute, Joydebpur, Gazipur, Bangladesh. BRRI pub. No. 79. pp. 236-238.

BRRI. (1991). Annual Report for 1988. Bangladesh Rice Research Institute, Joydebpur, Gazipur. pp. 8-15.

BRRI. (1994). Annual Report for 1993. Bangladesh Rice Research Institute, Jodebpur, Gazipur. pp. 8-9.

BRRI. (1995). Adhunik Dhaner Chash (in bengali). Bangladesh Rice Research Institute, Joydebpur, Gazipur. pp. 12-23.

BRRI. (1997). Adhunik Dhaner Chash (in bengali). Bangladesh Rice Research Institute, Joydebpur, Gazipur. pp. 15-18.

BRRI. (2003). Annual Internal Review, held on 19-23 October, 2003. Grain Quality and Nutrition Division. Bangladesh Rice Research Institute. pp. 1-20.

Chandra, B.V., Mahedvappa, M., Krishnamurthy, A.H. and Bhaskar, V. (1992). Performance of IRRI rice hybrids in Mandya, Karnataka, India. *Intl. Rice Res. Newsl*., **17**(2): 6.

Chen-Liang, C.Q., Li, Z.C. and Wang, X.K. (2000). Study on heterotic ecotype of two-line japonica hybrid rice in north China. *J. China Agric. Univ*., **5**(3): 30-40.

Chowdhury, M.J.U., Sarker, A.U., Sarkar. M.A.R. and Kashem, M.A. (1993). Effect of variety and number of seedlings hill$^{-1}$ on the yield and its components of late transplant *Aman* rice. *Bangladesh J. Agril. Sci*., **20**(2): 311-316.

Chowdhury, S.A., Majid, M.A., Huque, K.S., Islam, M. and Rahman, M.M. (1995). Effect of variety on yield and nutritive value of rice straw. *Asian-Australasian J. Ani. Sci*., **8**(4): 329-335.

Costa, D.J. and Hoque, M.N. (1986). Superimposed variety trial on T. *aman* [Transplanted rice in Bangladesh]. Proc. Central Review Workshop, On-Farm Research Div. Jul. 5-10. BARI., Joydebpur, Bangladesh. pp. 25-26.

Devaraju, K.M., Gowda, H. and Raju, B.M. (1998). Nitrogen response of Karnataka Rice Hybrid 2. *Intl. Rice Res. Notes*. **23**(2): 43.

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

FAO (Food and Agriculture Organization). (2006). Retrieved from: http// www.fao.org.

FAO (Food and Agriculture Organization). (1988). Production Yearbook for 1998. FAO, Rome, Italy. p. 118.

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

Faruk M.O., Rahman M.A. and Hasan M.A. (2009). Effect of seedling age and number of seedling per hill on the yield and yield contributing characters of BRRI dhan33. *Intl. J. Sustain. Crop Prod.*, **4**(1): 58-61.

Fatema, K., Rasul, M.G., Mian, M.A.K. and Rahman, M.M. (2011). Genetic variability for grain quality traits in aromatic rice (*Oryza sativa* L). *Bangladesh J. Pl. Breed. Genet*., **24**(2): 19-24.

Gomez K.A, Gomez A.A. (1984). Statistical procedure for agricultural research. International Rice Research Institute. *John Wiley and Sons*, New York, 139-240.

Guilani, A.A., Siadat, S.A. and Fathi, G. (2003). Effect of plant density and seedling age on yield and yield components in 3 rice cultivars in Khusestan growth conditions. *Iranian J. Agric. Sci*., **34**(2): 427-438.

Haque, M.S. and Nasiruddin, M. (1988). Effect of population density on yield and agronomic traits of deep water rice. In Proc. 1987. Intl. Deep Water Rice Workshop, Manila, Philippines. *Intl. Rice Res. Inst*. pp. 449-453.

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

Hosain, M.T., Ahamed, M.T., Haque, K.U., Islam, M.M., Fazle Bari, M.M. and Mahmud, J.A. (2014). Performance of Hybrid Rice (*Oryza sativa* L.)

Varieties at Different Transplanting Dates in *Aus* Season. *App. Sci. Report.* **1**(1): 1-4.

Hosain, S.M.A. and Alam, A.B.M.N. (1991). Productivity of cropping pattern of participating farmers. In: Fact searching and Intervention in two FSRDP Sites, Activities. Farming system Research and Development Programme, BAU, Mymensingh, Bangladesh. pp. 41-44.

Hossain, M. and Haque, M.S. (1990). Effect of population density on yield and agronomic traits of deep water rice. In Proc. 1987. Intl. Deep Water Rice Workshop, Manila, Philippines. *Intl. Rice Res. Inst*. pp. 449-453.

Hossain, M., Farooq, M., Basra, S. M. A. and Ahmed, N. (1989). Influence of seed priming techniques on the seedling establishment, yield and quality of hybrid rice. *Intl. J. of Agric. Biol*., **08**: 14-18.

Idris, M. and Matin, M.A. (1990). Response of four exotic strains of *aman* rice to urea. *Bangladesh J. Agric. Assoc.*, **118**: 48-61.

Ingale, M.S., Luis, B.K. and Brod, M.A. (2005). Effect of number of seedlings per hill (one or two) and nitrogen rates (50,100,150kg per ha) on the yield of Sahydri rice hybrid. *Japan J. Sci. Ind. Res.* **41**(4):205-2007.

IRRI (International Rice Research Institute). (2009). Rough rice production by country and geographical region-USDA. Trend in the rice economy. In: world rice statistics. Retrieved from: www.irri.org/science/ricestat.

Islam, M.A., Khan, M.N. and Rahman, M.M. (1980). Effects of cultural weed control practice on aus (summer) rice. *Bangladesh J. Agril. Sci*., **7**(1): 43-46.

Islam, M.R., Khan, M.A.H., Rahman, M.S., Alam, M.S. and Afrin, S. (2012). Effect of spacing and number of seedlings per hill on the yield performance of fine rice cv. Kalizira. *J. Agrofor. Environ*., **6**(1): 79-82.

Islam, M.Z. (1986). Effect of weeding regime on the growth and yield of BRRI dhan31 under varying seedlings number. M.S. Thesis, Dept. Agron. Bangladesh Agril. Univ., Mymensingh. pp. 76-77.

Islam, S. (1995). Effect of variety and fertilization on yield and nutrient uptake in transplant *aman* rice. M.S. thesis, Dept. Agron. Bangladesh Agril. Univ., Mymensingh. pp. 26-29.

Julfiquar, A.W., Haque, M.M., Haque, A.K.G.M.E. and Rashid, M.A. (2008). Current Status of Hybrid Rice Research and Future Program in Bangladesh. Proc. Workshop on use and development of hybrid rice in Bangladesh, held at BARC, 18-19, May, 2008.

Julfiquar, A.W., Haque, M.M., Haque, A.K.G.M.E. and Rashid, M.A. (1998). Current Status of Hybrid Rice Research and Future Program in Bangladesh. Proc. Workshop on Use and Development of Hybrid Rice in Bangladesh, held at BARC, 12-13, April, 1998.

Kamal, A.M.A., Azam, M.A. and Islam, M.A. (1988). Effect of cultivar and NPK combinations on the yield contributing characters of rice. *Bangladesh J. Agril. Sci.*, **15**(1): 105-110.

Kanfany, G., El-Namaky, R., Ndiaye, K., Traore, K. and Ortiz, R. (2014). Assessment of Rice Inbred Lines and Hybrids under Low Fertilizer Levels in Senegal. *Sustainability*. **6**: 1153-1162.

Khalifa, A.A.B.A. (2009). Physiological evaluation of some hybrid rice varieties under different sowing dates. *Australian J. Crop Sci.,* **3**(3):178-183.

Liu, X. (1995). You 92: new hybrid rice for late season. *Chinses Rice Res. Newsl*., **3**(2): 12.

Masum, M. (2009). Impact of hybrid rice on Bangladesh. In: ‘The Guardian”. pp. 56-58.

Masum, S.M., Ali, M.H. and Ullah, J. (2008). Growth and yield of two T. aman rice varieties as affected by seedling number per hill and urea supper granules. *J. Agric. Educ. Technol*., **11**(1&2): 51-58.

Miah, M.H., Karim, M.A., Rahman, M.S. and Islam, M.S. (1990). Performance of Nizersail mutants under different row spacing. *Bangladesh J. Train. Dev*., **3**(2): 31-34.

Mohapatra, A.K. (1989). Effect of dates of planting, age of seedling and levels of nitrogen on biological yield and harvest index of rice. *Environ. Ecol*., 7(4): 896-898.

Molla, M.A.H. (2001). Influence of seedling age and number of seedling on yield attributes and yield of hybrid rice in the wet season. *Intl. Rice. Res. Notes*. **26**(2): 73-74.

Momin, S.I. and Husain, M. (2009). Technology development and dissemination to augment rice production in Bangladesh. *In*: 'The Guardian'. pp. 33-35.

Muhammad, A.U.B., Sharker, M.S. and Nazir, M.S. (1987). The yield and yield components of fine rice as influenced by different spacings. *Pakistan J. Sci. Indust. Res*. **30**(7): 523-525.

Munoz, D., Gutierrez, P. and Carredor, E. (1996). Current status of research and development of hybrid rice technology in Colombia. In. Abst., Proc. 3r Intl. Symp. On Hybrid Rice. November 14-16. Directorate Rice Res., Hyderabad, India. p. 25.

Murthy, K.N.K., Shankaranarayana, V., Murali, K. and Jayakumar, B.V. (2004). Effect of different dates of planting on spikelet sterility in rice genotypes (*Oryza sativa* L.). *Res. Crops*. **5**(2/3): 143-147.

Myung, K. (2005). Yearly variation of genetic parameters for panicle characters of Japonica rice (*Oryza sativa* L.). *Australian J. Crop Sci*., **2**(1): 65-71.

Obulamma, U., Reddy, M.R. and Kumari, C.R. (2004). Effect of spacing and number of seedlings per hill on yield attributes and yields of hybrid rice. *Madras Agric. J.*, **91**(4-6): 344-347.

Obulamma, U.A. and Reddeppa, R. (2002). Effect of spacing and seedling number on growth and yield of hybrid rice. *J. Res. ANGRAU.* **30**(1): 76-78.

Pande, R.C., Pandry, R.P., Vyas, O.P. and Pandey, A. (1987). Effect of number of seedlings hill$^{-1}$ on grain yield of rice. *Indian J. Agron*., **32**(1): 106-107.

Patel, J.R. (2000). Effect of water regime, variety and blue green algae on rice (*Oryza sativa). Indian J. Agron*., **45**(1): 103-106.

Prakash, N.B. (2010). Different sources of silicon for rice farming in Karnataka. Paper presented in Indo-US workshop on silicon in agriculture, held at University of Agricultural Sciences, Bangalore, India, 25-27th February 2010, p.14.

Prasad, K., Room, S. and Sher, S. (1992). Effect of seedling age and number of seedlings hill$^{-1}$ on the yield of rice in a sodic soil. *Current Agric*., **16**(2): 67-70.

Rafey, A., Khan, P.A. and Srivastava, V.C. (1989). Effect of Nitrogen on growth, yield and nutrient uptake of upland rice. *Indian J. Agron*., **34**(2): 133-135.

Rao, S.P. and Reddy, C.K. (1993). High density grain and yield in rice as influenced by number of seedlings hill$^{-1}$ at varied population pressures. *Indian J. Plant Physiol*., **36**(3): 163-165.

Reddy, M.D. and Mittra, B.N. (1984). Effect of time of planting age and number of seedling hill$^{-1}$ on yield and yield components of rice varieties in flood prone situations. *Thailand J. Agric. Sci*., **17**(1): 41-49.

Relwani, I.L. (1982). Studies on the effect of spacing, number of seedlings hill$^{-1}$ and levels of nitrogen on paddy yields. *Indian J. Agron*., **6**(4): 279-288.

Salem, A.K.M., Elkhoby, W.M., Abou-Khalifa, A.B. and Ceesay, M. (2011). Effect of Nitrogen Fertilizer and Seedling Age on Inbred and Hybrid Rice Varieties. *American-Eurasian J. Agric. Environ. Sci*., **11**(5): 640-646**.**

Sarkar, M.A.R., Paul, S.K. and Hossain, M.A. (2011). Effect of row arrangement, age of tiller seedling and number of tiller seedlings per hill on performance of transplant aman rice. *The J. Agril. Sci.*, **6**(2): 59-68.

Sawant, A.C., Throat, S.T., Khadse, R.R. and Bhosalef, R.J. (1986). Response of early rice varieties to nitrogen levels and spacing in coastal Maharashtra. *J. Maharashtra Agril. Univ*., **11**(2): 182-184.

Shaloie, M., Gilani, A. and Siadat, S.A. (2014). Evaluation of sowing date effect on hybrid rice lines production in dry-bed of Khuzestan. *Intl. Res. J. Appl. Basic. Sci*., **8**(7): 775-779.

Shamsuddin, A.M., Islam, M.A. and Hossain, A. (1988). Comparative study on the yield and agronomic characters of nine cultivars of aus rice. *Bangladesh J. Agril. Sci*., **15**(1): 121-124.

Singh, A.K. Manibhushan, M.K. and Upadhyaya, A. (2012). Effect of Sulphur and Zinc on Rice Performance and Nutrient Dynamics in Plants and Soil of Indo Gangetic Plains. *J. Agril. Sci*., **4**(11): 162-170.

Singh, G. and Singh, O.P. (1992). Effect of age and number of seedlings hill$^{-1}$ on yield and yield attributes of rice under rainfed lowland. *Indian J. Crop. Res*., **5**(3): 417-419.

Singh, S. and Gangwer, B. (1989). Comparative studies on production potentials in traditional tall and improved rice cultivars. *J. Andaman Sci. Assoc*., **5**(1): 81-82.

Son, Y., Park, S.T., Kim, S.Y., Lee, H.W. and Kim, S.C. (1998). Effects of plant density on the yield and yield components of low-tillering large panicle type rice. *J. Crop Sci*., **40**: 2.

Srivastava, G.K. and Tripathi, R.S. (2000). Response of hybrid and composite rice to number of seedling and planting geometry. *Annual Agril. Res*., **19**(2): 235-236.

Suprihatno, B. and Sutaryo, B. (1992). Yield performance of some new rice hybrids varieties in Indonesia. *Intl. Rice Res. Newsl*., **17**(3): 12.

Swain, P., Annie, P. and Rao, K.S. (2006). Evaluation of rice (*Oryza sativa*) hybrids in terms of growth and physiological parameters and their relationship with yield under transplanted condition. *Indian J. Agric. Sci*., **76**(8): 496-499.

Tsai, J.C. (1987). Effect of cultural methods on the yield and some physiological characters of rice cultivars differing in grain weight. *J. Agril. Res. China*. **36**(1): 63-64.

Wang, J.L., Xu, Z.J. and Yi, X.Z. (2006). Effects of seedling quantity and row spacing on the yields and yield components of hybrid and conventional rice in northern China. *Chinese J. Rice Sci*., **20**(6): 631-637.

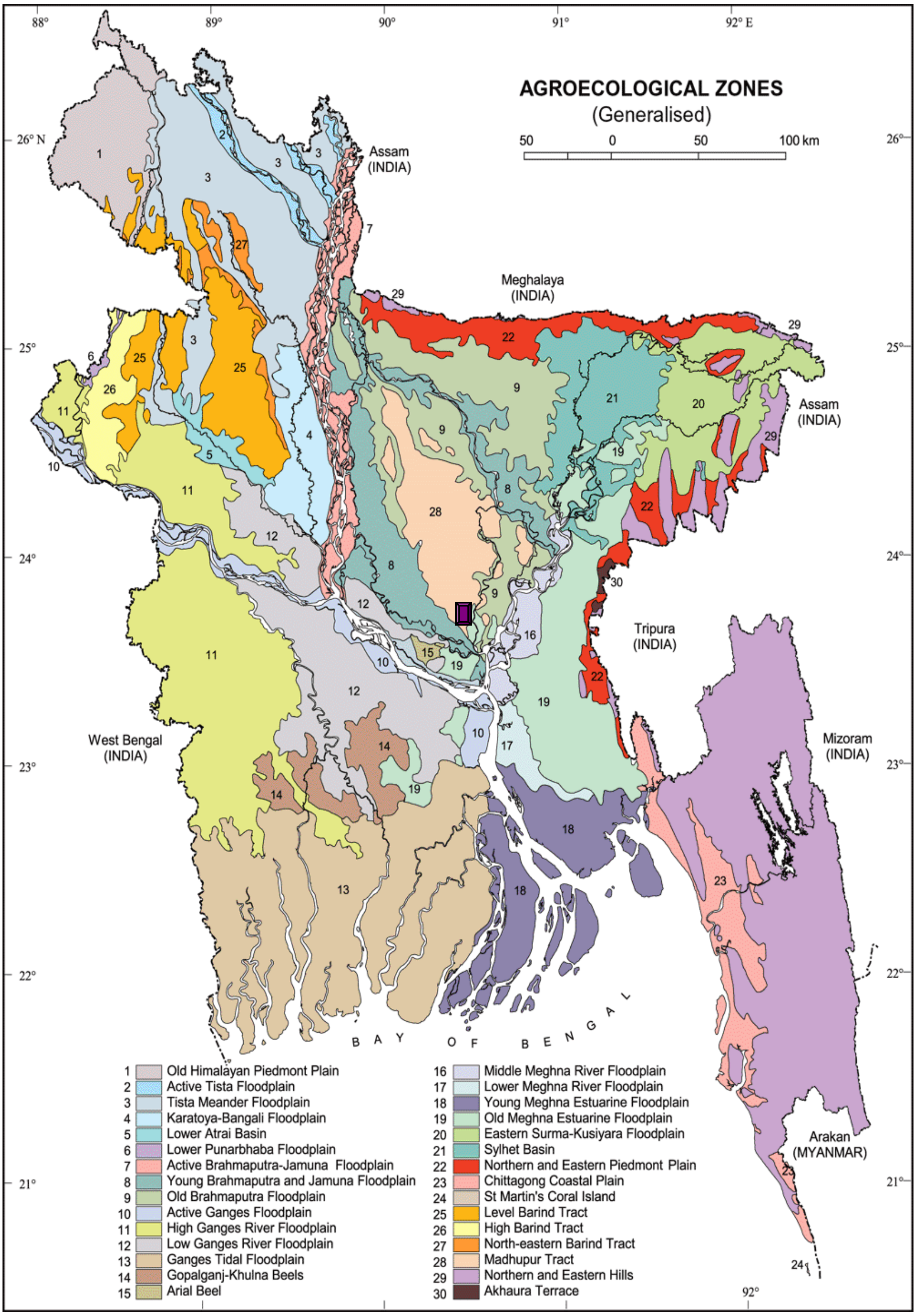
Xie, W., Wang, G. and Zhang, Q. (2007). Potential production simulation and optimal nutrient management of two hybrid rice varieties in Jinhua, Zhejiang Province. *J. Zhejiang Univ. Sci*., **8**(7): 486–492.

Xu, S. and Li, B. (1998). Managing hybrid rice seed production. IRRI, Manila, Philippines, pp. 157-163.

Yoshida, S. (1981). Fundamentals of Rice Crop Science, IRRI, Philipines. pp. 1-41.

# APPENDICES

## Appendix I. The Map of the experimental site



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

**A. Morphological characteristics of the soil of experimental field**

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

**B. Physical and chemical properties of the initial soil**

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

**Source:** SRDI, Khamarbari, Farmgate, Dhaka

**Appendix III. Monthly record of air temperature, relative humidity, rainfall, and sunshine (average) of the experimental site during the period from June to November, 2014**

| Month (2014) | Air temperature ($^0$C) | | Relative humidity (%) | Rainfall (mm) | Sunshine (hr) |
|---|---|---|---|---|---|
| | Maximum | Minimum | | | |
| June | 35.7 | 23.2 | 78 | 312 | 5.4 |
| July | 36.0 | 24.6 | 83 | 563 | 5.1 |
| August | 36.0 | 23.6 | 81 | 319 | 5.0 |
| September | 34.8 | 24.4 | 81 | 279 | 4.4 |
| October | 26.5 | 19.4 | 81 | 22 | 6.9 |
| November | 25.8 | 16.0 | 78 | 00 | 6.8 |

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

**Appendix IV. Analysis of variance of the data on plant height of rice as influenced by varieties and number of seedlings hill$^{-1}$**

| Source of variation | Degrees of freedom | Mean square | | | | |
|---|---|---|---|---|---|---|
| | | Plant height (cm) | | | | |
| | | 25 DAT | 35 DAT | 45DAT | 55 DAT | Harvest |
| Replication | 2 | 0.964 | 5.139 | 0.332 | 3.656 | 3.656 |
| Rice variety (A) | 1 | 28.448* | 465.606* | 267.802* | 389.593* | 402.674* |
| Error | 2 | 1.526 | 22.581 | 12.683 | 14.668 | 14.668 |
| Number of seedlings hill$^{-1}$ (B) | 4 | 17.213* | 50.685** | 72.808** | 114.115* | 114.115* |
| Interaction (A×B) | 4 | 19.722* | 50.412** | 98.876** | 100.395* | 100.395* |
| Error | 16 | 5.331 | 10.589 | 16.464 | 33.917 | 33.917 |

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

**Appendix V. Analysis of variance of the data on number of tillers hill$^{-1}$ of rice as influenced by varieties and number of seedlings hill$^{-1}$**

| Source of variation | Degrees of freedom | Mean square | | | |
|---|---|---|---|---|---|
| | | Number of tillers hill$^{-1}$ at | | | |
| | | 25 DAT | 35 DAT | 45DAT | 55 DAT |
| Replication | 2 | 0.048 | 0.005 | 0.064 | 0.233 |
| Rice variety (A) | 1 | 6.912* | 2.581** | 21.845* | 21.168* |
| Error | 2 | 0.144 | 0.021 | 0.837 | 0.532 |
| Number of seedlings hill$^{-1}$ (B) | 4 | 0.888** | 0.795** | 14.411** | 7.555** |
| Interaction (A×B) | 4 | 0.572* | 0.195* | 1.335* | 2.275* |
| Error | 16 | 0.156 | 0.062 | 0.497 | 0.661 |

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

**Appendix VI. Analysis of variance of the data on dry matter content (g) hill$^{-1}$ of rice as influenced by varieties and number of seedlings hill$^{-1}$**

| Source of variation | Degrees of freedom | Mean square | | | |
|---|---|---|---|---|---|
| | | Dry matter content (g) hill$^{-1}$ at | | | |
| | | 25 DAT | 35 DAT | 45DAT | 55 DAT |
| Replication | 2 | 0.010 | 0.030 | 0.198 | 0.293 |
| Rice variety (A) | 1 | 1.487* | 1.692* | 45.213* | 17.161* |
| Error | 2 | 0.046 | 0.033 | 2.005 | 0.682 |
| Number of seedlings hill$^{-1}$ (B) | 4 | 6.885** | 3.947** | 16.861** | 22.275** |
| Interaction (A×B) | 4 | 0.129* | 1.072* | 3.862* | 5.064** |
| Error | 16 | 0.053 | 0.061 | 0.876 | 0.814 |

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

**Appendix VII. Analysis of variance of the data on yield contributing characters of rice as influenced by varieties and number of seedlings hill$^{-1}$**

| Source of variation | Degrees of freedom | Mean square | | | |
|---|---|---|---|---|---|
| | | Total tillers hill$^{-1}$ (No.) | Effective tillers hill$^{-1}$ (No.) | Non-effective tillers hill$^{-1}$ (No.) | Panicle length (cm) |
| Replication | 2 | 0.049 | 0.033 | 0.076 | 0.050 |
| Rice variety (A) | 1 | 23.585* | 41.772* | 2.581* | 11.075* |
| Error | 2 | 0.945 | 0.964 | 0.129 | 0.329 |
| Number of seedlings hill$^{-1}$ (B) | 4 | 7.260** | 3.569** | 0.862** | 15.334** |
| Interaction (A×B) | 4 | 2.139** | 2.215** | 0.278** | 2.599* |
| Error | 16 | 0.302 | 0.282 | 0.031 | 1.108 |

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

**Appendix VII. Cont'd**

| Source of variation | Degrees of freedom | Mean square | | | |
|---|---|---|---|---|---|
| | | Filled grain panicle$^{-1}$ (No.) | Unfilled grains panicle$^{-1}$ (No.) | Total grains panicle$^{-1}$ (No.) | Weight of 1000-seeds (g) |
| Replication | 2 | 2.236 | 0.089 | 1.433 | 0.353 |
| Rice variety (A) | 1 | 312.341* | 4.485* | 391.685* | 12.269* |
| Error | 2 | 11.881 | 0.097 | 12.985 | 0.482 |
| Number of seedlings hill$^{-1}$ (B) | 4 | 410.015** | 10.381** | 303.115** | 11.410** |
| Interaction (A×B) | 4 | 32.238* | 0.875* | 31.275* | 2.534* |
| Error | 16 | 10.509 | 0.193 | 11.074 | 0.901 |

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

**Appendix VIII. Analysis of variance of the data on yield of rice as influenced by varieties and number of seedlings hill$^{-1}$**

| Source of variation | Degrees of freedom | Mean square | | | |
|---|---|---|---|---|---|
| | | Grain yield (t ha$^{-1}$) | Straw yield (t ha$^{-1}$) | Biological yield (t ha$^{-1}$) | Harvest index (%) |
| Replication | 2 | 0.020 | 0.001 | 0.014 | 0.944 |
| Rice variety (A) | 1 | 7.915** | 1.612* | 16.671** | 157.533* |
| Error | 2 | 0.111 | 0.081 | 0.179 | 8.031 |
| Number of seedlings hill$^{-1}$ (B) | 4 | 1.358** | 0.486** | 3.439** | 20.139** |
| Interaction (A×B) | 4 | 0.196** | 0.268** | 0.862** | 8.768* |
| Error | 16 | 0.036 | 0.039 | 0.058 | 3.639 |

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