ASSESSMENT OF SRI WITH CONVENTIONAL METHOD OF RICE CULTIVATION IN BORO SEASON

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CERTIFICATE

This is to certify that the thesis entitled, **"ASSESSMENT OF SRI WITH CONVENTIONAL METHOD OF RICE CULTIVATION IN BORO SEASON"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE** in **AGRONOMY,** embodies the result of a piece of bona fide research work carried out by **AMIT PARTHA MONDOL**, Registration No. **07-02357** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

(Prof. Dr. Parimal Kanti Biswas)
Supervisor

Dated:
Place: Dhaka, Bangladesh

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ASSESSMENT OF SRI WITH CONVENTIONAL METHOD OF RICE CULTIVATION IN BORO SEASON

ABSTRACT

A field experiment was carried out at Agronomy Field of Sher-e-Bangla Agricultural University Dhaka during the period from December 2012 to May 2013 to assess the System of Rice Intensification (SRI) with conventional method of rice cultivation in *boro* season. The experiment consisted of two factors. Factor A: Planting method (2 levels); P_1: conventional method, P_2: SRI method and factor B: Variety (5 levels); V_1: BR 16, V_2: BRRI dhan29, V_3: BRRI dhan50, V_4: BRRI hybrid dhan2 and V_5: Heera 4. The experiment was laid out in split-plot design with three replications. Experimental results showed that planting method had significant effect on all the agronomic parameters except leaf area index (LAI), total dry weight m^{-2}, unfilled grains panicle^{-1}, rachis branches panicle^{-1}and harvest index. The tallest plant (112.43 cm), root (29.10 cm), higher number of tillers hill^{-1}(43.45) at harvest was recorded in P_2. Higher effective tillers hill^{-1} (41.13), longer panicle (28.15 cm), higher total grains panicle^{-1} (216.89), number of filled grains panicle^{-1} (166.82), grain yield (9.10 t ha^{-1}) and straw yield (9.48 t ha^{-1}) were observed in SRI than the conventional method. Variety also significantly influenced all the growth and yield attributes except root length. The longest plant (119.1cm), highest number (11.62) of rachis branches panicle^{-1} (11.62), longest panicle (28.20 cm) and highest 1000-grains weight (29.91 g) were produced in V_5. Statistically similar grain yields (8.64, 9.16 and 8.97 t ha^{-1}) and biological yields (18.31, 18.58 and 18.08 t ha^{-1}) were produced by V_2, V_4 and V_5 respectively. The lowest grain yield (8.10 t ha^{-1}) and straw yield (8.75 t ha^{-1}) were recorded in V_1 and V_3 respectively. Maximum number of effective tillers hill^{-1} (52.47) was produced in treatment combination of P_2V_1 and minimum (8.87) in P_1V_5. The longest panicle (30.53 cm), maximum total grains panicle^{-1} (255.40) and unfilled grains (88.60) were also recorded in P_2V_2.The shortest panicle (23.52 cm) and lowest numbers of grains panicle-1 (145.80) were found in P_1V_3. The highest grain yield (9.60 t ha^{-1}) and straw yield (10.02 t ha^{-1}) were produced in P_2V_4. The lowest grain yield was obtained in P_1V_1 (7.56 t ha^{-1}) and straw yield (8.38 t ha^{-1}) in P_1V_3. All of the five varieties preformed better in SRI practice than in the conventional practice. SRI can give extra return about Tk. 26,788 ha^{-1} compared to the conventional method of rice cultivation in *boro* season.

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LIST OF ACRONYMS

AEZ	Agro-Ecological Zone
Anon.	Anonymous
AWD	Alternate Wet-Dry
BARC	Bangladesh Agricultural Research Council
BARI	Bangladesh Agricultural Research Institute
BAS	Bangladesh Academy of Science
BBS	Bangladesh Bureau of Statistics
BRAC	Bangladesh Rural Advancement Committee
BRRI	Bangladesh Rice Research Institute
CARE	Co-operations for American Relief Everywhere
cm	Centi-meter
CV %	Percent Coefficient of Variance
cv.	Cultivar (s)
DAE	Department of Agricultural Extension
DAS	Days After Sowing
DAT	Days After Transplanting
et al.	And others
e.g.	*exempli gratia* (L), for example
etc.	Etcetera
FAO	Food and Agricultural Organization
g	Gram (s)
HI	Harvest Index
i.e.	*id est* (L), that is
IRRI	International Rice Research Institute
Kg	Kilogram (s)
LSD	Least Significant Difference
m^2	Meter squares
M.S.	Master of Science
NGO	Non Governmental Organization
No.	Number
NS	Non significant
SAU	Sher-e-Bangla Agricultural University
SRDI	Soil Resource and Development Institute
SRI	System of Rice Intensification
var.	Variety
$t\ ha^{-1}$	Ton per hectare
UNDP	United Nations Development Programme
°C	Degree Centigrade
%	Percentage

CHAPTER 1

INTRODUCTION

Rice (*Oryza sativa* L.) is a semi-aquatic annual grass plant and belongs to the Family Poaceae. It is one of the staple cereal crops of the world. It is the 1st ranking cereal crop in terms of area and production in Bangladesh though the average yield of 2.82 t ha^{-1} was very low as compared to that of Egypt (8.4 t ha^{-1}) and USA (6.6 t ha^{-1}) (BBS, 2010). Bangladesh is not only a rice growing country but also a country of rice eating people (Annon. 1998a). It is consumed by nearly half of the world population and grown at least in 114 countries so that many people are engaged in rice cultivation around the world (Prasertsak and Fukai, 1997). Many scientists from different countries continue to work on rice to increase its productivity and quality and to reduce the cost of cultivation. About 75% of the world's rice supply comes from 79 million hectares of irrigated rice production in Asia (Cabangon, 2002).

Bangladesh is an agro-based developing country and still striving hard for rapid development of its economy. Although 63 percent of the labor force is directly engaged in Bangladesh agriculture and 78 percent of total cropped area is devoted to rice production, the country is still suffering from a chronic shortage of food grain (BBS, 2008). Rice contributes more than 80 percent to the total food supply. More than 95% of population consumes rice and it alone provides 76% of calorie and 66% of total protein requirement of daily food intake (Bhuiyan *et al.*, 2002). In fact, Agriculture sector is largely dominated by rice production. Growth in agriculture has tremendously centered on the expansion of modern rice production through investment in research, adopting modern technologies and extension services. Rice continues to remain main sources of food supply for the people of all the sectors.

Rice in Bangladesh is grown in three distinct seasons, namely *Boro* (January to June), *Aus* (April to August) and *Aman* (August to December) covering almost 11.0 million hectares of land, producing nearly 95% of the total food requirements, but there is still a need to increase production to feed the growing population which increases at the rate of 1.32% per annum (BER, 2010).

In Bangladesh cropping intensity is very low and crop production is very much dependent on the traditional methods, about 80% of the agricultural land is used for rice cultivation. The annual grain production (310.32 ton) is not sufficient to meet the demand of 144 million people of Bangladesh, which are increasing of the rate of 1.43% (BBS, 2006). The population pressure compels the Government to import food grains every year. Almost 85% of the population of Bangladesh lives in rural areas having the main occupation of farming. The Government of Bangladesh has given the highest priority to increase food production and availability in the country.

The food problem is still one of the most vital aspects of economic development in Bangladesh. It is necessary to enhance the growth of rice production through increasing land productivity to meet the increasing food demand for the vast population of the country as the country has serious land constraints. Significant differences in rice productivity among the different regions are also acting as barriers to the production growth (Hossain, 1980). Many steps to enhance the growth are being taken from the part of the government and non-government agencies since the independence of the country. For future planning, it is necessary to evaluate the growth patterns of rice production that are achieved more in the country as a whole and also within different varieties.

Bhuiyan *et al.* (2002) indicated that about 21% higher amount of rice than the level of production of 2000 have to be produced to feed the population of Bangladesh by the year 2025. There is no scope to increase rice growing area; much of the additional rice required will have to come from higher average yield on existing land. In accordance with the expansion of the population of our country, horizontal expansion of rice growing area, rice yield unit^{-1} area should urgently be increased to meet this ever-increasing demand of food. To achieve this increasing demand it requires new advanced technologies such as high management package, high yielding cultivar, higher input use etc. (Wang *et al.*, 2002). Alauddin (2004) mentioned that proper planting and management practices are the most effective means for increasing yield of rice at farmer's level using inbreed and hybrid varieties.

To satisfy the required world's food demand by 2025, it is estimated that rice production has to be increased globally by 60% (Fageria, 2007). But there is little scope to increase the area under rice production with the current practices that involve high production costs of fertilizers and protective chemicals (Sinavagari, 2006). As rice is semi aquatic plant, it requires larger amount of water for its optimum production and it is the largest water consumer in the agricultural sector (Bera, 2009; Mishra, 2009; Prasad and Ravindra, 2009).

That's why such new technologies are required that would reduce the inputs like water, chemicals, fertilizers and labor while increasing yields on the same piece of land would be possible to ensure sustainable rice production (Bouman *et al.*, 2005; Mati and Nyamai, 2009).

In this regard a rice cultivation system called System of Rice Intensification (SRI) which has been developed in Madagascar with the help of Malagasy farmers. Father Henri De Laulanie developed SRI in the early 1980s. The System of Rice Intensification (SRI) may be a technology to meet the required demand through increased rice productivity by changing the management of plants, soil, water and nutrients while reducing external inputs like fertilizers and herbicides (Thakur *et al.*, 2009; Vermeule, 2009). This system is different from the conventional method by using single but very younger seedling hill^{-1}, wider spacing among hills, practicing wetting and drying and use of mechanical weeder which facilitates the aeration in the root zoon and enhances the soil organic matter (Uphoff, and Kassam, 2009).

Now SRI is being promoted in rice growing countries worldwide since recent past. It is being promoted as system of rice cultivation rather than a technology. SRI is a technique with a set of practices and a set of principles rather than as a "technology package" (Uphoff, 2004). Adopting this technology grain yield could be increased as high as 20 t ha^{-1} or more or at least more than two times the yield level that is obtained with the conventional methods despite the climatic and edaphic variability (Uphoff, 2001). It has since been tested in many countries such as in India, china, Indonesia, Philippines, Srilanka, Bangladesh etc. with having promising results. SRI method differs from the traditional method of cultivating irrigated paddy in a number of ways. The most important advantage of SRI is to increase the yield performance in farmers' field without the use of any new seeds or chemicals or mechanical inputs (Stoop *et al.*, 2002). According to him SRI is not a fixed technological package, but rather a set of principles for raising the productivity of all of the factors involved in rice production, including land, labor, capital, seed and water. These principles include careful transplanting of young seedlings (< 15 days) at wide spacing on a precise grid with only one seedling hill^{-1}, water management that keeps the soil moist but not continuously flooded, frequent (i.e., three to six times during the growth period) manual or mechanical weeding before canopy closure; and reliance on high rates of organic compost instead of fertilizer.

According to Shao-hua (2002) and Uphoff (2009), aim of using young seedlings, wide spacing and a single seedling $hill^{-1}$ was to provide enough resources for producing stronger individual plants in the rice group.

SRI method composed of the application of certain management practices, which together provide better growing condition for the rice plant, particularly in the root zoon than the traditional method. Reduced demand of water in SRI method facilitates conservation of water and soil having greater biodiversity that is not formed in saturated condition. Such paddy field does produce methane at a reduced level which is one of the major greenhouse gases contributing to the global warming. This water saving and water use efficiency of rice plant in SRI method are suitable for our poor farmers and in water scarce area.

In response of these information, the present research work was conducted in *boro* season with three inbreeds and two hybrids varieties of rice with the following objectives

1. To compare the yield performance of SRI system with the traditional planting system.

2. To compare the performances of the 5 rice varieties in *boro* season.

CHAPTER 2

REVIEW OF LITERATURE

2.1 System of rice intensification

Laulanie (1993) and Uphoff (2001) described the system of rice intensification and suggested that SRI represents an integrated and agro-ecologically sound approach to irrigated rice (*Oryza sativa* L. var. *indica*) cultivation, which offer new opportunities for location-specific production systems of small farmers. SRI is a designer innovation that efficiently uses scarce land, labor, capital and water resources, protects soil and groundwater from chemical pollution, and is more accessible to poor farmers than input-dependent technologies that require capital and logistical support (Uphoff, 2004). SRI methods can lead to superior phenotypes and agronomic performance for a diverse range of rice genotypes (Lin *et al.*, 2006).

2.1. 1 History and background of system of rice intensification (SRI)

In 1983 after two decades of experimentation Fr. Henri de Laulaníe, a Jesuit priest in Madagascar, synthesized the "système de riziculture intensive" (French) and "system of rice intensification" (English). Under the pressures from a drought and shortages of rice seeds, he started to experiment at his agricultural school near Antsirabe (1500 m elevation). The experiments initially focused on transplanting very young rice seedlings of just 10-15 day old in a fairly wide spacing (25 cm x 25 cm) of single seedlings. A square planting pattern was used to facilitate mechanized weeding. The rice was not grown in flooded paddies, but in moist soil, with intermittent irrigation. Under such conditions Laulaníe observed tremendous increase in tillering and rooting as well as number of panicles and larger panicle size, contributing to spectacular grain yields.

In 1990, Laulaníe helped to establish a Malagasy NGO called Association Tefy Saina (ATS) and became its technical advisor. ATS began introducing SRI with farmers in a number of communities in the country. In 1994, Cornell International Institute for Food, Agriculture and Development (CIIFAD) started working with ATS to introduce SRI as an alternative to slash and burn cultivation. From 1998, CIIFAD has become increasingly active in drawing attention to the potential of SRI also in other major rice growing areas in Asia (Uphoff and Randriamiharisoa, 2002), leading to a serious controversy with scientists of some established rice research institutes (Stoop *et al.*, 2002).

2.2 Principles of System of Rice Intensification (SRI)

Laulanie established the following six key elements of SRI (Uphoff, 2007). The key physiological principle of SRI practices is to provide optimal growing conditions to individual rice plants so that tillering is maximized and phyllochrons are shortened, which is believed to accelerate growth rates (Nemoto *et al.*, 1995).

2.2.1 Transplanting of single seedling hill^{-1}

Under SRI management it can be suggested that early transplanting provides a longer vegetative growth period, and single seedling hill^{-1} reduces the competition and helps minimize the shading effect of lower leaves. This helps lower leaves to remain photosyntheitcally active, for much longer, and in turn, root activity remains higher for a longer period due to the plant's enhanced supply of oxygen and carbohydrates to the roots (Tanaka, 1958; Horie *et al.*, 2005). Further, higher root activity, in turn, supplies cytokinin to the lower leaves, delaying senescence and helping to maintain photosynthetic efficiency of the plant at latter growth stages. This outcome has been confirmed by a finding where a single seedling hill^{-1} had higher yield compared to three seedlings per hill (San-oh *et al.*, 2006).

Mishra *et al.* (2006) have linked single transplanting hill^{-1} to increases in root length, density and activity and their inter-dependence with above-ground canopy development, particularly resulting in prolonged photosynthetic activity by older leaves.

2.2.2 Transplanting of young (8–12 day old) seedlings

Recent trends in recommendations for rice cultivation are to increase the density of plant population. Considering the fact most research for improving rice yield have been oriented to: (1) increasing biomass production by improving radiation and its efficient use; and (2) increasing the harvestable biomass relative to the non-harvestable portion for the sake of a higher Harvest Index (HI), the ratio between grain biomass and total plant biomass. This thinking has led to a breeding strategy that aims to create a cultivar producing more grains but fewer tillers (Khush, 1993). The growing conditions under SRI facilitate an optimum environment for tillering expression (Laulanie, 1993).

Katayama presented the growth rules for leaf emergence on the main stem and tillers of rice, wheat and barley. According to him the first tiller off the main stem appears at the fourth phyllochron (Katayama,1951). If the rice seedling is transplanted later than the third phyllochron, the resulting plant will lose all of the incoming tillers from this first row of tillers which represents about 40% of the total tillers, and that any further delay of transplantation leads to a bigger loss of tillers (Association Tefy Saina, 1992). The impact of transplanting seedlings before the fourth phyllochron, in terms of tillering, root development and yield, is very dramatic as seen from our research and in factorial trials (Randriamiharisoa and Uphoff, 2002). Proponents of SRI recommend transplantation of the seedlings during the third phyllochron, at the stage when the plant has still only two leaves, in order to avoid reduction in subsequent tillering and root growth (Laulanie, 1993). Early transplantation in conjunction with the other practices allows a greater realization of the tillering potential of rice plants (Association Tefy Saina, 1992).

SRI methods give the highest yield when young seedlings are transplanted, less than 15 day old and preferably only 8–12 days, i.e., before the start of the fourth phyllochron (Stoop *et al.*, 2002).

In conventional management, it has been reported that around 40-60% of the roots remain in the soil during pulling up from the nursery. Pruning up to 60% of the root during transplanting significantly decreased subsequent root and shoot dry matter accumulation (Ros *et al.*, 1998). Therefore, it may be suggested that SRI practices lead to increased shoot and root dry matter accumulation by protecting root system during transplanting.

2.2.3 Transplanting of seedlings into a muddy field

Seedlings are raised in an un-flooded, garden-like nursery and then transplanted within 15–30 minutes after uprooting. SRI seedlings are heavier and sturdier compared to seedlings grown in conventional nursery beds (Stoop, 2005). Transplanting should be done carefully to avoid trauma to the plants' roots, and also quickly to avoid becoming desiccated. Shallow transplanting is recommended, only 1–2 cm deep, with roots laid in the soil as horizontally as possible. While plunging them into the soil vertically inverts the seedlings' root-tips upward, slowing the plants' recovery from the shock of transplantation and delaying their resumption of growth. Drained field conditions could induce higher root activity by enhancing root respiration and root revitalization, resulting in greater leaf area, higher photosynthesis activity, resulting in higher yield (Tsuno and Wang, 1988). The growth of shoots is very much dependent on root growth (Nikolaos *et al.*, 2000). Therefore, root quantity and root activity both are required for raising yield (Xuan *et al.*, 1989).

2.2.4 Wide spacing depending upon soil fertility

Plants grown with wider spacing have more area of soil around them to draw nutrients and have better access to solar radiation for higher photosynthesis. Spacing is critical in modifying the components that influence final grain yield.

Long duration varieties perform better with wider spacing than do short duration varieties (Baloch *et al.*, 2002). Stoop (2005) also suggested that long-duration varieties perform better under SRI management.

2.2.5 Mechanical weeding

In SRI system, weeds are controlled by the use of mechanical weeding with a rotary pushed weeder. The system relies on early and frequent weeding which varies from 3 to 4 times throughout the cultivation period. The first in the series of weeding is done about 10 days after transplantation and the others in a frequency of 10-20 days (Association Tefy Saina, 1992).

One of the main purposes for flooding rice with some controlled drainage is for weed control (Sahid and Hossain, 1995). This is the traditional way for managing weeds in conventional flooded rice systems.

2.2.6 Addition of organic manure instead of chemical fertilizer

The incorporation of organic manure into the soil can bring beneficial effect to root growth by improving the physical, chemical and biological environments in which root grow (Yang and Suang, 2004). Under continuous water logging condition, there is significant decrease in root growth (Sahrawat, 2000), whereas under intermittent irrigation, the incorporation of organic matter improves root morphological characteristics and root activity of rice plant. It has the effect of increasing root density, active absorption area, root oxidation ability and nutrient uptake (Yang *et al.*, 2004).

SRI advocates that the most extensive root system of SRI plants and the improved structure and biological condition of soil were achieved by compost application, which provides access to much larger pool of nutrients. The advantages from using compost have been seen from factorial trials (Uphoff, 2003), but if organic matter is not available, SRI practices can be also used successfully with chemical fertilizers.

2.2.7 Intermittent irrigation during vegetative growth stage

It was reported that 25-50% water could be saved by intermitted irrigation without any adverse effect on rice yield (Ramamoorhy *et al.*, 1993). Growth is not harmed when plants are exposed to limited water condition during their vegetative stage (Boonjung and Fukai, 1996).

A key justification for promoting intermittent irrigation as part of SRI (Stoop *et al.*, 2002; Uphoff, 2003; Randriamiharisoa *et al.*, 2006) is the stated assumption that rice is not an aquatic plant and that under continuous submergence most of the rice plant's roots remain in the top few cm of soil and degenerate by the reproductive phase so it is believed to improve oxygen supply to rice roots, thereby decreasing aerenchyma formation and causing a stronger, healthier root system with potential advantages for nutrient uptake (Stoop *et al.*, 2002).

2.3 Effect of SRI on Growth

2.3.1 Plant height

A field experiment was carried out by Chakrabortty (2012) at Agronomy research field, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh, during the period from December 2011 to May 2012 to find the growth and yield of *Boro* rice as affected by seedling age and planting geometry under SRI. BRRI dhan50 were used as the test crop in that experiment. He considered four seedling ages such as 12 days, 14 days, 16 days and 30 day old seedlings and five plant spacing. In 25 cm × 25 cm, 30 cm × 30 cm, 35 cm × 35 cm, 40 cm × 40 cm and 25 cm × 15 cm. At 110 DAT, he found that the longest plant (78.42 cm) was in the plant age of 12 days and plant spacing of 35 cm × 35 cm and the shortest plant (71.43 cm) were observed in the plant age of 14 days and plant spacing of 25 cm × 25 cm.

A field experiment was carried out by Rahman (2012) at Agronomy research field, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh, during the period from December 2011 to May 2012 to study the growth and yield of *Boro* rice under SRI with different water regime and manural status. In that experiment he considered three water regimes such as waterlogged condition, saturated condition and alternate wet and dry condition and six manure and fertilizer combinations viz., cowdung 100%, compost 100%, chemical fertilizer 100%, 50% chemical fertilizer + 25% compost + 25% cowdung, 50% chemical fertilizer + 50% cowdung and 50% chemical fertilizer + 50% compost. Significant interaction effect between the water regime and manural status was observed. At harvest, the tallest plant (80.27 cm) was obtained from chemical fertilizer (100%) at saturated condition similar similler with the other fertilizer combination at waterlogged condition and chemical fertilizer (50%) + compost (50%) at saturated condition. The shortest plant (68.27 cm) was recorded from cowdung (100%) at alternate wet and dry condition which was similar with cowdung (100%) at waterlogged condition, cowdung (100%) at saturated condition, chemical fertilizer (100%) at saturated condition, chemical fertilizer (50%) + cowdung (25%) + compost (25%) at alternate wet and dry condition and chemical fertilizer (50%) + Compost (50%) at alternate wet and dry condition.

A field experiment was carried out by Biswas *et al.,* (2013) at Agronomy research field, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh, during the period from December, 2010 to May 2011 for the screening of rice varieties responsive to SRI in *boro* season. The experiment consisted of sixteen treatments *viz.* BR3 (V_1), BR14 (V_2) BR16 (V_3), BRRI dhan28 (V_4), BRRI dhan29 (V_5), BRRI dhan36 (V_6), BRRI dhan45 (V_7), BRRI dhan50 (V_8), Binadhan-6 (V_9), Bina new line (V_{10}), BRRI hybrid dhan1 (V_{11}), BRRI hybrid dhan2 (V_{12}), BRRI hybrid dhan3 (V_{13}), Chamak (V_{14}), Hira1 (V_{15}) and Bhajan (V_{16}). Experimental results showed that the sixteen varieties cultivated in *boro* season had significant difference among them in plant height in SRI system.

A field experiment was carried out by Main *et al.* (2007) at Agronomy research field, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh, during the period from June to November, 2005 to study the influence of planting technique on growth and yield of *aman* rice. According to his research finding the plant height of *aman* rice was not significantly influenced by planting method at 45, 60, 75 days at different growth duration and at harvest.

Nissanka and Bandara (2004) conducted an experiment to test the productivity of System of Rice Intensification (SRI) method over the conventional rice farming systems in Sri Lanka. Average plant height growth and leaf chlorophyll content during the growing stages were also similar among the treatments.

Goel and Verma (2000) found the effects of 2 sowing methods, direct sowing and transplanting, on the yield and yield components of 2 rice cultivars, and observed plant height (104.8 cm) was higher in transplanting. No significant interactions were observed between cultivars and sowing methods.

De Datta (1981) stated in an experiment that the height of rice plant is directly related to the depth of water and generally increases with increasing water depth.

In accordance with the findings of Vijayakumar *et al.* (2006) who reported that the treatment combination of younger seedlings (14 days old), wider spacing (25 cm × 25 cm), water saving irrigation, mechanical weeding give taller plant height.

Shrirame *et al.* (2000) reported that the number of the functional leaves, leaf area and total number of the tiller hill^{-1} were higher at wider spacing which increased the photosynthetic rate leading to taller plant.

Uphoff (2001) found in an experiment that incorporation of weed with the mechanical weeder increased the root activity which stimulated the new cell division in roots by pruning of some upper roots encouraged deeper root growth thereby increased shoot : root ratio.

Salam *et al.* (2004) noted that at maturity, taller plant was found in the early-planted crop, and this might be due to the longer vegetative growth phase, which enhanced to increase height. The length of vegetative phase of rice progressively reduced due to delayed planting resulting in short plant height.

2.3.2 Number of tillers hill^{-1}

Saina (2001) reported in SRI practice fifty tillers per plant were easily obtained, and farmers who had mastered the methods and understand the principles had been able to get over 100 tillers from single tiny seedling.

A field experiment was carried out by Ahmed *et al.* (2007) conducted an experiment. According to him the production of total tillers hill^{-1} was significantly influenced by different cultivation method at 30, 50, 70 DAS/T and at harvest. Significantly maximum number of tillers hill^{-1} was recorded from the clonal seedling at 30 DAS/T, among the tillers of the nursery seedlings, the SRI and the sprouted seeds broadcast. But at harvest, SRI produced significantly maximum number of tillers hill^{-1}.

A field experiment was carried out by Biswas *et al.* (2013) at Agronomy research field, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh, during the period from December, 2010 to May 2011 for the screening of rice varieties responsive to SRI in *boro* season and reported that BR14 had the highest tiller number hill^{-1} at 90 DAT (32.80) and at harvest (26.37). BR16 had the highest number of effective tillers hill^{-1} (27.33) in SRI system.

A field experiment was carried out by Chakrabortty (2012) at Agronomy research field, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh, during the period from December 2011 to May 2012. He found significant differences for number of tillers hill^{-1} of interaction effect of seedling age and plant spacing in *boro* rice at 30, 60, 90 and at 110 DAT. The highest number of tillers hill^{-1} (50.93) was found in the treatment combination of 16 days old seedling and 40cm × 40cm plant spacing and the lowest number of tillers hill^{-1} (18.47) was observed in the treatment combination of 16 days old seedling and 25cm × 15cm plant spacing.

Vijayakumar *et al.* (2006) found in an experiment though the tiller density of individual hill is higher under wider spacing, considering the population per unit area, the total tiller production was higher with more plant population per unit area with closer spacing.

Ali *et al.* (2013) conducted afield experiment at the research farm of Crop Physiology and Ecology Department, Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh during November 2010 to May 2011 to find out the effect of seedlings age and water management on tillering behavior, growth dynamics, yield and yield contributing characters of BRRI dhan28. He observed tillering behavior was significantly influenced by the interaction effect of seedlings age and water management. At 45 DAT, the highest number of tillers hill^{-1} (31.5) was obtained when 15 days old seedlings were transplanted in intermittent irrigated plots which was followed by that (25.2) when the seedlings of the same age was transplanted in continuous flooded plots and 30 days old seedlings produced the lowest number of tillers hill^{-1} (18.0) when they were transplanted in continuous flooded plots which was followed by that (21.3) obtained from the seedlings of the same age transplanted in intermittent irrigated plots.

Ginigaddara and Ranamukhaarachchi (2011) also found that younger seedlings had greater ability to produce greater number of tillers hill^{-1} than older seedlings.

Singh *et al.* (2007) observed that when a seedling is transplanted carefully at the initial growth stage, the trauma of root damage caused during uprooting is minimized following a rapid growth with short phyllochrons and produce higher number of tillers hill^{-1}.

Aziz and Hasan (2000) stated that in transplanting of the seedling aged of two to three weeks against three four to five weeks with wider spacing and single seedling per hill root development is more and healthier under SRI method, tillering is almost double, the crop does not lodge and the grain weight is more with fewer pest and disease attack.

2.3.3 Leaf area index

A field experiment was carried out by Dhital (2010) at Agronomy research field, Institute of Agriculture and Animal Science, Rampur, Chitwan, Nepal. He found in his experiment at harvesting time maximum LAI value was observed in SRI.

Thakur *et al.* (2010) reported in spite of SRI having fewer hills per unit area, the leaf area index (LAI) with SRI practice was greater than recommended method due to larger leaves. These together with altered plant architecture, contributed to more light interception by SRI plants.

Research finding of an experiment of Shrirame *et al.* (2000) was that the younger seedling under wider spacing give better root growth which facilitated increased cell division and cell enlargement due to increased photosynthetic rate which subsequently increase leaf area index (LAI).

According to Thiyagarajan *et al.* (2002). water saving irrigation with mechanical weeding favorably influenced the soil aeration which facilitated more number of tillers and subsequently higher photosynthetic rate for increased LAI.

Ali *et al.* (2013) found in his experiment Age of seedlings at transplanting and water management interacted significantly to influence the LAI both at 45 days after transplanting and at anthesis At 45 DAT, the highest leaf area index was recorded from 15 days old seedlings transplanted in intermittent irrigated plots. Thirty days old seedlings transplanted in continuous flooded plots provided the lowest LAI (2.01).

2.3.4 Dry matter production

A field experiment was carried out by Main *et al.* (2007) at Agronomy research field, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh, during the period from June to November, 2005 to study the influence of planting technique on growth and yield of *aman* rice. He observed much more partitioning of dry weight in root than in shoot in SRI system. It is due to the alternate wetting and drying condition of the field that is an important character of System of Rice Intensification which makes the plant to generate more roots than shoot in vegetative period which is caused by partitioning of dry weight to the root zone.

Thakur *et al.* (2011) conducted a field experiment in Bhu-baneswar, Orissa, India, during the dry season (January– May) in 2008 and 2009. He observed significant improvements (38.5% increases in root length over standard management practices) in the morphology of SRI plants in terms of root growth. SRI produced 19.64% higher shoot length than standard management practices. Significant improvements were observed in SRI over in case of leaf number (55.39%), leaf size (26.22% increase in leaf length and 26.37% increase in leaf width) and leaf are index (34.18%).

Nissanka and Bandara (2004) conducted an experiment to test the productivity of System of Rice Intensification (SRI) method with conventional rice farming systems in Sri Lanka. Dry weights of stems, leaves, and roots and the total dry weights, leaf area and total root length per hill during the growing period and the tiller number per plant at heading were significantly higher in SRI compared to other treatments. However, all these parameters, when expressed per unit area basis, were not significantly different.

Longxing *et al.* (2002) studied the physiological effects of different rice crop management systems by comparing the results associated with traditional methods of flooded rice irrigation to non-flooded rice farming with young seedlings and wider spacing (SRI). In SRI, they observed, forms high biomass by larger individual plants, and dry mater accumulation after heading accounted for 40% of the total dry matter. More than 45% of the material from stem and sheath was contributed to grain yield in SRI. At the same time, SRI facilitates a heavier and deeper root system. Root growth was markedly greater in the plants raised under SRI than in traditional system, root dry matter and root depth were also more in SRI compared to traditional rice.

Uphoff (2002) stated the combination of limited irrigation with mechanical weeding increase dry matter rice plant. This might be due to the fact that mechanical weeding increase the soil aeration by dissolved oxygen in irrigation water rather than from the deeper part of the soil thereby increasing shoot : root ratio and Leaf Area Index (LAI) subsequently increased the total dry matter production.

According to Yoshida (1981) findings the seedling from dapog nursery contained more N and starch which helped in producing new roots, better root growth and more tiller production resulting the increase the total dry matter production.

Rajesh and Thanunathan (2003) found that increased shoot : root ratio and production of more number of tillers on individual hill under wider spacing were the reason to increase the total dry matter production of rice plant.

Ali *et al.* (2013) observed *that* at 45 days after transplanting the highest dry matter hill^{-1}(211 g) was recorded from 15days old seedlings transplanted in intermittent irrigated plots and 30 days old seedlings transplanted in continuous flooded plots provided the lowest dry matter hill^{-1} (180 g). At anthesis, 15 day old seedlings transplanted in intermittent irrigated plots provided the highest dry matter hill-1 (242 g) which was followed by that (228 g) recorded from the seedlings of same age transplanted in continuous flooded plots. Thirty days old seedlings transplanted in continuous flooded plots provided significantly the lowest dry matter hill^{-1} (210 g) which was followed by that (215 g) recorded from the seedlings of same age transplanted in intermittent irrigated plots.

2.3.5 Days to flowering and maturity

Ahmed *et al.* (2007) conducted and experiment at Agronomy Field Laboratory, Sher-e-Bangla Agricultural University, Dhaka during the period from December 2005 to May 2006 to study the influence of different cultivation methods on hybrid and inbred rice in *boro* season. He found the plants from sprouted seeds and SRI matured early compared to the nursery seedlings and clonal tillers.

Krishna *et al.* (2009) conducted an experiment to study the Influence of age of seedlings and spacing on seed yield and quality under SRI (system of Rice Intensification) method of cultivation in ES-18 short duration variety during rabi season at Agricultural Research Station Gangavati, Karnataka during 2004-05. The younger seedlings (8 days old) flowered early. Time of 50 % flowering increased as the age of the seedling increased from 8 days old to 12 days old, 16 days old, 25 days old.

According to the result an experiment of Vijayakumar *et al.*(2006) during wet season the number of days to first flowering (85 DAS) was significant in the treatment combination of 14 days old seedlings planted at (20 cm × 20 cm) spacing + conventional irrigation , weeding and nitrogen while during dry season the combination of the seedlings of 14 days old planted at a spacing of (15 cm × 10 cm) under limited irrigation of 2 cm on hairline crack development + conventional weeding significant days to first flowering (80 days). Between panicle initiation to flowering and flowering to maturity stage the crop growth rate, relative growth rate and net assimilation ret were significantly increased by the treatment combination of 14 days old seedlings, wider spacing of 25 cm × 25 cm, limited irrigation of 2 cm with incorporation of weeds and distributing the soil through SRI weeding using the rotary weeder.

Joseph (1991) repotted that synergistic effect of the combination of younger seedlings, closer spacing, either conventional irrigation or water saving irrigation and the conventional weeding resulted in early flowering than the combination of wider spacing of 25 cm x 25 cm and mechanical weeding due to the reason that planting of younger seedlings have taken more number of days for vegetative growth after transplanting.

Yang *et al.* (2000) under 25 cm × 25 cm spacing, lesser competition for water and nutrients resulted in slower growth and more CHO assimilation per plant.

Rao and Raju (1987) reported that under higher plant density, more competition among the plants induced quick growth and early flowering.

Krishna *et al.* (2008) conducted an experiment to evaluate the influence of system of rice intensification (SRI) on seed yield and quality in rice variety BPT-5204 was conducted at Agricultural Research Station (Paddy), Sirsi during kharif 2004-05. They found that the younger seedlings (8 days-old) flowered about four to five days earlier as compared to 25 days old seedlings. The early flowering in SRI method might be attributed to transplanting of younger seedlings, which might have established quickly in the field and started growing at a faster rate. Close spacing of 20cm x 20cm took lesser days to flowering compared to wider spacing. This difference in flowering and maturity might be due to quick vegetative growth of the plants under closer spacing and than resulting in early switch over to reproductive phase.

Chapagain *et al.* (2011) found a significant response of SRI management was shown in reducing the days to flowering (by 10 days) and days to harvest (by 8 days) while accounting the age of transplanted seedlings. On average, SRI plots began flowering at 84 d after sowing and harvested after 128 days compared to 94 days and 136 days for flowering and harvest, respectively, in conventional plots.

Vijayakumar *et al.* (2006) supported the findings of the SRI effects with enhanced tillering and earlier flowering.

2. 4 Effect on yield contributing characters

2.4.1 Number of effective tillers m^{-2}

Aziz and Hasan (2000) reported that in SRI practice, the average number of tillers hill^{-1} and effective tillers hill^{-1} were 117 and 103, respectively in Parija variety at Rajshahi. The highest number of effective tillers m^{-2} (531) was found with 35 cm × 35 cm spacing in Department of Agricultural Extension trials at Kishoregonj. But with the same spacing the number was 342 m^{-2} in Locally Intensified Farming Enterprises trials at Kishoregonj. On the other hand, in farmers practice the average number of effective tillers m^{-2} was 290 and 393 with 20 cm × 20 cm and 20 cm × 15 cm, respectively.

A field experiment was carried out by Biswas *et al.* (2013) at Agronomy research field, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh, during the period from December, 2010 to May 2011 for the screening of rice varieties responsive to SRI in *boro* season. BR16 had the highest number of effective tillers hill^{-1} (27.33).

Latif *et al.* (2005) conducted a series of experiments in eastern Bangladesh to investigate the System of Rice Intensification (SRI). They observed that, BRRI dhan29 had the highest number of effective tillers m^{-2} (312.3). BRRI dhan29 had 250.3 effective tillers m^{-2}. BRRI dhan35 had 284.0 effective tillers m^{-2}, BRRI dhan36 had 282.7 effective tillers m^{-2}, and BRRI Hybrid dhan1 had 286.78 effective tillers m^{-2}.

Krishna *et al.* (2008) found in an experiment the increase in the productive tillers with SRI method was to the extent of 217% over traditional method. The increase in the effective tillers per plant might be due to the better spacing provided to the plants by planting in square method. Profused tillering due to lower plant density was noticed under wider spacing compared to closer spacing. A spacing of 40 cm x 40 cm had given more number of productive tillers per plant at harvest. Number of tillers per plant reduced significantly with decrease in spacing.

Gani *et al.* (2002) stated that conversion of the majority of the tillers into productive tillers have facilitated better utilization of recourse by the plan in SRI system.

Veeramani (2007) observed transplanting very young seedlings (14 days old) raised from modified mat nursery recorded more tillers m^{-2}.

Ali *et al.* (2013) reported that at anthesis (70 DAT), 15 days old seedlings transplanted in intermittent irrigated plots produced the highest number of tillers $hill^{-1}$ (32.2) which was followed by the seedlings of same age that was transplanted in continuous flooded plots and 30 days old seedlings produced the lowest number of tillers $hill^{-1}$ (21.2) when they were transplanted in continuous flooded plots which was followed by the seedlings of same age transplanted in intermittent irrigated plots (22.9).

Mazid *et al.* (2003) reported in experiment that in SRI method with 30 cm×30cm and 40 cm×40cm spacing and younger seedlings increased number of panicles/hill but total number of panicles per unit area was found to be low.

Nissanka and Bandara (2004) evaluated the productivity of System of Rice Intensification (SRI) method with conventional rice farming systems in Sri Lanka. The tiller numbers at heading were significantly higher in SRI compared to other treatments. However when expressed in unit area basis, were not significantly different.

Saina (2001) reported in SRI practice fifty tillers $plant^{-1}$ were easily obtained and farmers who had mastered the methods and understand the principles had been able to get over 100 tillers from single tiny seeding.

2.4.2 Total number of grains $panicle^{-1}$

Bozorgi *et al.* (2011) conducted an experiment at a paddy field in Lahijan Township (north of Iran) in 2009. This experiment was consist of three levels of plant spacing (15 cm × 15 cm, 20 cm × 20 cm and 25 cm × 25 cm) and three levels of number of seedling 1 2 3 per hill (1, 3 and 5 seedlings per hill). He observed the maximum amount of panicle length with 26.99 cm, number of grain per panicle with 87 was found from plant spacing of 25 cm × 25 cm. Minimum amount of panicle length and number of grain per panicle respectively with 25.70 cm, 79.11 was obtained from 15 cm × 15 cm treatment.

Ali *et al.* (2013) observed that panicle length was not influenced significantly by the combined effect of seedlings age and water management. The longest panicle (23.67 cm) was recorded from 30 days old seedlings transplanted in intermittent irrigated plots and 30days old seedlings transplanted in continuous flooded plots provided the shortest panicle (21.38 cm).

Thakur *et al.* (2011) conducted a field experiment in Bhubaneswar, Orissa, India, during the dry season (January–May) in 2008 and 2009. They found that the average panicle length in SRI (22.5 cm) was higher than panicles in currently recommended scientific management practices (SMP) 18.7cm). SRI produced higher number of total grains panicle^{-1} than standard management practice (SMP).

2.4.3 Filled grains panicle^{-1}

According to the result an experiment of Ali *et al.* (2013) number of filled grains panicle^{-1} was significantly influenced by the interaction effect of seedlings age and water management. The highest number of filled grains panicle^{-1} was obtained from intermittent irrigated plots where 15 days old seedlings were transplanted (188). 30 days old seedlings produced the lowest number of filled grains panicle^{-1} (170) when they were transplanted in continuous flooded plots.

Thakur *et al.* (2010) conducted an experiment in eastern India over three years, 2005-2007, to compare the performance of certain System of Rice Intensification (SRI) practices: transplanting single, young (10 days old) seedlings in a square pattern; no continuous flooding; and use of a mechanical weeder with those currently endorsed by the Central Rice Research Institute of India, referred to here as recommended management practices (RMP). They observed significant measurable changes in physiological processes and plant characteristics, such as longer panicles, more grains panicle^{-1} and higher percentage of grain-filling in SRI.

2.4.4 Weight of 1000 grains

Mannan *et al.* (2009) observed the individual grain weight of rice slightly varied due to planting of rice on different dates. Heavier grain weight was found in early planted crop and grain weight decreased with the delay transplanting. Probably the grain filling was hampered due to late planting and decreased individual seed weight.

Baloch *et al.*, (2002) reported that1000 grainS weight increase with the increase in spacing.

Latif *et al.* (2005) observed in an experiment BRRI dhan28 had 21.56 g thousand grain weight, BRRI dhan29 had 21.58 g thousand grain weight, BRRI dhan35 had 21.25 g thousand grain weight, BRRI dhan36 had 21.60 g thousand grain weight, BRRI Hybrid dhan1 had 21.53 g thousand grain weight. Thousand grain weight of BRRI dhan29 for 1 and 2 seedlings in SRI were 21.84 g and 22.12 g respectively, for BRRI recommended practice with 2-3 seedlings, thousand grain weights was 22.17 g and all of them were statistically similar.

2.4.5 Grain yield

Krishna *et al.* (2008) observed in one of their experiment that SRI method had recorded significantly higher seed yield ha^{-1} (3.99 t ha^{-1}) as compared to traditional method (3.45 t ha^{-1}). The percent increase in seed yield ha^{-1} under SRI method was 15.65 ton over traditional method.

Maiti and Sen (2003) found too short growth duration may not produce high yields because of limited vegetative growth where time for tiller production is less traditional planting.

Chapagain *et al.* (2011) reported that the grain yield was marginally greater under conventional method (6.7 t ha^{-2}) than under SRI management (6.3 t ha^{-2}), although not statistically significant.

Baloch *et al.* (2002) examined that an increase in spacing induced vigorous plant growth as well as increased the number of panicles $hill^{-1}$, grain yield $hill^{-1}$, and filled grains $panicle^{-1}$.

Migo and Datta (1982) reported that the very young seedling (10 days old) produced higher grain yield and yield attributing characters such as productive tillers than the old seedling (21 and 45 days old). The infant seedling (grown as seedling mats) showed higher existence under field condition and produced higher (or) equal yields compared to the young seedling.

Suganthi *et al.* (2003) observed a significant decline in productive tillers was observed with delayed transplanting resulting in reduced grain yield.

Baloch *et al.* (2002) reported that the plants largely depend on temperature, solar radiation, moisture and soil fertility for their growth and nutrition requirements. A dense population of crops may have limitations in the maximum availability of these factors. It is, therefore, necessary to determine the optimum density of plants population per area unit for obtaining maximum yields.

Anitha (2005) found that planting of single seedling hill^{-1} in straight rows both ways, alternate wetting and drying, early and frequent weeding using a mechanical weeder encouraged the proliferation of microorganisms that symbiotically enhanced the plant capability to produce more tillers, with vigorous and healthy root growth, and a larger number of panicles heavily laden with grains.

Ali *et al.* (2013) stated that younger seedlings performed better in grain yield than older seedlings but intermittent irrigation influenced the grain yield more than continuous flooding.

Ginigaddara and Ranamukhaarachchi (2011) confirmed that the yield increase with younger seedlings in water saving rice production system is mainly attributed to more effective tillers hill^{-1} filled grains per plant, panicle length compared to conventional system.

Latif *et al.* (2005) found in their experiment that SRI always resulted in higher panicle lengths than BRRI recommended practices and farmers practices. BRRI dhan 29 had 24.48 cm panicle length in SRI practice, 24.12 cm in BRRI recommended practice and 22.32 cm in farmers practice in Vagurapara, Chandina. In Matiara, sadar panicle lengths were 24.89 cm, 24.14 cm and 22.28 cm in respectively SRI, BRRI recommended and farmers practice. In comparison of short and long-duration varieties, the long-duration variety BRRI dhan29 yielded highest with SRI practices.

Mazid *et al.* (2003) found that conventional practices of rice cultivation gave significantly higher grain yield compared to the SRI method of crop establishment. They concluded that, the SRI practice was not necessary for growing rice near the yield potential, and the conventional method of crop establishment was recommended for twice cultivation.

McDonald *et al.* (2005) assembled 40 site of System of Rice Intensification (SRI) versus best management practices (BMP) comparisons into a common database for analysis. Indeed, none of the 35 other experimental records demonstrated yield increases that exceeded BMP by more than 22%. Excluding the Madagascar examples, the typical SRI outcome was negative, with 24 of 35 site demonstrating inferior yields to best management and a mean performance of 11%.

Nissanka and Bandara (2004) compared the productivity of System of Rice Intensification (SRI) method with conventional rice farming systems in experiment in Sri Lanka. They found that grain yield was 7.6 t ha^{-1} in the SRI and it was 9%, 20% and 12% greater than the conventional transplanting and normal and high density broadcasting.

Rajaonarison (2000) conducted an experiment to SRI practices during the 2000 minor season on the West Coast of Madagascar and found that SRI practices produced 6.83 t ha^{-1} grain yield where standard practices produced 2.84 t ha^{-1}.

Reddy (2005) conducted a field experiment to compare the SRI with existing traditional cultivation methodology. In both of the systems of traditional and SRI, it was found that SRI could produce similar yield with less inputs.

Sato (2006) reported that comparison trails had given an average SRI yield of 7.23 t ha^{-1} compared to 3.92 t ha^{-1} with conventional methods, an 84% increase.

Thakur *et al.* (2010) stated that the decreased plant density with SRI management was compensated for by increased per plant productivity.

Anon. (2004a) embarked on trialing SRI in the project target area in the Districts of Kralanh and Angkor Chum in Siem Province in Cambodia. Harvest of the trials was conducted in December 2002, which showed average yield increases of 148% and 85% respectively or 3.24 t ha^{-1} and 2.3 t ha^{-1}. Results from the 2003 season showed 130% and 92% increase or 2.94 t ha^{-1} and 2.16 t ha^{-1} this showed a consistent higher yield. Reduced results in 2003 were due to poor rainfall in the area, many families were unable to grow any rice which had resulted in food shortages and reinforces the need to improve methodologies to increase rice yields.

Karmakar *et al.* (2004) reported that, conventional practice (25 cm × 15 cm spacing with 15 days old seedling) gave higher yield than the SRI practices with wider spacing. Number of tillers and panicle per unit area were higher in closer spacing that contributed to obtain higher yield.

Zheng *et al.* (2004) mentioned that the features of the SRI were: transplanting of young seedlings singly in a square pattern with wide spacing, using organic fertilizers and hand weeding, and keeping the paddy soil moist during the vegetative growth phase. Significant phenotypic changes occur in plant structure and function and in yield and yield components under SRI cultivation. The production increased could be notable. With these modifications, grain yield exceeded 12 t ha^{-1} which is 46% greater than in control.

Hossain *et al.* (2003) conducted an experiment at the Agronomy Field Laboratory of Bangladesh Agricultural University, Mymensingh from July to December, 2001 to study the performance of BRRI dhan32 in SRI and conventional methods and their technology mixes. They obtained the highest grain yield of SRI planting method that was mostly the outcome of higher total number of tillers $hill^{-1}$, highest panicle length and highest number of grains $panicle^{-1}$.

Husain *et al.* (2004) conducted SRI trial in two Upazilas of Noakhali district. The farmers practiced both SRI and conventional cultivation at the same time to compare the results regarding production cost, yield, and net return. Based on their experiment they stated that SRI practices permitted soil aeration, better root development, more effective tillering and more panicles, which ultimately increase the yield in SRI method. During the Boro season 2002-2003, SRI farmers got 43% more yield than with conventional methods.

Deichert and Yang (2002) enlisted the experiences of 400 Cambodian farmers in adapting on how many elements of SRI were applied. They observed most of the enlisted farmers obtained yields from 3 to 6 t ha^{-1} and the overall yields showed an increase from 50 to more than 200% over the national average.

Anon. (2001) stated changes to rice transplanting through SRI increased yield by 50%. For instance, in Bangladesh, the SRI increased yield from 4 to 6 t ha^{-1} and reduced seed requirement for planting by 80%.

Aziz and Hasan (2000) reported that in SRI practice, 35 cm × 35 cm spacing showed better performance both at Locally Intensified Farming Enterprises and Department of Agricultural Extension trials at Kishoregonj where the average yield was 7.5 and 8.9 t ha^{-1}, respectively. On the other hand, in case of farmers practice the average yields were 5.2 and 4.7 t ha^{-1} with 20 cm × 15 cm and 20 cm × 20 cm spacings, respectively.

Rajaonarison (2000) conducted an experiment to assess SRI practices during the 2000 minor season on the West Coast of Madagascar and found that SRI practices produced 6.83 t ha^{-1} grain yield where standard practices produced 2.84 t ha^{-1}.

An experiment was conducted by Song Chen *et al.* (2013) to test the impact of the system of rice intensification (SRI) and conventional management on grain yield, yield components, and tillering capacity. They found that SRI produced significantly higher yield than the conventional management. SRI produced a higher tillering rate than conventional management without affecting ear-bearing tiller rate significantly. Moreover, the net photosynthetic rate of the recent fully expanded leaf at mid-tillering stage was significantly higher in SRI under method of transplanting. They also stated that SRI increased biomass accumulation before heading and improved utilization of photosynthates in the grain-filling stage.

Satyanarayana *et al.* (2007); Uphoff (2007) agreed by their experiment that the system of rice intensification provide an opportunity for reducing water demand accompanied by yield enhancement of rice.

SRI offer the use of single young seedlings, drastically reduced plant densities, keeping fields unflooded, use of a mechanical weeder which also aerates the soil, and enhanced soil organic matter as much as possible, not relying on synthetic fertilizer, although this can be used if there is not sufficient biomass available. According to Stoop *et al.* (2002) these practices have the aim of providing optimal growth conditions for the plant, to get better performance in terms of yield and resource productivity.

SRI has been found to increase yields significantly compared to the conventional system when implemented on strongly weathered soils of low fertility and to produce relatively high yields in more fertile soils. Chapagain and Yamaji (2010) found in an experiment SRI practice increase the yields of irrigated rice by 25–50% or even more while reducing water requirements.

Water is the single most important component of sustainable rice production, especially in the traditional rice growing areas of Asia. Rice has been grown in lowland areas under flooded conditions. Van der Hoek *et al.* (2001) mentioned that more than 75 percent of the world's rice is produced under these conventional irrigation practices that is continuous flooding. The SRI system shows that keeping paddy soils moist but not continuously saturated gives better results, both agronomically and economically, than flooding rice throughout its crop cycle. According to Uphoff and Randriamiharisoa, 2002; Namara et al., 2004; Li et al., 2005 and Sato, 2005. SRI methods enable farmers to reduce their irrigation by 25-50% while realizing higher and more profitable production.

According to Bassi *et al.* (1994) age of seedlings at transplanting is an impotent factor for uniform stand of rice and regulating its growth and yield.

Mobasser *et al.* (2007) found in an experiment that tillering and growth of rice highest when optimum aged seedlings are transplanted at right time.

In our country, farmers think that if they give as much as possible irrigation and maintain high submergence throughout the crop period they will get much increased yield. But Ghildyal (1978) concluded in one of his experiment that submerging rice field brings a series physical, chemical and microbial changes in the soil, which profoundly affect of rice plant as well as availability, loss and absorption of nutrients. Bouman, (2001). stated the continuous submergence leads to considerable loss of water through deep percolation and other means that lead unnecessary economic loss. Excess use of water in the rice field not only increase the cost of irrigation, but also declines the water table, increase arsenic contamination and may emit the green house gases from submerged field that lead to climatic change in the world (Wang *et al.*, 1998).

Basavaraja *et al.* (2008). analyzed the yield performance between traditional and SRI method . They found that the average net return were higher in SRI method than the traditional method. The technological change in paddy production has brought about

33.72% productivity differences between the two methods. The major component of the productivity difference was dew the difference in method of production.

The yield increase in SRI method over the traditional method was 41 percent (Anthofer, 2004) in Cambodia and 37.4 percent in Madagascar (Barrett *et al.*, 2004).

Rekha (2004) in Kerala, Rajendra (2005) in Nepal, Yang and Suon (2004) in Cambodia reported yield increase of more than 40% in SRI method than the traditional method.

A field experiment was conducted by Babu *et al.* (2014) at Agricultural Research Institute, Rajendranagar to determine whether there is any difference in the active root distribution of rice crop under normal and SRI method of cultivation. They found in SRI method, the root activity of rice plant was significantly high and has contributed 34 per cent to its total lateral root activity. As a whole, SRI method of planting resulted in 38 per cent mean higher total lateral root activity than that of normal method. The vertical distribution of root activity of rice plants under these methods of planting indicated that SRI method of planting resulted in about 48, 34 and 30 per cent higher root activity than that of normal method at 7.5, 15 and 22.5 cm vertical depth, respectively. Despite variations in root activity, the mean grain yield of rice was higher by 11 per cent in SRI system (6750 kg ha^{-1}) when compared to that of normal method (6081 kg ha^{-1}).

2.4.6 Straw yield

A field experiment was carried out by Biswas *et al.* (2013) at Agronomy research field, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh, during the period from December, 2010 to May 2011 for the screening of rice varieties responsive to SRI in *boro* season. He observed that straw yield was much higher in standard management practices (SMP) compared to SRI.

Mannan *et al.* (2009) reported that the straw yield decreased with the advancement of planting date. The early planted crop had longer vegetative growth period that produced higher amount of biomass resulting in higher straw yield than the late-planted crop.

Das (2003) reported that the System of Rice Intensification (SRI) gave more straw (12%) compared to the hay produced in the farmers practice plot.

Husain *et al.* (2004) conducted SRI trial in two Upazilas of Noakhali district and found 39% higher straw yield in SRI compared to traditional methods.

Thakur *et al.* (2011) found that SRI produced 7.28 t ha^{-1}straw yield compared to the 9.17 t ha^{-1}straw yield produced in standard management practices.

2.4.7 Biological yield

Thakur *et al.* (2011) found in an experiment that, SRI produced 13.79 t ha^{-1} biological yield compared to 13.57 t ha^{-1} of biological yield produced in standard management practices (SMP).

Haque (2002) and Hossain *et al.* (2003) found highest biological yield in the SRI compared to the conventional planting method.

Ahmed *et al.* (2007) found that the lowest biological yield was found from the SRI. This might be due to the wider spacing which is associated with the lower dry matter production.

2.4.8 Harvest index

Chapagain *et al.* (2011). Observed the straw yield under conventional method was significantly greater (6.5 t ha^{-2}) than under SRI (4.9 t ha^{-2}), thereby lowering the harvest index for conventional management.

More *et al.* (2007) reported that proportion of grain yield to straw yield was more when 15 days old seedlings were used compared to normally used seedlings of 20 and 28 days old suggesting efficient translocation of photosynthates from source to sink in former case.

Thakur *et al.* (2011) found in an experiment that harvest index in SRI was 47.21% over to the harvest index of 32.42%. Hossaen *et al.* (2011) found in an experiment that BRRI dhan29 produced highest harvest index of 48.84%.

Stoop (2005) and Hossain *et al.* (2003) also found higher harvest index in SRI comparing the conventional method.

CHAPTER 3

MATERIALS AND METHODS

The experiment is a part of a three years project, where entire three experiments find out the SRI package and here is the fourth experiment those SRI package was just compared to the conventional method of rice cultivation in *boro* season to validate the SRI technology with the conventional one. The experiment was conducted at the Agronomy field of Sher-e-Bangla Agricultural University, Dhaka-1207 during the period from December, 2012 to May, 20013. This chapter deals with a brief description on experimental site, climate, soil, and land preparation, layout of the experimental design, intercultural operations, data recording and their analyses.

3.1 Site Description

3.1.1 Geographical Location

The experimental area was situated at 23°77′N latitude and 90°33′E longitude at an altitude of 8.6 meter above sea level (Anon., 2004b).

3.1.2 Agro-Ecological Region

The experimental field belongs to the Agro-ecological zone of "The Modhupur Tract", AEZ-28 (Anon., 1988a). This was a region of complex relief and soils developed over the Modhupur clay, where floodplain sediments buried the dissected edges of the Modhupur Tract leaving small hillocks of red soils as 'islands' surrounded by floodplain (Anon., 1988b). The experimental site was shown in the map of AEZ of Bangladesh in Appendix I (Anon., 2004c).

3.1.3 Climate

The area had sub tropical climate, characterized by high temperature, high relative humidity and heavy rainfall with occasional gusty winds in Kharif season (April-September) and scanty rainfall associated with moderately low temperature during the Rabi season (October-March). Weather information regarding temperature, relative humidity, rainfall and sunshine hours prevailed at the experimental site during the study period was presented in Appendix II.

3.1.4 Soil

The soil of the experimental site belongs to the general soil type, Shallow Red Brown Terrace Soils under Tejgaon Series. Top soils were clay loam in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. Soil pH ranges from 5.4-5.6 and had organic carbon 0.82%. The experimental area was flat having available irrigation and drainage system and above flood level. Soil samples from 0-15 cm depths were collected from experimental field. The analyses were done by Soil Resource and Development Institute (SRDI), Dhaka.

3.2 Details of the Experiment

3.2.1 Treatments

Two sets of treatments included in the experiment were as follows:

A. Planting method (2)

- Conventional method (P_1)
- SRI method (P_2)

B. Variety (5)

- BR16 (V_1)
- BRRI dhan29 (V_2)
- BRRI dhan50 (V_3)
- BRRI hybrid dhan2 (V_4)
- Heera 4 (V_5)

3.2.2 Experimental Design

The experiment was laid in a split-plot design with three replications having planting method in the main plots and varieties in the sub-plots. There were 10 treatment combinations. The total numbers of unit plots were 30. The size of unit plot was $12m^2$ (5m x 2.4m). The distances between plot to plot and replication to replication were 0.5 m and 1.0 m respectively. The layout of the experiment has been shown in Appendix III.

3.2.3 Conventional Method

During main field preparation 4 ploughing by power tiller then laddering were done to level the field. At the time of field preparation TSP (100 kg ha^{-1} for inbred and 120 kg ha^{-1} for hybrid), MP (120 kg ha^{-1}), Gypsum (110 kg ha^{-1}), Zink sulphate (10 kg ha^{-1} for inbred and 15 kg ha^{-1} for hybrid) were applied and Urea (260 kg ha^{-1} for inbred and 266 kg ha^{-1} for hybrid) were splitted 4 time in the conventional practice. 34 day aged seedlings were transplanted in main field maintaining 25 cm × 15 cm spacing. More or less continuous flood irrigation and hand weeding was given.

3.2.4 SRI method

Organic fertilizer was spread and 4 ploughing by power tiller was done during field preparation and leveled. 16 day aged seedling was uprooted just before transplanting and maintaining 40 cm × 40 cm spacing. Alternate Wetting and Drying (AWD) were practiced in the SRI plots. Hand racking was done for weeding in the SRI plots.

3.3 Crop/Planting Material

Five rice varieties (BR16, BRRI dhan29, BRRI dhan50, BRRI hybrid dhan2 and Heera 4) were used as plant material. These varieties are screened on the basis of their better performance of the first experiment of the project.

3.3.1 Description of variety: BR 16

BR16, a high yielding variety of *boro* season was developed by the Bangladesh Rice Research Institute (BRRI), Joydebpur, Gazipur, Bangladesh. BR16 is also known as Shahibalam. It is a variety for both *aus* and *boro*. This variety was released in 1983 and it is actually the advanced genetic line known as IR 2793-80-1. It was introduced in Bangladesh after intense examination and designated as BR16. Plant of this variety attains an average height of 90 cm and has growth duration of 165 days in *boro* season. The average yield is 6.0 t ha^{-1} and the grain is long and slender. Rice is white in color.

3.3.2 Description of Variety: BRRI Dhan29

BRRI dhan29, a high yielding variety of *boro* season was developed by the Bangladesh Rice Research Institute (BRRI), Joydebpur, Gazipur, Bangladesh. The pedigree line (BR802-118-4-2) of the variety was derived from a cross (BG902/BR51-46-5) and was released in 1994. It takes about 155 to 160 days to mature. It attains at a plant height of 95-100 cm and at maturity the flag leaf remains green and erect. The grains are medium slender with light golden husks and kernels are white in color. This genotype is known for its bold grains, with a 1000-grains weight of about 29 g, grain length of 5.9 mm, and grain width of 2.5 mm. The cultivar gives an average grain yield of 7.5 t ha^{-1}. The milled rice is medium fine and white. It is resistant to damping off and moderately resistant to blast (*Pyricularia oryzae*) and bacterial blight (*Xanthomonas oryzae*) in terms of yield, this is the best variety so far released by BRRI (Anon., 2003).

3.3.3 BRRI dhan50

BRRI dhan50, a high yielding variety was developed by the Bangladesh Rice Research Institute (BRRI), Joyedebpur, Gazipur. It is the only *boro* variety developed by BRRI which is aromatic in nature. It was released in the year of 2008. This variety is popular in the name of Banglamoti. This is a relatively shorter variety with an average plant height of 82 cm. Being an aromatic variety the yield is very high reaching up to average 6 t ha^{-1} at 155 days of growth duration. Rice grains are long, slender and aromatic white.

3.3.4 Description of variety: BRRI hybrid dhan2

Bangladesh Rice Research Institute (BRRI), Joydebpur, Gazipur released BRRI hybrid dhan2 for *boro* season in the year of 2008. This variety was obtained from the hybridization between BR10 and BR016-5-3-2-4R.This variety gives a very high yield of 8.0 t ha^{-1} in 145 days of growth duration and the plant height reaches almost 105 cm. It is an alternative cultivar of BRRI dhan28.

2.3.5 Description of variety: Heera 4

Heera4 is a hybrid rice variety which is released by the Supreme Seed Co. Ltd. This rice variety was imported from China. The life cycle is around 150 days.

3.4 Crop Management

3.4.1 Seedling raising

3.4.2 Seed collection

Seeds of BR-16, BRRI dhan29, BRRI dhan50, BRRI hybrid dhan2, were collected from Genetic Resource and Seed Division, BRRI, Joydebpur, Gazipur, Bangladesh and the hybrid rice seed, Heera4 was collected from the Supreme Seed Co. Ltd.

3.4.3 Seed sprouting

Seeds were selected by following specific gravity method. Seeds were immersed into water in a bucket for 24 hours. These were than taken out of water and kept tightly in cloth bags. The seeds started sprouting after 48 hours which were suitable for sowing in 72 hours.

3.4.4 Preparation of Seedling Nursery

A common procedure was followed in raising seedlings in the seedbed. The seedbed was prepared by puddling with repeated ploughing followed by laddering. Weeds were removed and irrigation was gently provided to the bed as and when necessary. No fertilizer was used in the nursery bed.

For SRI, sprouted seeds were sown as broadcast in five portable trays containing soil and cowdung each for BR 16, BRRI dhan29, BRRI dhan50, BRRI hybrid dhan2 and Heera 4. Thin plastic sheets were placed at the base of the trays to protect water loss. The moisture of the trays was controlled accurately by applying water every day, which ensured proper growth of all the seedlings in the trays. These trays were kept inside a room at night to protect the seedlings from freezing temperature of the season and kept in sunlight at daytime for proper development of seedlings. A mosquito net was used to cover the five trays to protect the seed from birds.

3.4.5 Seed Sowing

Seeds were sown on the seedbed on December 07, 2012 for raising nursery seedlings treatments. For SRI, seeds were sown in the portable trays on December 25, 2012. The sprouted seeds were sown as uniformly as possible.

3.4.6 Preparation of Experimental Land

The experimental field was first ploughed on December 10, 2012 with the help of a tractor drawn rotary plough, later on December 12, 2012 the land was irrigated and prepared by three successive ploughings and cross ploughings with a tractor drawn plough and subsequently leveled by laddering. All weeds and other plant residues of previous crop were removed from the field. Immediately after final land preparation, the field layout was made on December 15, 2012 according to experimental specification. Compost was spread only in the SRI plots on December 17, 2012. Individual plots were cleaned and finally leveled with the help of wooden plank so that no water pocket could remain in the puddled field.

3.4.7 Fertilizer Application

The experimental area was fertilized with 260, 100, 120, 110 and 10 kg ha^{-1} of urea, triple super phosphate (TSP), muriate of potash (MP), gypsum and zinc sulphate, respectively for the inbreed verities. 266, 125, 120, 110, 15 kg ha^{-1} of urea, triple super phosphate (TSP), muriate of potash (MP), gypsum and zinc sulphate, respectively for the hybrid verities. The entire amounts of triple super phosphate, muriate of potash, gypsum and zinc sulphate were applied as basal dose at final land preparation. Urea was top-dressed in four equal installments with considering the life cycle each of the different varieties, one after seedling recovery, two during the vegetation stage and finally at 7 days before panicle initiation.

3.4.8 Uprooting and Transplanting of Seedlings

For nursery seedlings 34 day old seedlings were uprooted carefully on January 11, 2013 and were kept in soft mud in shade. The seedbeds were made wet by application of water in previous day before uprooting the seedlings to minimize mechanical injury of roots. Seedlings were than transplanted with 25 cm × 15 cm spacing on the well-puddled plots. In each plot, there were 10 rows, each row contains 33 hills of rice seedlings.

In case of SRI treatment, 16 day old seedlings were uprooted from the trays and transplanted on January 11, 2012. The trays were brought to the main field and seedlings were planted in the prepared plot just after uprooting and this process was completed within one minute. Seedlings were transplanted with 40 cm × 40 cm spacing on the well-puddled plots. In each plot, there were 6 rows, each row contains 12 hills of rice seedlings.

3.4.9 Intercultural Operations

3.4.9.1 Gap Filling

After one week of transplanting gap filling were done to maintain the constant population number. After transplanting the nursery and SRI seedlings gap filling was done whenever it was necessary using the seedling from the previous source.

3.4.9.2 Weeding

The crop was infested with some weeds during the early stage of crop establishment. Two hand weedings were done for every method, first weeding was done in all of the plot at 16 days after transplanting followed by second weeding at 15 days after first weeding only in conventional practice plot. In SRI plots, first raking was done after hairline crack developed. Each plot needs 7 minute to be racked.

3.4.9.3 Application of Irrigation Water

Irrigation water was added to each plot according to the treatments. All the plots were kept irrigated as per treatment and dried before harvesting.

Water management was the most complicated variable in SRI method. The logic was to supply the plant as much water as it needs to meet physiological requirements, not any excess. With SRI, rice crops kept unflooded during vegetative growth and irrigation was applied after hairline crack developed. From panicle initiation (PI) to hard dough stage, a thin layer of water (2-3 cm) was kept on the plots. Again water was drained from the plots during ripening stage.

3.4.9.4 Plant Protection Measures

Plants were infested with rice stem borer (*Scirphophaga incertolus*) and leaf hopper (*Nephotettix nigropictus*) to some extent which were successfully controlled by applying Diazinone @ 10 ml/10 liter of water for 5 decimal lands on February 13 and by Furadan 5 G at rate of 10 kg/ha on march 14, 2013. Crop was protected from birds and rats during the grain filling period. For controlling the birds watching was done properly, especially during morning and afternoon.

3.4.9.5 Harvesting and Post Harvest Operation

Maturity of crop was determined when 90% of the grains become golden yellow in color. The harvesting of BR16 was done on May 20; June 2, BRRI dhan 29 was done on May 20; June 2, BRRI dhan50 was done on May 8; May 28, BRRI hybrid dhan2 was done on May 8; May 17, Heera 4 was done on May 8; May 14 2013 for nursery seedlings, and SRI respectively.

Five pre-selected hills plot^{-1} from which different data were collected and 6 m^2 areas from middle portion of each of conventional plot and 4 m^2 were for SRI plot separately harvested and bundled, properly tagged and then brought to the threshing floor for recording grain and straw yield. Threshing was done manually. The grains were cleaned and sun dried to a moisture content of 14%. Straw was also sun dried properly. Finally grain and straw yields plot^{-1} were determined and converted to ton ha^{-1}.

3.5 Recording of Data

Experimental data were determined from 30 days of growth duration and continued until harvest. Dry weights of plant were collected by harvesting two hills at different dates from the inner rows leaving border rows and harvest area for grain. The followings data were determined during the experiment.

A. Crop Growth Characters

i. Plant height (cm) at 25 days interval

ii. Tillers hill^{-1} at 25 days interval (no.)

iii. Leaf m^{-2} (no.)

iv. Root length (cm.)

v. Leaf area index at 25 days interval

vi. Dry weight of plant at 30 days interval

vii. Time of flowering and maturity

B. Yield and other crop characters

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

ii. Number of ineffective tillers $hill^{-1}$

iii. Length of panicle (cm)

iv. Filled grains $panicle^{-1}$ (no.)

v. Unfilled grains $panicle^{-1}$ (no.)

vi. Total grains $panicle^{-1}$ (no.)

vii. Weight of 1000-grains (g)

viii. Grain yield (t ha^{-1})

ix. Straw yield (t ha^{-1})

x. Biological yield (t ha^{-1})

xi. Harvest index (%)

3.5.1 Detailed Procedures of Recording Data

A brief outline of the data recording procedure followed during the study is given below:

A. Crop Growth Characters

i. Plant height (cm)

Plant height was measured for preselected hills at 30, 55, 80, 105 DAT and at harvest. The height of the plant was determined by measuring the distance from the soil surface to the tip of the leaf height before heading, and to the tip of panicle after heading.

ii. Tillers hill^{-1} (no.)

Number of tillers hill^{-1} were counted at 30, 55, 80, 105 DAT and at harvest from ten randomly pre-selected hills and was expressed as number hill^{-1}. Only those tillers having three or more leaves were used for counting.

iii. Leaf area index (LAI)

Leaf area index were estimated measuring the length and average width of leaf and multiplying by a factor of 0.75 followed by Yoshida (1981).

iv. Dry weight of plant (g)

The sub-samples of 2 hills plot^{-1} uprooted gently with sufficient amount of surrounding soil from second line and were washed properly and oven dried until a constant leveled. From which the root length and weights of above ground dry matter were recorded at 30 day intervals and at harvest.

v. Time of flowering

Time of flowering (days) was recorded when about 50% flower of the plants within a plot emerged.

B. Yield and other characters

i. Effective tillers hill^{-1} (no.)

The panicles which had at least one grain was considered as effective tillers. The number of effective tillers of 5 hills was recorded and expressed as effective tillers hill^{-1}.

ii. Ineffective tiller hill^{-1} (no.)

The tillers having no panicle were regarded as ineffective tillers. The number of ineffective tillers 5 hills^{-1} was recorded and was expressed as ineffective tiller number hill^{-1}.

iii. Panicle length (cm)

Measurement of panicle length was taken from basal node of the rachis to apex of each panicle. Each observation was an average of 10 panicles.

iv. Filled grains panicle^{-1} (no.)

Grain was considered to be filled if any kernel was present there in. The number of total filled grains present on ten panicles were recorded and finally averaged.

v. Unfilled grains panicle^{-1} (no.)

Unfilled grain means the absence of any kernel inside in and such unfilled grains present on each of ten panicles were counted and finally averaged.

vi. Total grains panicle^{-1} (no.)

The number of filled grains panicle^{-1} plus the number of unfilled grain panicle^{-1} gave the total number of grain panicle^{-1}.

vii. Weight of 1000 grains (g)

One thousand cleaned dried seeds were counted randomly from each sample and weighed by using a digital electric balance at the stage the grain retained 14% moisture and the mean weight were expressed in gram.

viii. Grain yield (t ha^{-1})

Grain yield was determined from the central 6 m^2 area of each plot for conventional system and 4 m^2 for SRI. Grain yield was expressed as t ha^{-1} and adjusted with 14% moisture basis. Grain moisture content was measured by using digital Moisture Meter.

ix. Straw yield (t ha^{-1})

Straw yield was determined from the central 6 m^2 area of each plot for conventional system and 4 m^2 for SRI. After separating of grains, the sub-samples were oven dried to a constant weight and finally converted to t ha^{-1}.

x. Biological yield (t ha^{-1})

Grain yield and straw yield were all together regarded as biological yield. Biological yield was calculated with the following formula and expressed as %.

$$\text{Biological yield (t ha}^{-1}\text{)} = \text{Grain yield (t ha}^{-1}\text{)} + \text{Straw yield (t ha}^{-1}\text{)}$$

xi. Harvest index (%)

It denotes the ratio of economic yield (grain yield) to biological yield and was calculated with following formula (Donald, 1963; Gardner *et al.*, 1985).

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

3.6 Statistical Analysis

All the collected data were analyzed following the analysis of variance (ANOVA) technique using MSTAT C package and the mean differences were adjudged by LSD technique (Gomez and Gomez, 1984) and 5% level of significance.

CHAPTER 4

RESULTS AND DISCUSSION

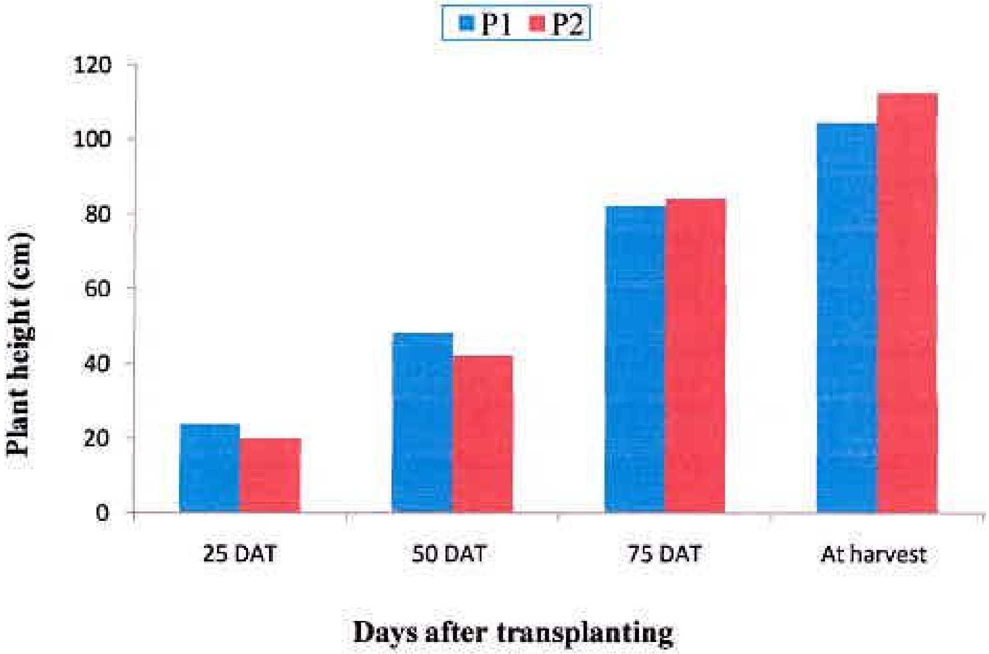
Results obtained from the present study regarding the effects of planting method and variety of inbred and hybrid rice and their interactions on the yield and yield components have been presented, discussed and compared in this chapter. The analytical results have been presented in Tables 1 through 12, Figures 1 through 40 and Appendices IV through XIV. A general view of the experimental plots and treatments has been shown in Plates 1 through 5.

4.1 Crop Growth Characters

4.1.1 Plant height at different days after transplantation

4.1.1.1 Effect of planting method

The plant height of *boro* rice was significantly influenced by different planting methods at 25, 50, 75 days after transplanting (DAT) and at harvest (Appendix IV and Figure 1). This result showed that at 25 and 50 DAT, plant height was significantly higher for conventional method than System of Rice Intensification (SRI). At 75 DAT, conventional method and SRI gave statistically similar plant height but at harvesting SRI (112.43 cm) produced taller plants than in conventional method (104.43 cm). Plant height at 25 DAT was 15.4% lower in SRI but finally at harvesting, it was 7.67% than in the conventional method. Similar findings were observed by Vijayakumar *et al.* (2006). These results were also similar to that of Shrirame *et al.* (2000) who concluded that it might be due to increased number of functional leaves, leaf area and total number of the tillers hill^{-1} at wider spacing which increased the photosynthetic rate leading to taller plants. At maturity taller plants in the early-planted crop might be due to the longer vegetative growth phase (Salam *et al.*, 2004).

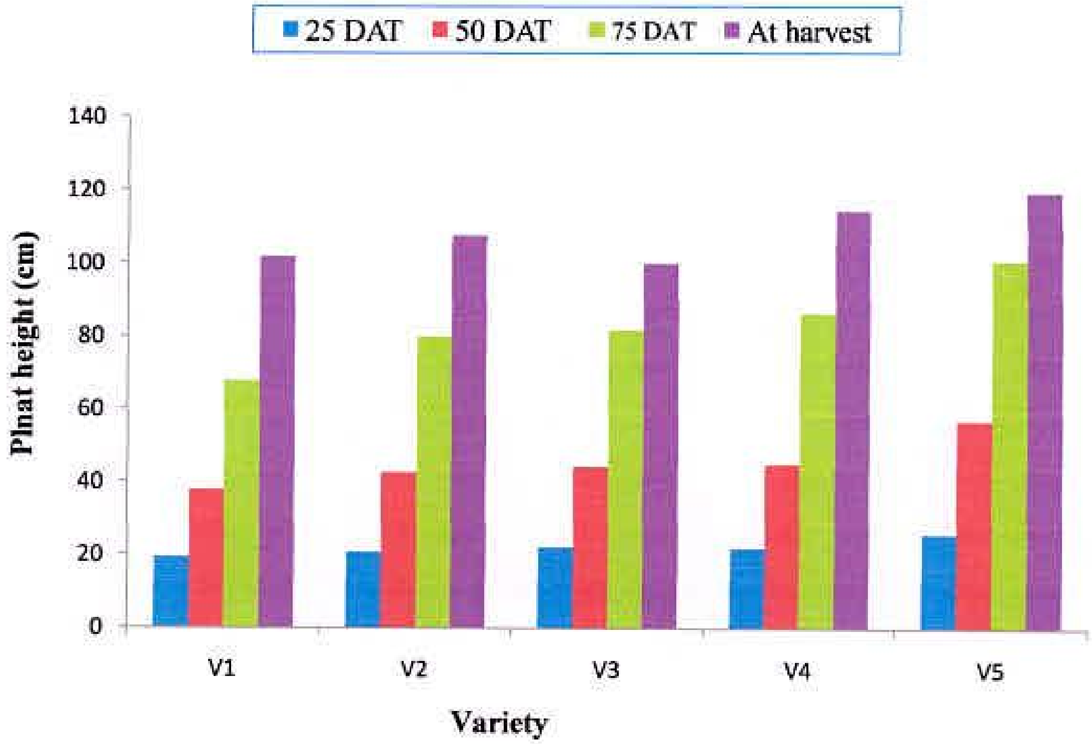


P_1=Conventional method and P_2 = SRI

Figure 1. Effect of planting method on plant height at different growth duration of inbred and hybrid *boro* rice ($LSD_{0.05}$ = 1.37, 6.11, 6.69 and 7.1 at 25, 50, 75 DAT and at harvest, respectively)

4.1.1.2 Effect of variety

Plant height was significantly influenced by different varieties at 25, 50, 75 days after transplanting and at harvest (Appendix IV and Figure 2). The result reveled that V_5 (25.71 cm) produced tallest plant at 25 DAT. The shortest plant was observed in V_1 (19.25c) which were statistically similar with V_2 (20.58 cm) and V_4 (21.80 cm). The tallest plant was obtained of V_5 (19.25 cm) and the lowest plant was from V_1 (37.79 cm) at 50 DAT. At 75 DAT the height plant height was observed for V_5 (100.6 cm) and the shortest plant was obtained from V_2 (79.79 cm) which was statistically similar with V_3 (81.70 cm). At harvest tallest plant was obtained from V_5 (119.1 cm) and the shortest plant was obtained from V_3 (99.82 cm) which was statistically similar with V_1 (101.6 cm). The variation of plant height might be due to its genetic characters and thus the differences were observed in such cases. Higher plant height in hybrid than the inbred varieties might be due to higher dry matter accumulation in hybrid than the inbred varieties. In the initial stage of growth, the increase of plant height was very slow and than the crop remained in vegetative stage. The rapid increase of plant height was observed from 50 to 75 DAT. After reaching the maximum vegetative stage, the growth of plant became very slow.



V_1 = BR 16, V_2 = BRRI dhan29, V_3 = BRRI dhan50, V_4 = BRRI hybrid dhan2 and V_5 = Heera 4

Figure 2. Effect of variety on plant height at different growth duration of inbred and hybrid *boro* rice ($LSD_{0.05}$ = 2.572, 4.651, 5.834 and 3.416 at 25, 50, 75 DAT and at harvest, respectively)

4.1.1.3 Interaction effect of planting method and variety

Significant interaction effect was observed for planting method and varieties on plant height at different DAT (Appendix IV and Table 1). These result showed that at 25 DAT tallest plant (29.57 cm) was obtained from method of P_1 with the variety of V_5 and the smallest (18.91 cm) plant was obtained from method of P_2 with the variety of V_1 which was statistically similar with the method of P_2 with the variety of V_2 (19.06 cm), method of P_2 with the variety of V_3 (19.33 cm), method of P_2 with the variety of V_4 (20.72 cm), method of P_2 with the variety of V_5 (21.85 cm), method of P_1 with the variety of V_1 (19.59 cm), method of P_1 with the variety of V_2 (22.11 cm). The tallest plant (60.72 cm) was obtained from the method of P_1 with the variety of V_5 and the shortest plant (35.59 cm) was observed from the method of P_2 with the variety of V_1 which was statistically similar with the method of P_1 with the variety of V_1 (39.99 cm), method of P_2 with the variety of V_2 (39.99 cm), method of P_2 with the variety of V_3 (39.61 cm) at 50 DAT. At 75 DAT the tallest plant (100.8 cm) was obtained from the method of P_1 with the variety of V_5 which was statistically similar with the planting method of P_2 with the variety of V_5 (100.3 cm) and the shortest plant (was obtained from the planting method of P_1 with variety of V_1 (66.24 cm) which was statistically similar with the planting method P_2 with the variety of V_2 (69.00 cm). At harvesting the tallest plant was obtained from the planting method of P_2 with the variety of V_5 (124.0 cm) and the shortest plant (96.47 cm) was observed from the planting method of P_1 with the variety of V_3 which was statistically similar with the planting method of P_1 with the variety of V_1 (99.70 cm). Higher plant height were observed for SRI might be due to wider spacing, longer vegetative growth for using younger seeding , longer root length, better development of root for proper aeration of the soil by adopting alternate wetting and drying (AWD) and mechanical weeding. Initial higher plant height of P_1 might be due to older age of seedlings. Similar finding was observed by Chakrabortty (2012) who concluded that longest plant was from the combination of younger seedlings (14 days) with wider plant spacing (35 cm x 35 cm). But Main *et al.* (2007) observed in his experiment that the plant height of *aman* rice was not significantly influenced by planting method at different growth durations and at harvest.

Table 1. Interaction effect of planting method and variety on plant height of inbred and hybrid *boro* rice

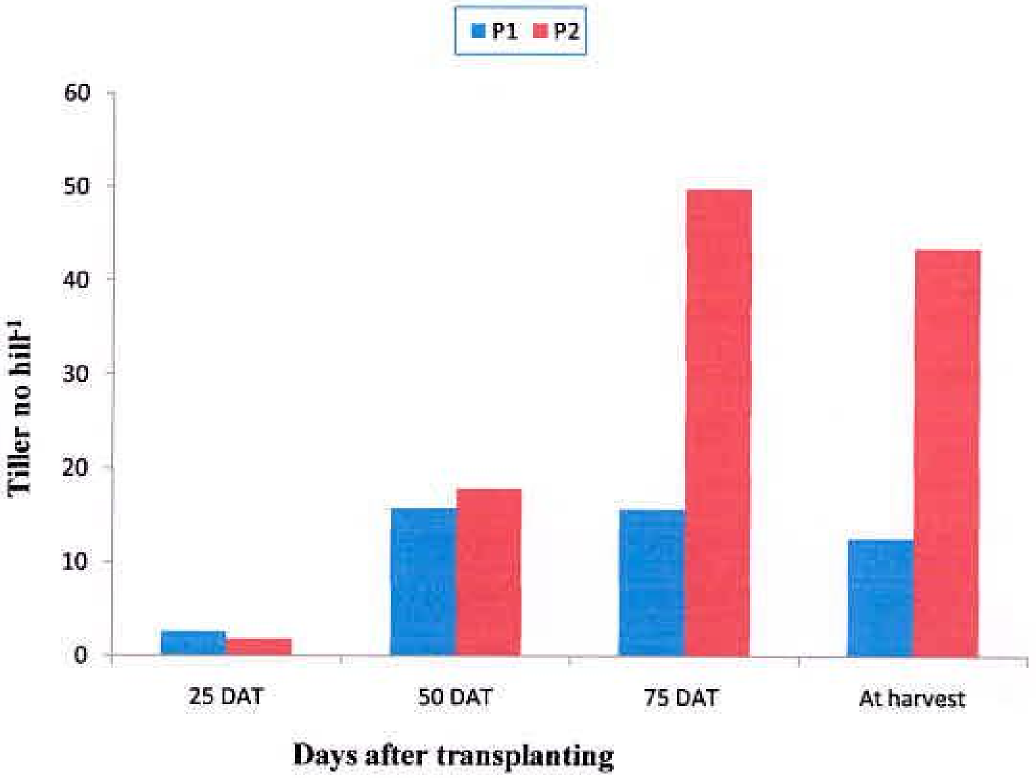
Treatments	Plant height (cm) at different DAT			
	25	50	75	At harvest
P_1V_1	19.59cd	39.99de	66.24d	99.70ef
P_1V_2	22.11bcd	45.06cd	78.96c	102.70e
P_1V_3	24.56b	48.89bc	81.35bc	96.47f
P_1V_4	22.88bc	46.65bc	83.68bc	109.10d
P_1V_5	29.57a	60.72a	100.80a	114.20c
P_2V_1	18.91d	35.59e	69.00d	103.40e
P_2V_2	19.06d	39.99de	80.62bc	112.30cd
P_2V_3	19.33cd	39.61de	82.05bc	103.20e
P_2V_4	20.72cd	43.05cd	88.61b	119.20b
P_2V_5	21.85bcd	52.50b	100.30a	124.00a
$LSD_{(0.05)}$	3.637	6.577	8.251	4.832
CV (%)	9.61	8.41	5.73	2.57

P_1 = Conventional method, P_2 = SRI, V_1 = BR 16, V_2 = BRRI dhan29, V_3 = BRRI dhan50, V_4 = BRRI hybrid dhan2, V_5 = Heera 4

4.1.2 Number of tillers hill^{-1} at different days after transplantation

4.1.2.1 Effect of planting method

The production of total number of tillers hill^{-1} was statistically insignificant for planting method at 25 DAT but incase at 50, 75 DAT and at harvest significantly different (Appendix V and Figure 3). Numerically higher Number of tillers hill^{-1} at 25 DAT was observed P_1 (2.61) than P_2 (1.85). At 50, 75 DAT and at harvest P_2 (17.83, 49.85 and 43.45) produced higher number of tiller hill^{-1} than P_1 (15.73, 15.68 and 12.61) respectively. The 13.5%, 217.92% and 244.57% higher number of tillers hill^{-1} at 50, 75 DAT and at harvest ware observed for P_2 than P_1. Higher number of tillers hill^{-1} in P_2 might be due to wider plant spacing, less compaction of soil around the hill, adopting alternate wetting and drying (AWD), longer vegetative growth period and better development of root. Ginigaddara and Ranamukhaarachchi (2011) were also in agreement of this result. Vijayakumar *et al.* (2006) concluded that the tiller density of individual hill was higher under wider spacing. Similar finding was observed by Chakrabortty (2012) who reported that the highest number of tiller hill^{-1} was from wider plant spacing (40 cm x 40 cm) than the closer plant spacing (25cm x 15 cm).

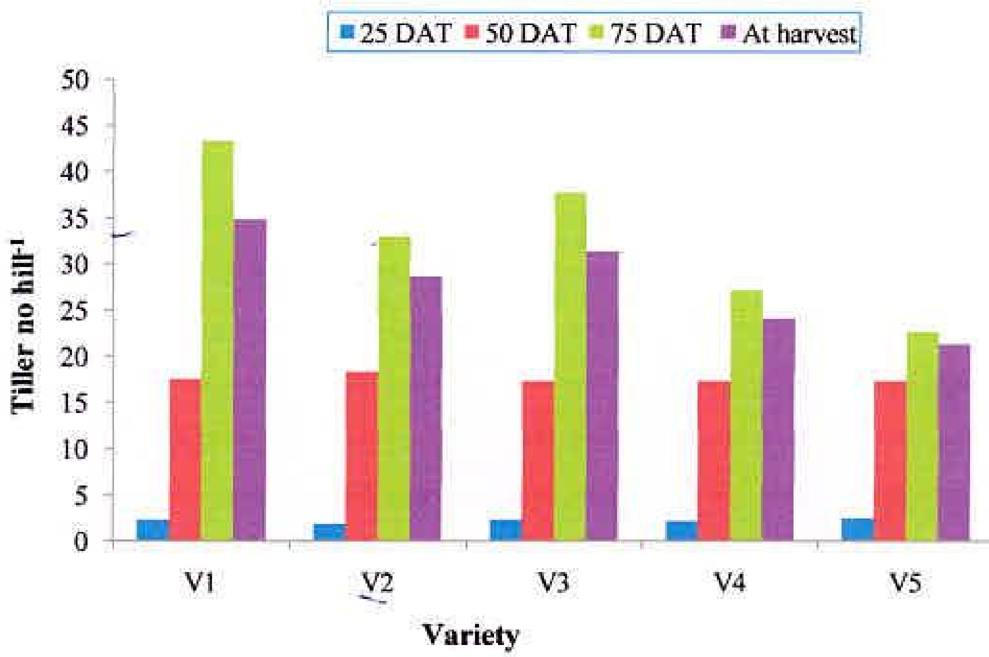


P_1=Conventional method and P_2 = SRI

Figure 3. Effect of planting method on number of tillers hill^{-1} at different growth duration of inbred and hybrid *boro* rice ($LSD_{0.05}$ = 0.95, 2.96, 6.77 and 3.03 at 25, 50, 75 DAT and at harvest, respectively)

4.1.2.2 Effect of variety

These result revealed that the total number of tillers hill^{-1} were significantly different for variety at 25, 50, 75 DAT and at harvest (Appendix V and Figure 4). At 25 DAT, the highest number of tillers hill^{-1} was observed for V_5 (2.50) which was statistically similar to V_1 (2.33), V_3 (2.30), and V_4 (2.20). The lowest number of tillers hill^{-1} was observed in V_2 (1.83) which was statistically similar with V_1, V_3 and V_4. At 50 DAT, the highest number of tillers hill^{-1} was observed V_2 (18.30) which was statistically similar with V_1 (17.53), V_3 (17.30), V_4 (17.30) and V_5 (17.30). At 75 DAT, the highest number of tillers hill^{-1} was produced in V_1 (43.30) and the lowest number of tillers hill^{-1} was obtained from V_5 (22.67). Similar trend was observed for V_1 (34.77) and V_5 (21.33) at harvesting. Increasing rate of tillers hill^{-1} was faster at 25 DAT to 50 DAT, become slower at later on 50 to 75 DAT. But at harvest number of tillers hill^{-1} was decreased. Different tillering capacity of the varieties might be due to their different genetic character.



V_1 = BR 16, V_2 = BRRI dhan29, V_3 = BRRI dhan50, V_4 = BRRI hybrid dhan2 and V_5 = Heera 4

Figure 4. Effect of variety on number of tillers hill^{-1} at different growth duration of inbred and hybrid *boro* rice ($LSD_{0.05}$ = 0.5236, 3.853, 4.49 and 2.471 at 25, 50, 75 DAT and at harvest, respectively)

4.1.2.3 Interaction effect of planting method and variety

Tiller number hill^{-1} was significantly differed with the interaction effect of planting method and varieties at 25, 50, 75 DAT and at harvest (Appendix V and Table 2).

At 25 DAT the highest number of tillers hill^{-1} was observed in planting method of P_1 with the combination of variety V_5 (3.33) and the lowest number of tillers hill^{-1} in planting method of P_2 with the combination of variety V_2 (1.60 cm) which was statistically similar in planting method of P_1 with the combination of variety V_2 (2.07), planting method of P_1 with the combination of variety V_4 (2.27), planting method of P_2 with the combination of variety V_1 (2.20), planting method of P_2 with the combination of variety V_3 (1.67), planting method of P_2 with the combination of variety V_4 (2.13) and planting method of P_2 with the combination of variety V_5 (1.67). At 50 DAT, the highest number of tillers hill^{-1} was produced in planting method of P_2 with the combination of variety V_2 (20.73) which was statistically similar in planting method of P_1 with the combination of variety V_1 (16.00), planting method of P_1 with the combination of variety V_2 (15.87), planting method of P_1 with the combination of variety V_3 (18.60), planting method of P_2 with the combination of variety V_1 (19.07), planting method of P_2 with the combination of variety V_3 (16.00), and in planting method of P_2 with the combination of variety V_4 (19.00). The lowest number of tillers hill^{-1} at 50 DAT was obtained from the planting method of P_1 with the combination of variety V_5 (13.60) which was statistically similar with the planting method of P_1 with the combination of variety V_1, planting method of P_1 with the combination of variety V_2, planting method of P_1 with the combination of variety V_3, planting method of P_1 with the combination of variety V_4 (14.60), planting method of P_2 with the combination of variety V_3, planting method of P_1 with the combination of variety V_4 and planting method of P_1 with the combination of variety V_5 (14.33). At 75 DAT, the highest number of tillers hill^{-1} was observed in planting method of P_2 with the combination of variety V_1 (66.67) and the lowest number of tillers hill^{-1} was observed in planting method of P_1 with the combination of variety V_5 (11.53) which was statistically similar with the planting method of P_1 with the combination of variety V_2 (14.27) and planting method of P_1 with the combination of variety V_4 (13.53). Finally at harvest the highest number of tillers hill^{-1} was obtained from the planting method of P_2 with the combination of variety V_1 (54.40) and the lowest number of tillers hill^{-1} was obtained from the planting method of P_1 with the combination of variety V_5 (10.00) which gave statistically similar result with the planting method of $P_1$with the combination of variety V_2 (11.80) and from the planting method of P_1 with the combination of variety V_4 (10.20).

Higher number of tillers hill^{-1} were observed for SRI with combination of inbred or hybrid verity than the conventional method. These results might be due to wider plant spacing, less injury of root during transplanting, longer vegetative growth, less compaction of soil, better development of root which ensure maximum uptake of nutrients, proper aeration in the soil of SRI than the conventional method. Ali *et al.* (2013) was also support that highest number of tillers hill^{-1} produced from the younger seedling with intermittent irrigation than older seedling (30 days) with flooded irrigation. These result was also in agreement with Singh *et al.* (2007) that as in SRI a single tiny seedling was transplanted, the trauma of root damage caused during uprooting was minimized following a rapid growth with short phyllochrons and produced higher number of tillers hill^{-1}.

Table 2. Interaction effect of planting method and variety on number of tillers hill^{-1} of inbred and hybrid *boro* rice

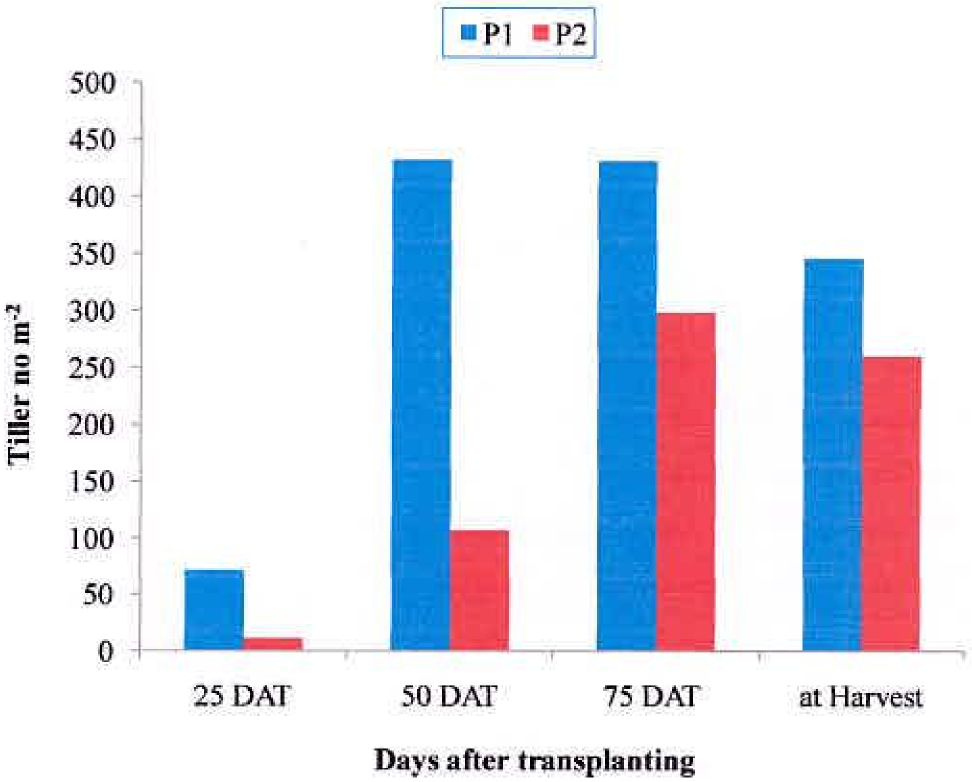
Treatments	Tiller number hill^{-1} at different DAT			
	25	50	75	At harvest
P_1V_1	2.45bc	16.00abc	19.93e	15.13ef
P_1V_2	2.07cd	15.87abc	14.27efg	11.80fg
P_1V_3	2.93ab	18.60abc	19.13ef	15.93e
P_1V_4	2.27bcd	14.60bc	13.53fg	10.20g
P_1V_5	3.33a	13.60c	11.53g	10.00g
P_2V_1	2.20bcd	19.07ab	66.67a	54.40a
P_2V_2	1.60d	20.73a	51.73b	45.40b
P_2V_3	1.67d	16.00abc	56.27b	46.73b
P_2V_4	2.13cd	19.00abc	40.80c	38.07c
P_2V_5	1.67d	14.33bc	33.80d	32.67d
LSD $_{(0.05)}$	0.7405	5.449	6.351	3.495
CV (%)	9.14	18.76	11.20	7.20

P_1 = Conventional method, P_2 = SRI, V_1 = BR-16, V_2 = BRRI dhan29, V_3 = BRRI dhan50, V_4 = BRRI hybrid dhan2, V_5 = Heera 4

4.1.3 Number of tillers m^{-2} at different days after transplantation

4.1.3.1 Effect of planting method

Tiller number m^{-2} significantly differed with the planting method at 25, 50, 75 DATs and at harvest (Appendix VI and Figure 5). Tiller number m^{-2} was higher for P_1 at 25, 50, 75 DATs and at harvest than P_2. The production of tiller number m^{-2} was 6.02 times higher from 25 DAT to 50 DAT in P_1 where it was 9.55 times higher in P_2. At 50 to 75 DAT 0.99 time tiller m^{-2} reduced for P_1 where 2.80 times tiller m^{-2} increased in P_2. At harvesting 19.70% tiller m^{-2} was reduced for P_1 where 12.79% reduced for P_2.



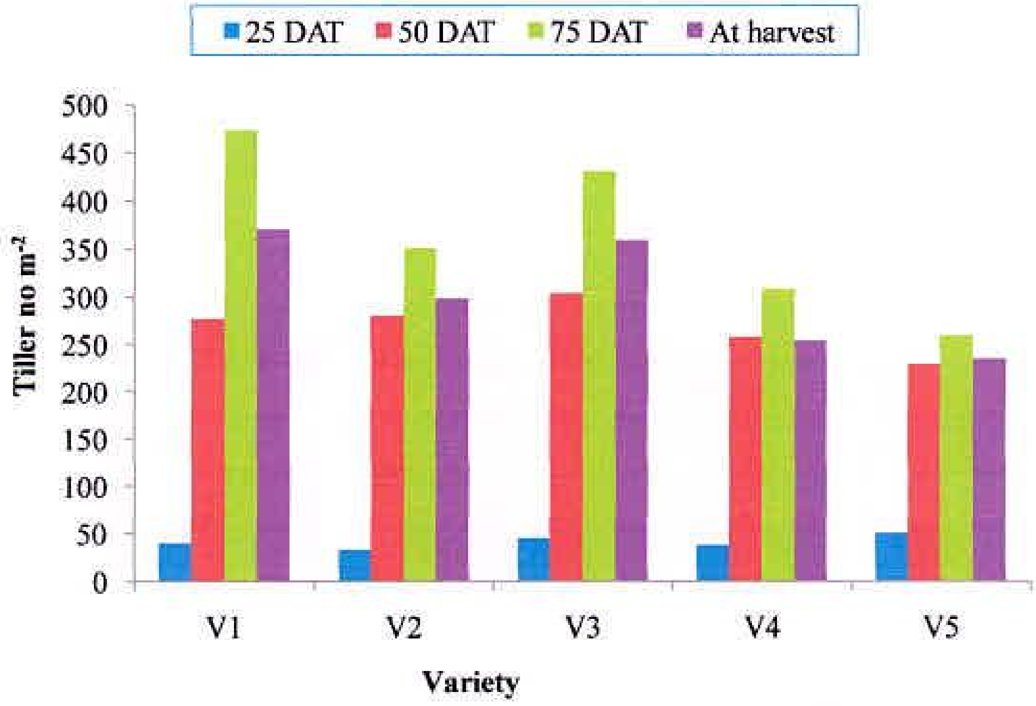
P_1 = Conventional method, P_2 = SRI

Figure 5. Effect of planting method on number of tillers m^{-2} at different growth duration of inbred and hybrid *boro* rice ($LSD_{0.05}$ = 13.63, 72.29, 93 and 44.97 at 25, 50, 75 DAT and at harvest, respectively)

4.1.3.2 Effect of variety

Significant variation for tiller number m^{-2} was observed among the varieties at 25, 50, 75 DAT and at harvest (Appendix VI and Figure 6).

At 25 DAT, the highest number of tillers m^{-2} was found for V_5 (50.83) which was statistically similar with V_3 (45.33) and the lowest tiller number m^{-2} was found for V_2 (33.22) which was statistically similar for V_1 (40.52) and V4 (37.57). At 50 DAT, the highest number of tillers number m^{-2} was produced in V_3 (303.80) which was statistically similar with V_1 (277.20), V_2 (280.40) and V_4 (257.80) and followed by V_5. The highest number of tillers m^{-2} was observed in V_1 (474.10) at 75 DAT which was statistically similar with V_3 (431.90) and the lowest was obtained from V_5 (260.00). At harvest the highest tiller number m^{-2} was again in V_1 (371.30) which was statistically similar with V_3 (359.30). The lowest tiller number m^{-2} number was observed in V_5 (235.50) which statistically similar with V_4 (254.40).



V_1 = BR 16, V_2 = BRRI dhan29, V_3 = BRRI dhan50, V_4 = BRRI hybrid dhan2, V_5 = Heera 4

Figure 6. Effect of variety on number of tillers m^{-2} at different growth duration of inbred and hybrid *boro* rice ($LSD_{0.05}$ = 10.02, 56.38, 47.09 and 35.66 at 25, 50, 75 DAT and at harvest, respectively)

4.1.3.3 Interaction effect of planting method and variety

Tiller number m^{-2} was significantly influenced by interaction effect of planting method and variety at 25, 50, 75 DAT and at harvest (Appendix VI and Table 3). At 25 DAT the highest tiller number m^{-2} was observed in the planting method of P_1 with the combination of variety V_5 (91.67) and the lowest tiller number m^{-2} was observed in planting method of P_2 with the combination of variety V_2 (9.60). At 50 DAT, the highest tiller number m^{-2} was found in the planting method of P_1 with the combination of variety V_3 (511.50) and the lowest tiller number m^{-2} was observed in planting method of P_2 with the combination of variety V_5 (86.00). At 75 DAT, the highest tiller number m^{-2} was observed in the planting method of P_1 with the combination of variety V_1 (548.20) the lowest tiller number m^{-2} was observed in the planting method of P_2 with the combination of variety V_5 (202.80). At harvesting the highest tiller number m^{-2} was observed in the planting method of P_1 with the combination of variety V_3 (438.20) and the lowest tiller number m^{-2} was observed in the planting method of P_2 with the combination of variety V_5 (196.00).

Table 3. Interaction effect of planting method and variety on tiller number m^{-2} of inbred and hybrid *boro* rice

Treatments	Tiller number m^{-2} at different DAT			
	25	50	75	At harvest
P_1V_1	67.83bc	440.00ab	548.20a	416.20a
P_1V_2	56.83c	436.30ab	392.30b	324.50bc
P_1V_3	80.67ab	511.50a	526.20a	438.20a
P_1V_4	62.33c	401.50b	372.20bc	280.50bcd
P_1V_5	91.67a	374.00b	317.20c	275.00cde
P_2V_1	13.20d	114.40c	400.00b	326.40b
P_2V_2	9.60d	124.40c	310.40cd	272.40de
P_2V_3	10.00d	96.00c	337.60bc	280.40bcd
P_2V_4	12.80d	114.00c	244.80de	228.40ef
P_2V_5	10.00d	86.00c	202.80e	196.00f
$LSD_{(0.05)}$	14.180	79.730	66.590	50.430
CV (%)	19.74	17.07	10.54	9.59

P_1 = Conventional method, P_2 = SRI method, V_1 = BR 16, V_2 = BRRI dhan29, V_3 = BRRI dhan50, V_4 = BRRI hybrid dhan2, V_5 = Heera 4

4.1.4 Leaf number hill^{-1} at different days after transplantation

4.1.4.1 Effect of planting method

Leaf number hill^{-1} was significantly different for the planting methods at 75, 100 DAT except 25 and 50 DAT (Appendix VII and Figure 7). At 25 and 50 DAT there was no significant difference of leaves hill^{-1} between the two planting method P_1 and P_2. But at 75 DAT and at harvest increasing trend was observed for P_2. Higher number of leaves hill^{-1} was produced in P_2 (249.27) than P_1 (78.6) at 75 DAT. Finally at harvest higher number of leaves hill^{-1} was produced in P_2 (211.60) than P_1 (60.88) which were 247.56% higher than P_1. Higher number of leaves hill^{-1} was in P_2 than P_1 might be due to higher number of tillers hill^{-1}.

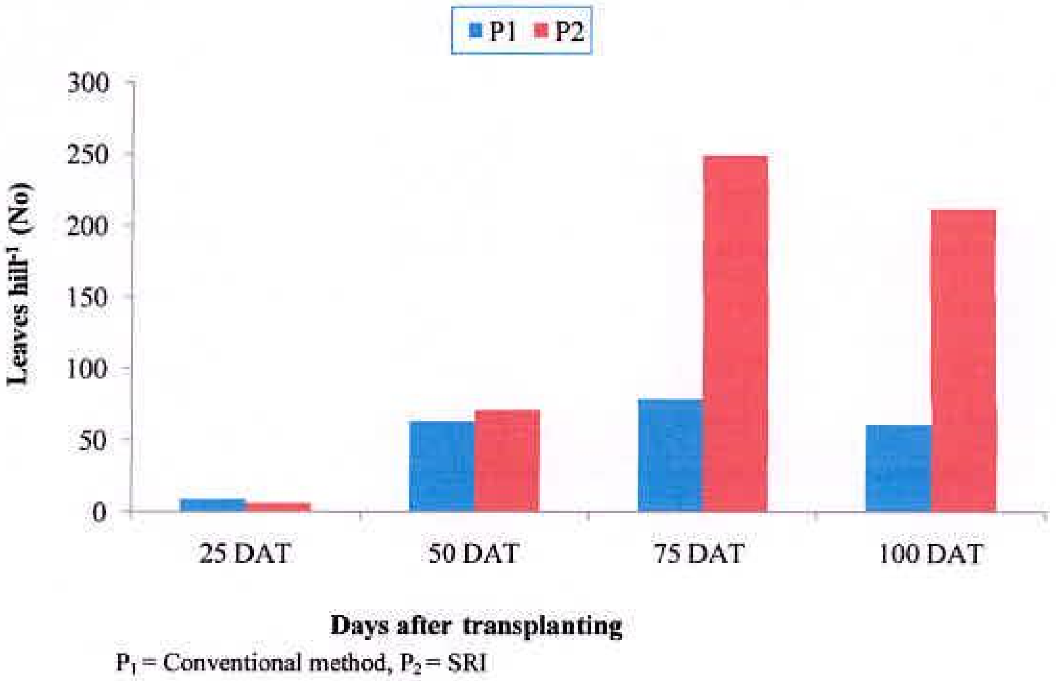
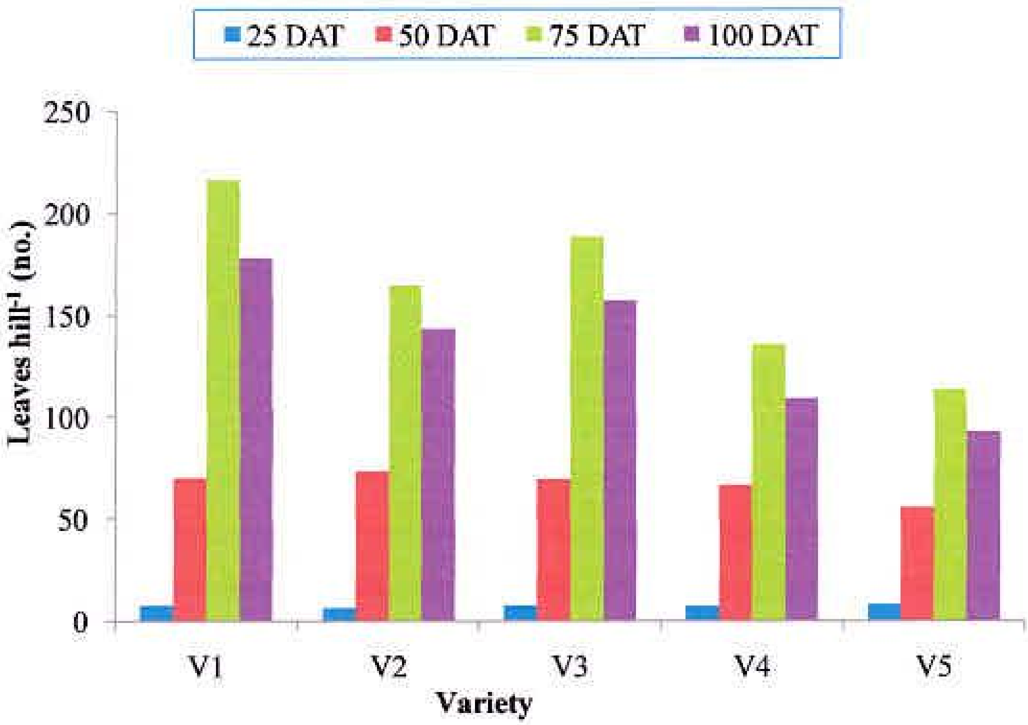


Figure 7. Effect of planting method on leaf number hill^{-1} at different growth duration of inbred and hybrid *boro* rice ($LSD_{0.05}$ = 5.669, 26.458, 74.001 and 34.451 at 25, 50, 75 and 100 DAT, respectively)

4.1.4.2 Effect of variety

Leaf number hill^{-1} was significantly influenced by varieties at 25, 50, 75 and 100 DAT (Appendix VII and Figure 8). At 25 DAT the highest number of leaves was produced in V_5 (8.267) which was statistically similar with V_1 (7.60), V_3 (7.57), and V_4 (7.20).The lowest number of leaves hill $^{-1}$ was produced in V_2 (6.27) which was also statistically similar with V_1, V_3 and V_4 at 25 DAT. At 50 DAT highest number of leaves was produced in V_2 (73.27) which was statistically similar with V_1 (69.93), V_3 (69.33), V_4 (66.80) and the lowest number of leaves hill $^{-1}$ was produced in V_5 (55.93) which was also statistically similar with V_1, V_3 and V_4. At 75 DAT, the highest numbers of leaves hill $^{-1}$ was produced in V_1 (216.50) and the lowest number of leaves hill $^{-1}$ was produced in V_5 (113.70) which were also statistically similar with V_4 (135.80). Similar trend for V_1 and V_5 was observed at 100 DAT. The highest number of leaves hill $^{-1}$ was produced in V_1 (178.20) and lowest number of leaves hill $^{-1}$ was produced in V_5 (93.00). The variation of number of leave hill $^{-1}$ in different variety might be due to the different genetic characters and environmental condition.



V_1 = BR 16, V_2 = BRRI dhan29, V_3 = BRRI dhan50, V_4 = BRRI hybrid dhan2, V_5 = Heera 4

Figure 8. Effect of variety on leaf number hill^{-1} at different growth duration of inbred and hybrid *boro* rice ($LSD_{0.05}$ = 1.474, 15.31, 22.48 and 11.34 at 25, 50, 75 DAT and 100 DAT, respectively)

4.1.5.3 Interaction effect of planting method and variety

Leaf number hill^{-1} was influenced by the interaction of planting methods with the variety at 25, 50, 75 and 100 DAT (Appendix VII and Table 4). At 25 DAT, the highest leaf number hill^{-1} was produced in the planting method of P_1 with the variety V_5 (10.67) which was statistically similar to the interaction of planting method of P_1 with the variety V_3 (9.40) and the lowest leaf number hill^{-1} was observed in the planting method of P_2 with the variety V_2 (5.53) that was statistically similar with the planting method of P_1 with the variety V_2 (7.00), planting method of P_2 with the variety V_1 (7.13), planting method of P_2 with the variety V_3 (5.73) , planting method of P_2 with the variety V_4 (6.73) and planting method of P_2 with the variety V_5 (5.87). At 50 DAT, the highest leaf number hill^{-1} was produced in the planting method of P_2 with the variety V_2 (82.67) which was statistically similar with the planting method of

P_1 with the variety V_1 (64.00), the planting method of P_1 with the variety V_2 (63.87), the planting method of P_1 with the variety V_3 (74.67), the planting method of P_2 with the variety V_1 (75.87), the planting method of P_1 with the variety V_3 (64.00) the planting method of P_1 with the variety V_2 (75.73) and the lowest leaf number hill^{-1} was produced in the planting method of P_1 with the variety V_5 (54.40) that was not significantly different with the planting method of P_1 with the variety V_1 (64.00), planting method of P_1 with the variety V_2 (63.87), planting method of P_1 with the variety V_3 (74.67), planting method of P_1 with the variety V_4 (57.87), planting method of P_2 with the variety V_1 (75.87), planting method of P_2 with the variety V_3 (64.00), planting method of P_2 with the variety V_4 (75.73) and planting method of P_2 with the variety V_5 (57.47). At 75 DAT, the highest leaf number hill^{-1} was produced in the planting method of P_2 with the variety V_1 (333.30) and the lowest leaf number hill^{-1} was produced in the planting method of P_1 with the variety V_5 (58.33) which result was statistically similar with the planting method of P_1 with the variety V_2 (71.33) and planting method of P_1 with the variety V_4 (67.67). At 100 DAT, the highest leaf number hill^{-1} was also observed in the planting method of P_2 with the variety V_1 (277.00) and the lowest leaf number hill^{-1} was produced in the planting method of P_1 with the variety V_5 (44.67g) which was statistically similar with the planting method of P_1 with the variety V_2 (59.67) and the planting method of P_1 with the variety V_4 (47.40).

Table 4. Interaction effect of planting method and variety on number leaves hill^{-1} of inbred and hybrid *boro* rice

Treatments	Leaf number hill^{-1} at different DAT			
	25	50	75	100
P_1V_1	8.07bc	64.00ab	99.67e	79.33e
P_1V_2	7.00cde	63.87ab	71.33efg	59.67fg
P_1V_3	9.40ab	74.67ab	96.00ef	73.33ef
P_1V_4	7.67bcd	57.87b	67.67fg	47.40g
P_1V_5	10.67a	54.40b	58.33g	44.67g
P_2V_1	7.13cde	75.87ab	333.30a	277.00a
P_2V_2	5.53e	82.67a	258.70b	227.30b
P_2V_3	5.73de	64.00ab	281.30b	241.00b
P_2V_4	6.73cde	75.73ab	204.00c	171.30c
P_2V_5	5.87de	57.47b	169.00d	141.30d
LSD $_{(0.05)}$	2.085	21.660	31.790	16.040
CV (%)	16.32	18.66	11.20	6.80

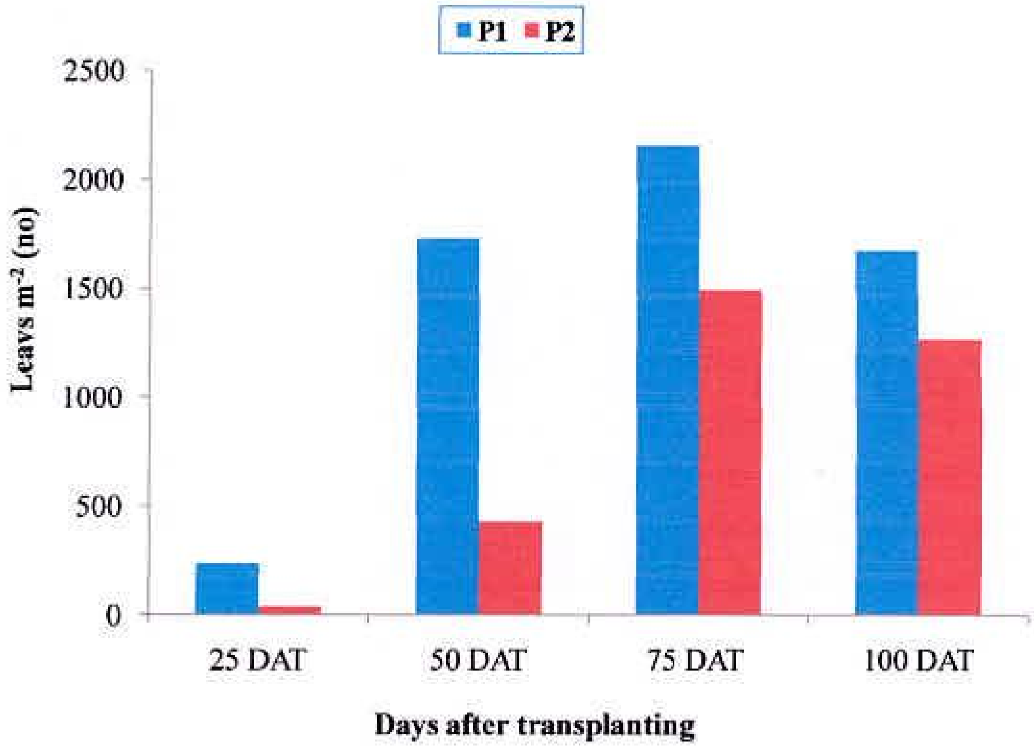
P_1 = Conventional method, P_2 = SRI, V_1 = BR16, V_2 = BRRI dhan29, V_3 = BRRI dhan50, V_4 = BRRI hybrid dhan2, V_5 = Heera 4

4.1.5 Number of leaves m^{-2} at different days after transplantation

4.1.5.1 Effect of planting method

Leaf number m^{-2} was significantly influenced by the planting method at 25 DAT, 50 DAT, and 75 and 100 DAT (Appendix VIII and Figure 9).

The P_1 (235.40, 1731.40, 2161.50 and 1674.83) produced higher leaf number m^{-2} at 25, 50 DAT, 75 DAT and at 100 DAT than P_2 (37.20, 426.88, 1495.60 and 1269.60, respectably) P_1 produced higher number of leaves m^{-2} might be due to higher tiller number m^{-2} in P_1 than P_2.



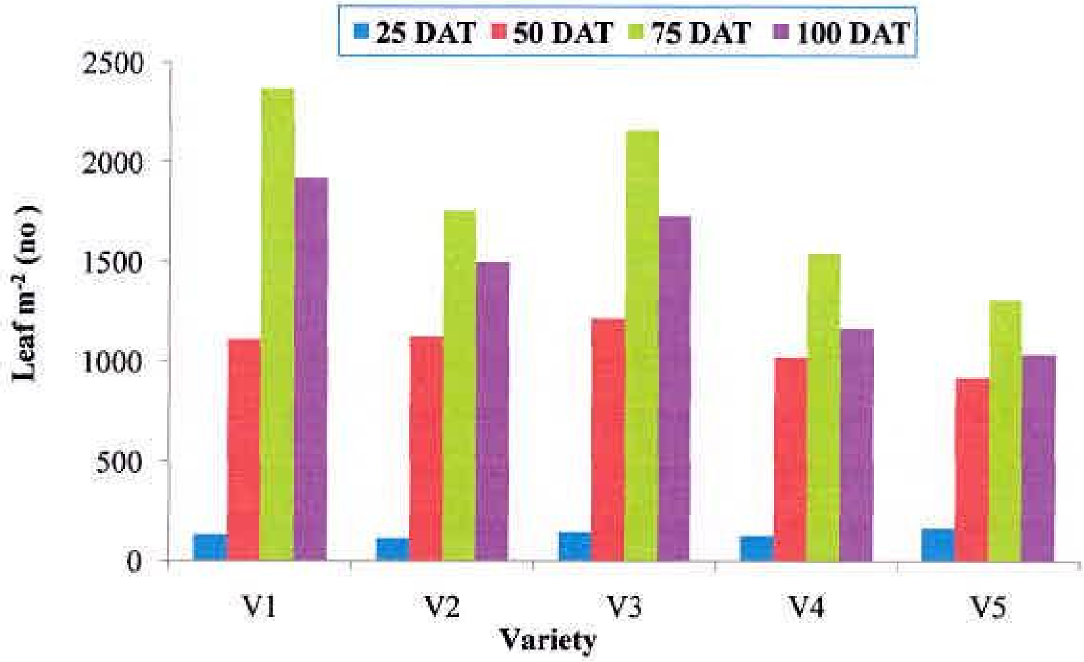
P_1 = Conventional method, P_2 = SRI

Figure 9. Effect of planting method on leaf number m^{-2} at different growth duration of inbred and hybrid *boro* rice (LSD $_{0.05}$ = 34.69, 292.85, 444.09 and 194.94 at 25, 50, 75 and 100 DAT, respectively)

4.1.5.2 Effect of variety

Significant difference for leaf number m^{-2} was observed among the varieties at 25, 50, 75 and 100 DAT (Appendix VIII and Figure 10).

At 25 DAT, the highest leaf number m^{-2} was recorded in V_5 (164.3) which was statistically similar with V_2 (112.80) and the lowest leaf number m^{-2} was recorded in V_2 (112.8) which was statically similar with V_1 (132.3) and V_4 (125.6). At 50 DAT the highest leaf number m^{-2} was observed in V_3 (1219.00) which was statically similar with V_1 (1108.00), V_2 (1126.00), and V_4 (1023.00). The lowest leaf number m^{-2} was observed at 50 DAT for V_5 (920.40) which were also statistically similar with V_1, V_2 and V_4. At 75 DAT highest leaf number m^{-2} was obtained from V_1 (2370.00) that was statistically similar with V_3 (2164.00) and the lowest leaf number m^{-2} was obtained from V_5 (1309.00) which was statistically similar with V_4 (1542.00. At 100 DAT the highest leaf number m^{-2} was produced in V_1 (1922.00) and the lowest leaf number m^{-2} was obtained from V_5 (1038.00) which was followed by V_4 (1038.00).



V_1 = BR 16, V_2 = BRRI dhan29, V_3 = BRRI dhan50, V_4 = BRRI hybrid dhan2, V_5 = Heera 4

Figure 10. Effect of variety on leaf number m^{-2} at different growth duration of inbred and hybrid *boro* rice ($LSD_{0.05}$ = 29.08, 220.4, 237.6 and 180.5 at 25, 50, 75 and 100 DAT, respectively)

4.1.5.3 Interaction effect of planting method and variety

The leaf number m^{-2} was significantly influenced by the interaction of planting methods with the different varieties at 25, 50, 75and 100 DAT (AppendixVIII and Table 5). At 25 DAT, significantly maximum leaf number m^{-2} was produced in the planting method P_1 with the variety V_5 (293.3) which was statistically similar with the planting method of P_1 with the variety V_3 (258.5) and the lowest leaf number m^{-2} was produced in the planting method of P_2 with the variety V_2 (33.20) which statistically similar with the planting method of P_2 with the variety V_1 (42.80), planting method of P_2 with the variety V_3 (34.40), planting method of P_2 with the variety V_4 (40.40)and planting method of P_2 with the variety V_5 (35.20). At 50 DAT, maximum leaf number m^{-2} was obtained from planting method of P_1 with the variety of V_3 (2053.00) which was statistically similar in the planting method of P_1 with the variety of V_1 (1760.00) and the lowest leaf number m^{-2} was produced in the planting method of P_2 with the variety of V_5 (344.80) which was statistically similar in the planting method P_2 with the variety of V_1 (455.20), planting method P_2 with the variety of V_2 (496.00), planting method P_2 with the variety of V_3 (384.0) and planting method P_2 with the variety V_4 (454.40). At 75 DAT, significantly maximum leaf number m^{-2} was obtained from planting method of P_1 with the variety V_1 (2741.00) which was similar in the planting method P_1 with the variety V_3 (2640.0) and the lowest leaf number m^{-2} was obtained from planting method of P_2 with the variety V_5 (1014.00) which was statistically similar with the planting method of P_2 with the variety V_4 (1224.00). Similar trend was observed at 100 DAT that maximum number of leaf number m^{-2} was produced in the planting method of P_1 with the variety V_1 (2182.00) which were statistically similar with the planting method P_1 with the variety V_3 (2017.00) and the lowest leaf number m^{-2} was obtained from planting method of P_2 with the variety V_5 (848.00) which was statistically similar with the planting method of P_2 with the variety V_4 (1028.00). Lower leaf number m^{-2} might be due lower tiller production per unit square meter area, higher amount (4.58 times more) hill transplanting per unit area in P_1 than P_2.

Table 5. Interaction effect of planting method and variety on number leaf m^{-2} of inbred and hybrid *boro* rice

Treatments	Leaf number m^{-2} at different DAT			
	25	50	75	100
P_1V_1	221.8bc	1760.ab	2741.a	2182.a
P_1V_2	192.5c	1756.b	1962.b	1641.b
P_1V_3	258.5ab	2053.a	2640.a	2017.a
P_1V_4	210.8c	1591.b	1861.bc	1304.c
P_1V_5	293.3a	1496.b	1604.c	1228.cd
P_2V_1	42.80d	455.2c	2000.b	1662.b
P_2V_2	33.20d	496.0c	1552.cd	1364.c
P_2V_3	34.40d	384.0c	1688.bc	1446.bc
P_2V_4	40.40d	454.4c	1224.de	1028.de
P_2V_5	35.20d	344.8c	1014.e	848.0e
$LSD_{(0.05)}$	41.12	311.7	336	255.3
CV (%)	17.43	16.69	10.61	10.02

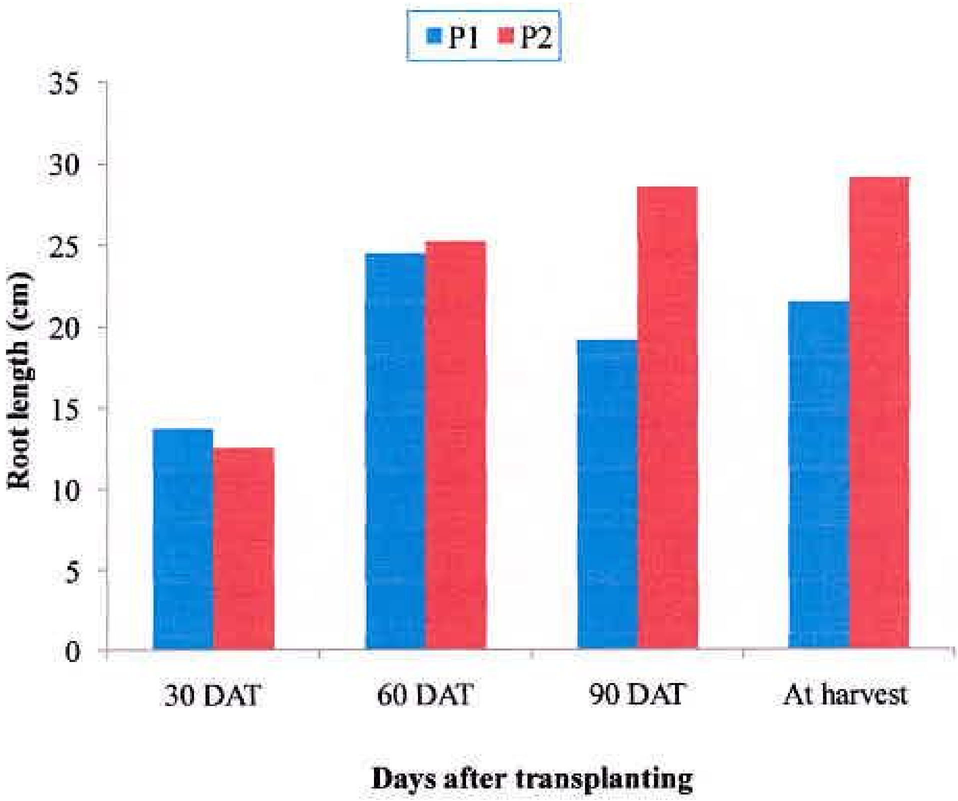
P_1 = Conventional method, P_2 = SRI, V_1 = BR 16, V_2 = BRRI dhan29, V_3 = BRRI dhan50, V_4 = BRRI hybrid dhan2, V_5 = Heera 4

4.1.6 Length of root (cm) at different days after transplantation

4.1.6.1 Effect of planting method

This result revealed that root length (cm) was significantly influenced by the planting method at 90 DAT and at harvest but was not influenced at 30 DAT and 60 DAT (Appendix IX and Figure 11).

At 30 ADT and 60 DAT the root length was affected by both of the planting method P_1 and P_2. Numerically longer root was observed in conventional method P_1 (13.73 cm) than SRI P_2 (12.57 cm) at 30 DAT but they are statistically insignificant. At 60 DAT numerically longer root length was recorded in P_2 (25.22 cm) than the planting method P_1 (24.51 cm) but they were also statistically insignificant. At 90 DAT longer root length was recorded in P_2 (228.53 cm) than P_1 (19.17 cm). Similar trend was observed at harvest that was longer root in P_2 (29.10 cm) than P_1 (21.50 cm). Longer root in SRI might be due to loose soil than the conventional method for using organic matter, intermittent supply of water and mechanical weeding which facilitate the aeration in the soil, minimum injury in root during transplanting of younger seedling, higher number of tillers $hill^{-1}$. Uphoff (2001) was also support these result by his one of research findings. According to his findings as in SRI practice mechanical weeder is used, weed become incorporated with the soil; increase the root activity which stimulate the new cell division in roots by pruning of some upper roots encouraged deeper root growth. Aziz and Hasan (2000) was also agreed with these research finding who observed that using single seedling per hill root development was more and healthier under SRI method.



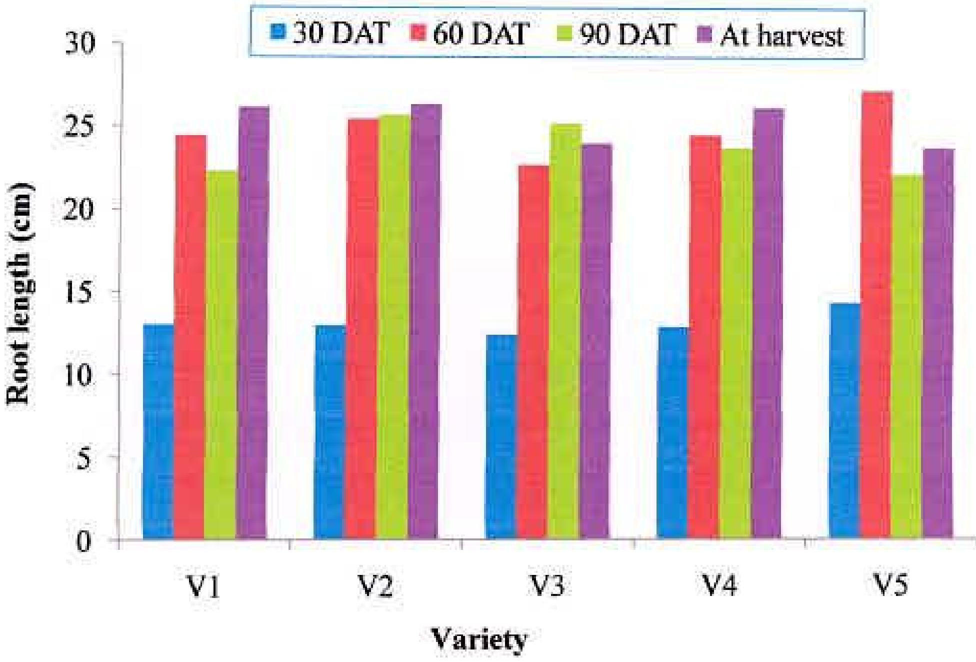
P_1 = Conventional method, P_2 = SRI

Figure 11. Effect of planting method on root length at different growth duration of inbred and hybrid *boro* rice (LSD 0.05 = 2.39, 1.94, 4.05 and 2.17 at 30, 60, 90 DAT and at harvest, respectively)

4.1.6.2 Effect of variety

Root length was significantly influenced by the variety at 30, 60, 90 DAT and but at harvest it was statistically similar (Appendix IX and Figure 12).

At 30 DAT longest root was produced in hybrid variety V_5 (14.36 cm) which was statistically similar with inbred verity V_1 (13.0 cm 4), V_2 (13.00 cm) and hybrid variety V_4 (12.90 cm) followed by inbred variety V_3 (12.45 cm). The longest root was found in hybrid variety V_5 (27.23 cm) at 60 DAT which was statistically similar with inbred variety V_2 (25.46 cm) and the shortest root was observed in the inbreed variety V_3 (22.71 cm) which was statistically similar with the variety V_1 (24.42 cm) and V_4 (24.50 cm). At 90 DAT, the longest root was produced in the inbreed variety V_2 (25.71 cm) which statistically similar in inbreed variety V_3 (25.25 cm) and hybrid breed variety V_4 (23.75 cm) and the shortest root length was observed in hybrid variety V_5 (22.21 cm) which statistically similar to inbred variety V_1 (22.33 cm) and hybrid variety V_4 (23.75 cm). At harvest there was no significant difference of root length observed among the varieties. Numerically the maximum root length was observed in V_2 (26.38 cm) and the shortest root was recorded in V_5 (23.79 cm). The variation in root length might be due to the genetic character of the variety and as the hill was uprooted by hand some root might be lost.



V_1 = BR 16, V_2 = BRRI dhan29, V_3 = BRRI dhan50, V_4 = BRRI hybrid

Figure 12. Effect of variety on root length at different growth duration of inbred and hybrid *boro* rice ($LSD_{0.05}$ = 1.677, 2.253, 2.975, and 3.233 at 30, 60, 90 DAT and at harvest, respectively)

4.1.6.3 Interaction effect of planting method and variety

Root length was significantly influenced by the interaction effect of plating method and variety at 30, 60, 90 DAT and at harvest (Appendix IX and Table 6).

The longest root was produced at 30 DAT in the planting method of P_1 with the variety V_5 (16.15 cm) and the shortest root was recorded in planting method of P_2 with variety V_3 (11.13 cm) which was statistically similar in the planting method of P_1 with the variety V_1 (12.78b cm), planting method of P_1 with the variety V_2 (13.03 cm), planting method of P_1 with the variety V_4 (12.90 cm), planting method of P_2 with the variety V_1 (13.30 cm), planting method of P_2 with the variety V_2 (12.97 cm), planting method of P_2 with the variety V_4 (12.90 cm) and planting method of P_2 with the variety V_5 (12.57 cm). At 60 DAT, the longest root was recorded in the planning method P_2 with the variety V_5 (27.42 cm) which was statistically similar in the planning method P_1 with the variety V_2 (24.25 cm), the planning method P_1 with the variety V_3 (24.50 cm), the planning method P_1 with the variety V_5 (27.05 cm), the planning method P_2 with the variety V_1 (25.25 cm), the planning method P_2 with the variety V_2 (26.67 cm) and the planning method P_2 with the variety V_4 (25.83 cm).

Length of the root was the longest in the planting method of P_2 with the variety V_2 (30.83 cm) which was statistically similar in the planting method of P_2 with the variety V_1 (28.50 cm), planting method of P_2 with the variety V_3 (28.50 cm) and planting method of P_2 with the variety V_4 (29.67 cm). The shortest root was produced in the planting method of P_1 and variety V_1 (16.17 cm) which was similar with the planting method of P_1 with the variety V_4 (17.83 cm) and planting method P_1 with variety V_5 (19.25 cm). Finally at harvest the longest root was produced in the combination of planting method of P_2 with the variety V_2 (30.17 cm) that was statistically similar among all of the combination of SRI with different varieties and the shortest root length was produced in the combination of the planting method of P_1 with the variety V_5 (19.58 cm) there was no significant difference among the combination of conventional planting method with different varieties.

Table 6. Interaction effect of planting method and variety on root length at different growth duration of inbred and hybrid *boro* rice

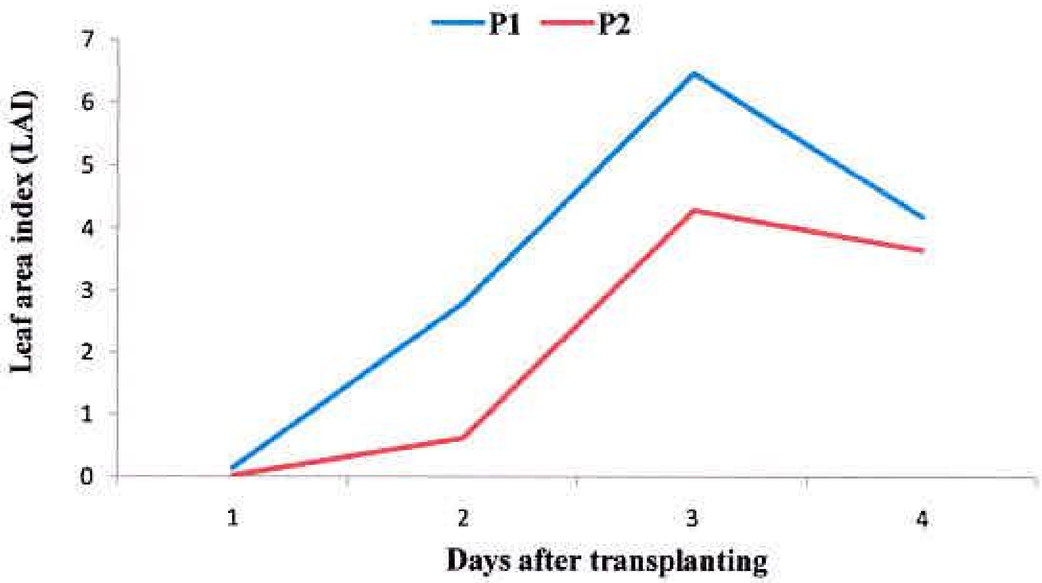
Treatments	Root length (cm) at different DAT			
	30	60	90	At harvest
P_1V_1	12.78bc	23.58bcd	16.17e	22.75b
P_1V_2	13.03bc	24.25abc	20.58d	22.58b
P_1V_3	13.77b	24.50abc	22.00cd	19.92b
P_1V_4	12.90bc	23.17cd	17.83de	22.67b
P_1V_5	16.15a	27.05a	19.25de	19.58b
P_2V_1	13.30bc	25.25abc	28.50ab	29.50a
P_2V_2	12.97bc	26.67ab	30.83a	30.17a
P_2V_3	11.13c	20.92d	28.50ab	28.17a
P_2V_4	12.90bc	25.83abc	29.67a	29.67a
P_2V_5	12.57bc	27.42a	25.17bc	28.00a
$LSD_{(0.05)}$	2.372	3.186	4.208	4.573
CV (%)	10.42	7.40	10.19	10.44

P_1 = Conventional method, P_2 = SRI, V_1 = BR 16, V_2 = BRRI dhan29, V_3 = BRRI dhan50, V_4 = BRRI hybrid dhan2, V_5 = Heera 4

4.1.7 Leaf Area Index (LAI) at different days after transplantation

4.1.7.1 Effect of planting method

Leaf area index (LAI) was influenced by planting method at 25, 50, 75, and 100 DAT (Appendix X and Figure 13). At 25 DAT, the higher was observed in the planting method of P_1 than the planting method P_2 and at 50 DAT also higher LAI was observed in planting method of P_1 than planting method P_2. But incase at 75 DAT and at harvest LAI was not significantly influenced; they were statistically similar in LAI. From 25 DAT to 50 DAT LAI was increased 20 times in conventional method P_1 where it was 31 times in SRI. From 50 DAT to 75 DAT the increasing rate of LAI become slow. It was 2.30 times in conventional method P_1 where it was 6.91 times in SRI. At 100 DAT LAI decrease 35.14% in conventional method P_1 where it was 13.99% in SRI method P_2 from LAI at 75 DAT. Faster increasing rate of LAI in SRI might be due to rapid vegetative growth rate, rapidly increase of tillers, comparatively longer and wider leaves in SRI than conventional method. Thakur *et al.* (2010) also agreed that SRI produced longer leaf than conventional method.



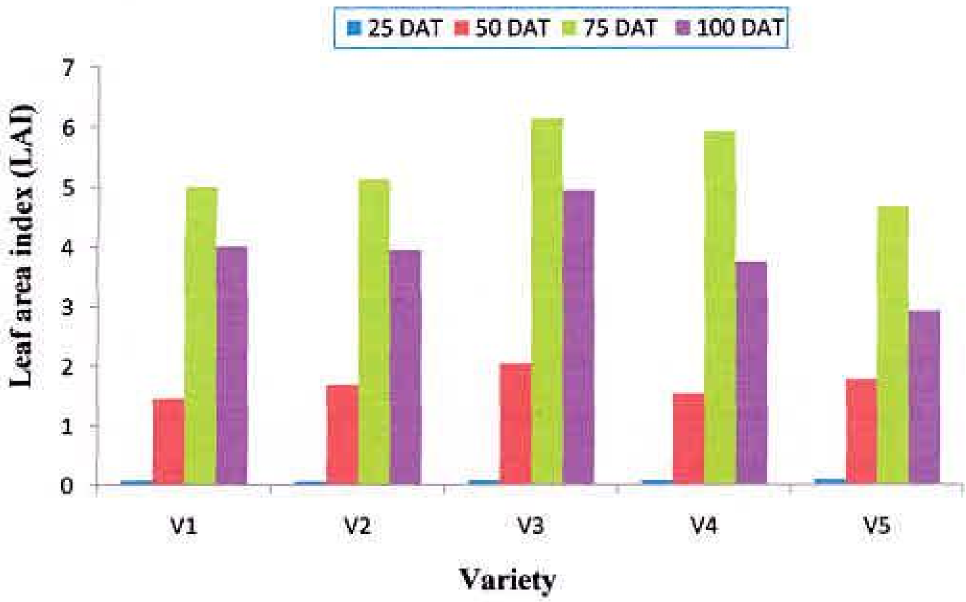
P_1 = Conventional method, P_2= SRI, 1 = 25 DAT, 2= 50 DAT, 3 = 75 DAT, 4 = 100 DAT

Figure 13. Effect of planting method on leaf area index at different growth duration of inbred and hybrid *boro* rice ($LSD_{0.05}$ = 0.05, 0.42, 2.33 and 0.49 at 25 DAT, 50 DAT, 75 DAT and 100 DAT, respectively)

4.1.7.2 Effect of variety

Leaf area index (LAI) was significantly influenced by variety at 50 and at 100 DAT except 25 and 75 DAT (Appendix XI and Figure 14).

AT 25 DAT there was no statistical difference among the varieties for LAI. Numerically, the maximum LAI was obtained in V_5 (0.107) and the minimum was in V_2 (0.065). At 50 DAT the highest LAI was recorded in inbreed variety V_3 (2.05) and similar result was obtained from inbreed variety V_2 (1.69), hybrid variety V_4 (1.54) and hybrid variety V_5 (1.79) followed by inbreed variety V_1 (1.47). At 75 DAT, LAI was not influenced by the variety of inbreed or hybrid, they showed statistically similar result. At 100 DAT, the highest LAI was produced in inbred variety of V_3 (4.95) and the lowest variety was produced in V_5 (2.94) which was statistically similar with V_4 (3.75).



V_1 = BR 16, V_2 = BRRI dhan29, V_3 = BRRI dhan50, V_4 = BRRI hybrid dhan2, V_5 = Heera 4

Figure 14. Effect of variety on leaf area index at different growth duration of inbred and hybrid *boro* rice ($LSD_{0.05}$ = NS, 0.5542, 1.531and 0.831 at 25, 50, 75 and 100 DAT, respectively)

4.1.7.3 Interaction effect of planting method and variety

Leaf area index (LAI) was significantly influenced by the interaction effect of plating method and variety (Appendix X and Table 7). At 25 DAT there was no significant difference among the interaction effect of planting methods and varieties. The highest LAI at 50 DAT was observed in the planting method of P_1 with the variety V_3 (3.59) which was similar in planting method of P_1 with the variety V_5 (2.98) and the lowest LAI was produced in planting method of P_2 with the variety V_3 (0.51) which was statistically similar in the planting method of P_2 with the variety V_1 (0.60), planting method of P_2 with the variety V_3 (0.69), planting method of P_2 with the variety V_4 (0.70) and planting method of P_2 with the variety V_5 (0.61). AT 75 DAT, the highest LAI was produced in the planting method of P_1 with the variety V_3 (7.77) which was statistically similar in the planting method of P_1 with the variety V_1 (6.08), planting method of P_1 with the variety V_2 (5.69), planting method of P_1 with the variety V_4 (7.51) and the lowest LAI was produced in the planting method of P_2 with the variety V_1 (3.95). Finally at harvest the highest LAI was obtained from interaction of plating method of P_1 and the variety V_3 (5.82) and the lowest for the interaction of planting method of P_2 with the variety V_5 (2.58) which was statistically similar in the planting method of P_1 with the variety V_2 (3.71), the planting method of P_1 with the variety V_5 (3.21) and the planting method of P_2 with the variety V_4 (3.42).

Table 7. Interaction effect of planting method and variety on leaf area index at different growth duration of inbred and hybrid *boro* rice

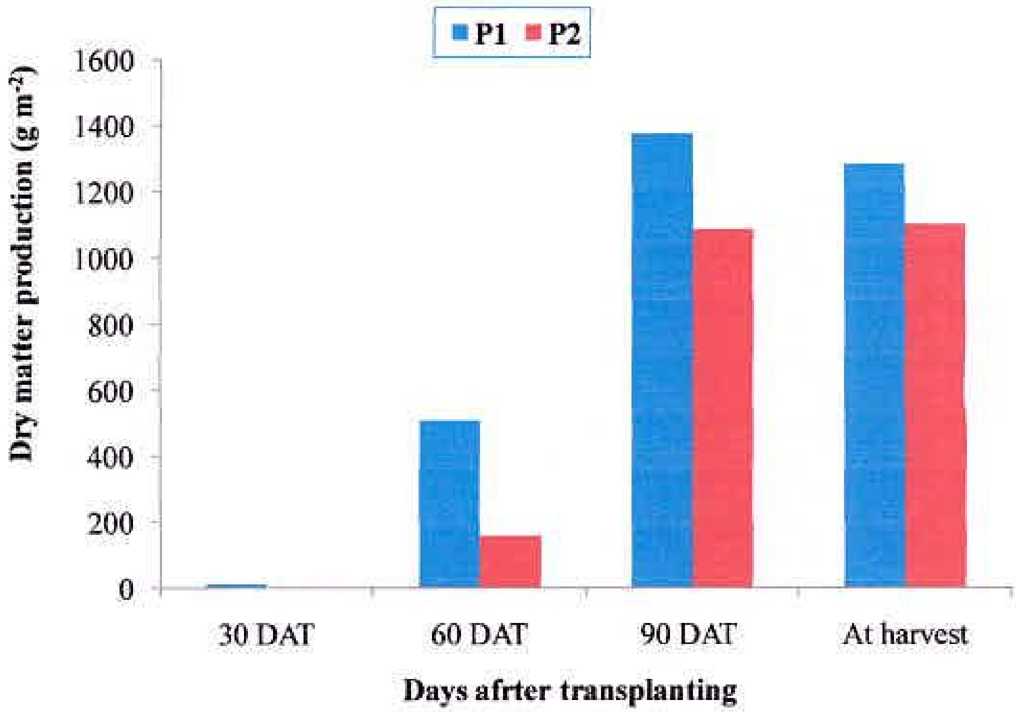
Treatments	Leaf area index at different DAT			
	25	50	75	100
P_1V_1	0.13	2.33b	6.08ab	4.04b
P_1V_2	0.11	2.70b	5.69ab	3.71bc
P_1V_3	0.15	3.59a	7.77a	5.82a
P_1V_4	0.14	2.38b	7.51a	4.09b
P_1V_5	0.19	2.98ab	5.32b	3.21bc
P_2V_1	0.02	0.60c	3.95b	3.97b
P_2V_2	0.02	0.69c	4.57b	4.18b
P_2V_3	0.01	0.51c	4.57b	4.08b
P_2V_4	0.02	0.70c	4.35b	3.42bc
P_2V_5	0.02	0.61c	4.01b	2.58c
LSD $_{(0.05)}$	NS	0.7837	2.165	1.175
CV (%)	14.82	26.53	23.27	17.34

P_1 = Conventional method, P_2 = SRI, V_1 = BR 16, V_2 = BRRI dhan29, V_3 = BRRI dhan50, V_4 = BRRI hybrid dhan2, V_5 = Heera 4

4.1.8 Dry matter production (g m^{-2}) at different days after transplantation

4.1.8.1 Effect of planting method

Total dry matter production was significantly affected by the planting method at 30, 60, 90 DAT and at harvest (Appendix XI and Figure 15). At 30, 60 and 90 DAT dry matter production was higher in P_1 than P_2. But in case of harvesting time there was no significant difference among conventional method P_1 and SRI. Both of them revealed statistically similar result for LAI. This result was also supported by Nissanka and Bandara (2004) who observed that the dry weight was significantly higher in SRI when hill^{-1} considered but when considered unit^{-1} basis, there was no significant difference between SRI and conventional method.



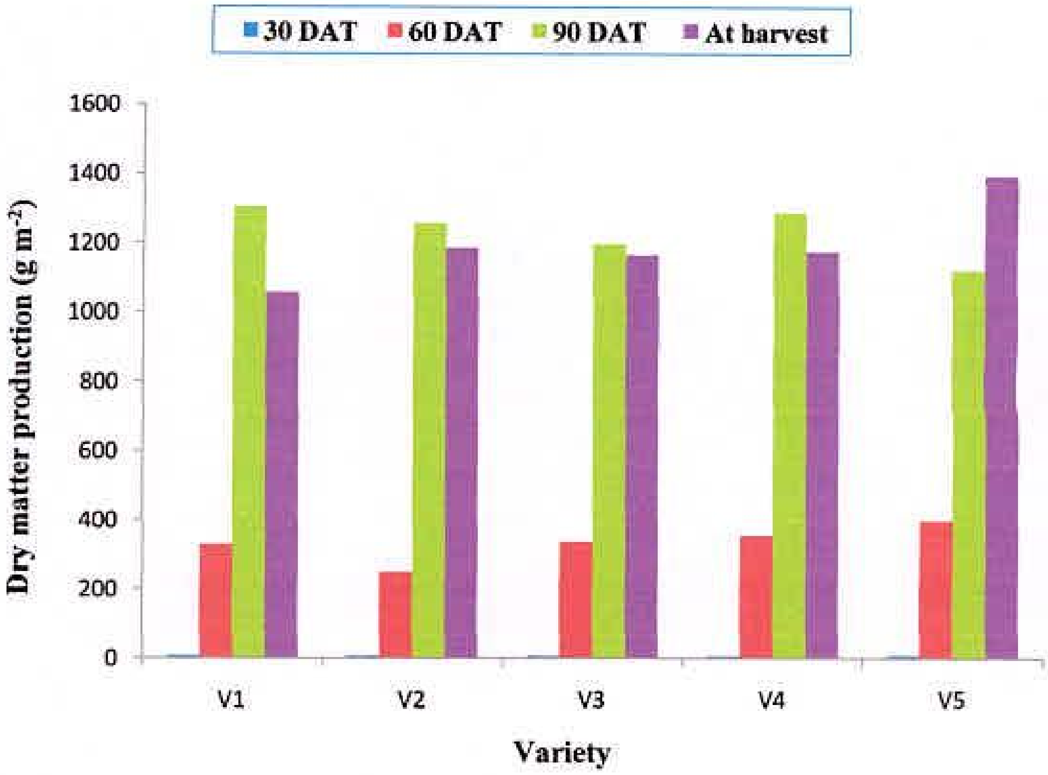
P_1 = Conventional method, P_2 = SRI

Figure 15. Effect of planting method on dry matter production at different growth duration of inbred and hybrid *boro* rice ($LSD_{0.05}$ = 6.71, 231.78, 265.76 and 220.52 at 30, 60, 90 DAT and at harvest, respectively)

4.1.8.2 Effect of variety

Total dry weight was significantly influenced by variety at 60 DAT and harvest but not at 25 and 90 DAT (Appendix XI and Figure 16).

At 30 and 90 DAT, total dry weight m^{-2} was statistically similar among inbred and hybrid varieties. At 60 DAT, the highest dry weight m^{-2} was produced in hybrid variety V_5 (399.10 g) which was statistically similar with V_1 (330.00 g), V_3 (337.30 g) and V_4 (337.30 g) followed by V_2 (249.40 g). At harvest the highest dry weight m^{-2} was observed in variety of V_5 (1396.00 g) which was statistically similar with V_2 (1187.00 g), V_3 (1165.00 g) and V_4 (1175.00 g) followed by V_1 (1058.00 g). The variation in the dry matter production might be due to the different genetic character of the varieties.



V_1 = BR 16, V_2 = BRRI dhan29, V_3 = BRRI dhan50, V_4 = BRRI hybrid dhan2, V_5 = Heera 4

Figure 16. Effect of variety on dry matter production at different growth duration of inbred and hybrid *boro* rice ($LSD_{0.05}$ = 3.529, 142.00, 190.3 and 278.2 at 30, 60, 90 DAT and at harvest, respectively)

4.1.7.3 Interaction effect of planting method and variety

Interaction effect of planting method and variety significantly influenced the total dry matter production m^{-2} (Appendix XI and Table 8).

At 30 DAT, the highest dry matter m^{-2} was produced in the combination of P_1V_5 (15.86 g) which was statistically similar with P_1V_1 (15.68 g), P_1V_2 (12.47 g) and P_1V_3 (11.73 g). The lowest was produced at 30 DAT in the combination P_2V_3 that was statistically similar with P_2V_1 (1.80 g), P_2V_2 (1.60 g), P_2V_4 (2.50 g) and P_2V_5 (1.84 g). At 60 DAT, the highest dry matter m^{-2} was produced in P_1V_5 (615.20 g) which was statistically similar with P_1V_1 (461.90 g), P_1V_3 (562.50 g) and P_1V_4 (557.00 g) and the lowest was produced in P_2V_3 (112.10 g) and statistically similar with P_2V_1 (198.00 g), P_2V_2 (150.80 g), P_2V_4 (151.70 g) and P_2V_5 (183.10 g). At 90 DAT, the highest dry matter was in P_1V_4 (1485.00 g) and the lowest was produced in P_2V_3 (1032.00 g). Finally at harvest the highest dry weight m^{-2} was produced in P_1V_5 (1590.00 g) and the lowest was produced in P_1V_1 (981.00 g).

Table 8. Interaction effect of planting method and variety on total dry weight at different growth duration of inbred and hybrid *boro* rice

Treatments	Total dry weight (g m^{-2}) at different DAT			
	30	60	90	At harvest
P_1V_1	15.68a	461.90ab	1361.0abc	981.0b
P_1V_2	12.47ab	348.10bc	1478.0ab	1206.0ab
P_1V_3	11.73ab	562.50a	1361.0abc	1316.0ab
P_1V_4	10.18b	557.00a	1485.0a	1342.0ab
P_1V_5	15.86a	615.20a	1210.0bcd	1590.0a
P_2V_1	1.80c	198.00cd	1250.0abcd	1135.0b
P_2V_2	1.60c	150.80cd	1040.0d	1168.0b
P_2V_3	1.18c	112.10d	1032.0d	1013.0b
P_2V_4	2.50c	151.70cd	1093.0cd	1007.0b
P_2V_5	1.84c	183.10cd	1036.0d	1201.0ab
$LSD_{(0.05)}$	4.990	200.900	269.100	393.400
CV (%)	38.53	34.74	12.60	19.00

P_1 = Conventional method, P_2 = SRI, V_1 = BR 16, V_2 = BRRI dhan29, V_3 = BRRI dhan50, V_4 = BRRI hybrid dhan2, V_5 = Heera 4

4.2 Yield and Other Crop Characters

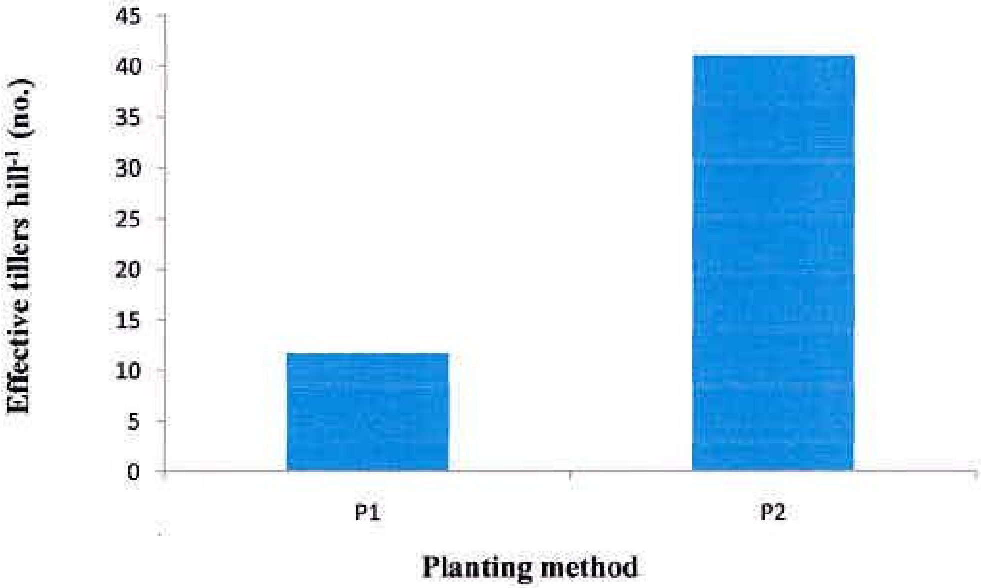
4.2.1 Number of effective tillers hill^{-1}

4.2.1.1 Effect of planting method

The number effective tillers hill^{-1} was greatly influenced by the planting methods (Appendix XII and Figure 17).

Significantly higher number of effective tillers hill^{-1} was produced in the planting method of SRI and the lower number of effective tiller hill^{-1} was produced in the conventional method. It was 250.04% higher in SRI than conventional method.

Krishna *et al.* (2008) also observed the similar result in SRI method that was to the extent of 217% over traditional method. Gani *et al.* (2002) assumed that the majority of the tillers convert into productive tillers. Mazid *et al.* (2003) was also in agreement in SRI method with 30 cm×30cm and 40 cm×40cm spacing and younger seedlings increased number of effective tillers hill^{-1}.

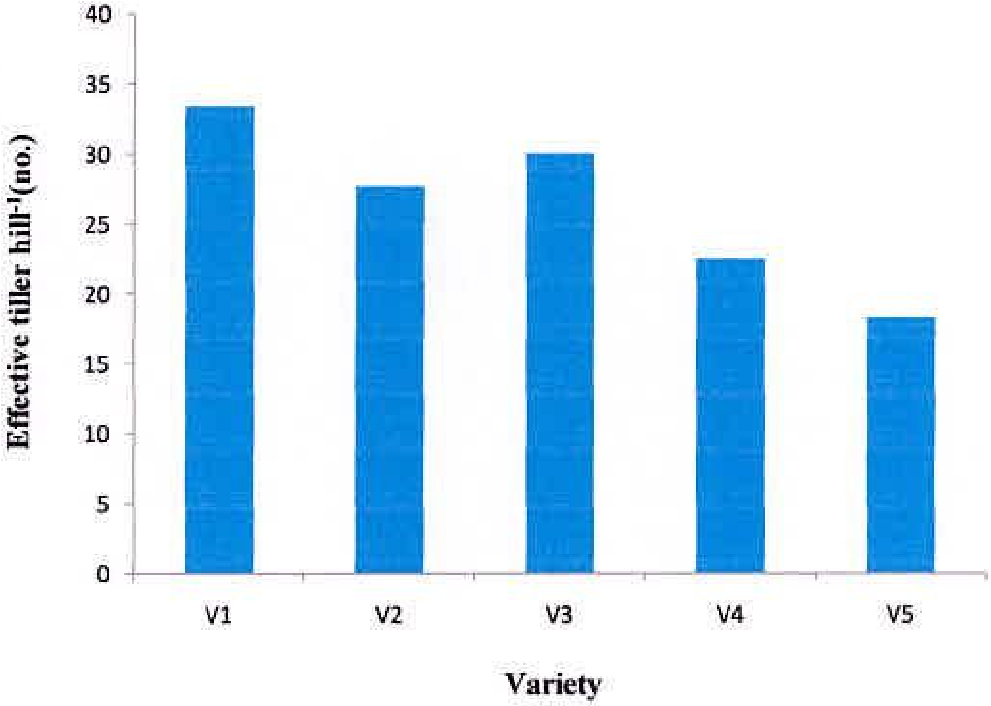


P_1 = Conventional method, P_2 = SRI

Figure 17. Effect of planting method on effective tillers hill^{-1} of inbred and hybrid *boro* rice ($LSD_{0.05}$ = 2.267)

4.2.1.2 Effect of variety

The number of effective tillers hill^{-1} was significantly influenced by variety (Appendix XII and Figure 18). The highest number of effective tillers hill^{-1} was produced in the variety V_1 (33.43) and the lowest number of effective tillers hill^{-1} was produced in V_5 (18.30). Variation in the number of effective tillers hill^{-1} might be due to the variation of different genetic character as well as environmental and soil benefits of SRI.



V_1= BR 16, V_2 = BRRI dhan29, V_3 = BRRI dhan50, V_4 = BRRI hybrid dhan2, V_5 = Heera 4

Figure 18. Effect of variety on effective tillers hill^{-1} of inbred and hybrid *boro* rice ($LSD_{0.05}$ = 2.169)

4.2.1.3 Interaction effect of planting method and variety

The number of effective tillers hill^{-1} was significantly influenced by the interaction effect of planting method and variety (Appendix XII and Table 9).

These revealed that highest number of tillers were observed in interaction of planting method P_2 and variety V_1 (52.47) followed by the interaction of the planting method P_2 and variety V_3 (45.93) and the lowest number of tiller was produced in the planting method of P_1 and variety V_5 (8.87) which statistically similar with the planting method P1 and variety V2 (11.67) and planting method P1 and variety V_4 (9.47). Biswas *et al.* (2013) also observed higher number of effective tillers hill^{-1} in BR 16 in SRI. Nissanka and Bandara (2004) support the result that the tillers numbers hill^{-1} at heading was significantly higher in SRI compared to other treatments.

Table 9. Interaction effect of planting method and variety on number of tillers hill^{-1} of inbred and hybrid *boro* rice

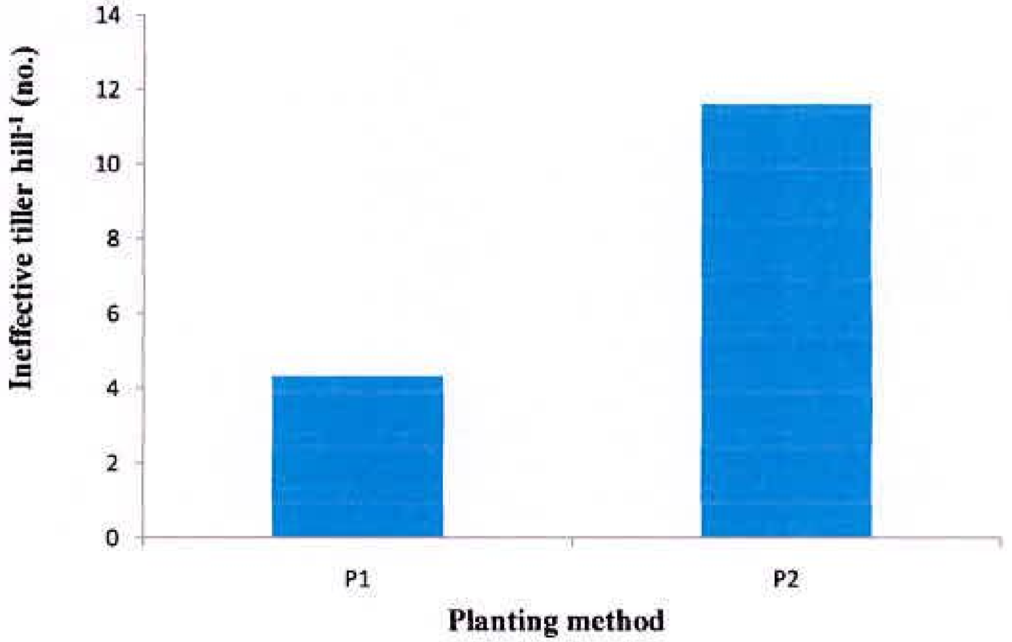
Treatments	Effective tillers hill^{-1} (no.)	Ineffective tillers hill^{-1} (no.)
P_1V_1	14.40e	3.67cd
P_1V_2	11.67ef	0.67d
P_1V_3	14.33e	8.00bc
P_1V_4	9.47f	3.67cd
P_1V_5	8.87f	5.67bcd
P_2V_1	52.47a	9.67bc
P_2V_2	43.87b	7.67bc
P_2V_3	45.93b	4.00cd
P_2V_4	35.67c	12.00b
P_2V_5	27.73d	24.67a
LSD $_{(0.05)}$	3.067	6.925
CV (%)	6.70	50.22

P_1 = Conventional method, P_2 = SRI, V_1 = BR 16, V_2 = BRRI dhan29, V_3 = BRRI dhan50, V_4 = BRRI hybrid dhan2, V_5 = Heera 4

4.2.2 Number of ineffective tillers hill^{-1}

4.2.2.1 Effect of planting method

The number of ineffective tillers hill^{-1} was significantly influenced by planting method (Appendix XII and Figure 19). Higher number of ineffective tillers hill^{-1} was produced in the planting method of P_2 than P_1. These might be due to higher number of tertiary tillers hill^{-1} produced in the planting method of SRI as they got wider plant spacing in which mortality rate was higher than the primary and secondary tillers. Chakrabortty (2012) also found the similar result that the highest number ineffective tillers hill^{-1} was produced in the wider plant spacing than the lower plant spacing.

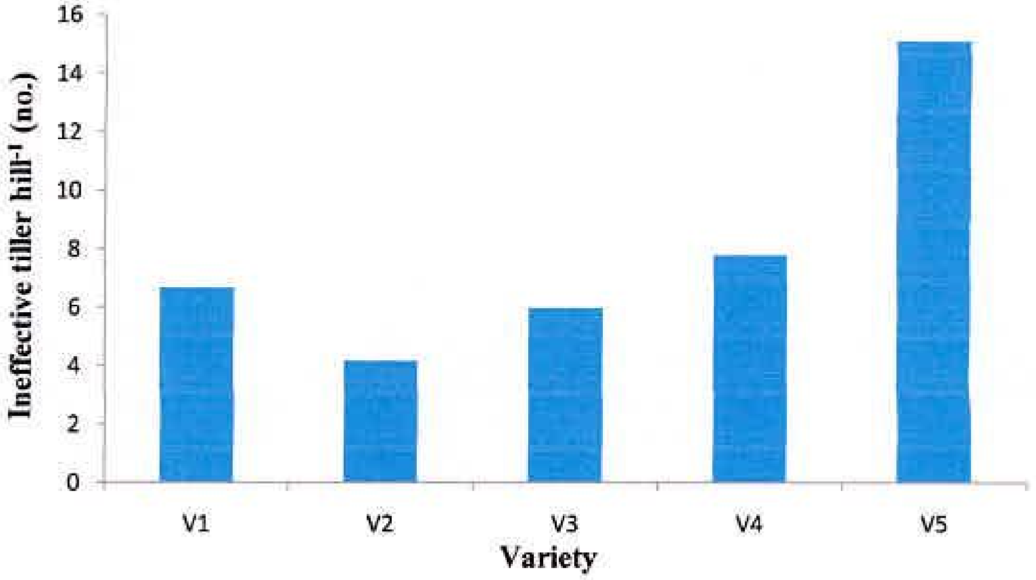


P_1 = Conventional method, P_2 = SRI

Figure 19. Effect of planting method on ineffective tillers hill^{-1} of inbred and hybrid *boro* rice ($LSD_{0.05}$ = 5.359)

4.2.2.2 Effect of variety

The five varieties had significant difference for the number of ineffective tillers hill^{-1} (Appendix XII and Figure 20). Heera 4 produced the highest number of ineffective tillers hill^{-1} than the other varieties. Descending order of the varieties for ineffective tillers hiil^{-1} was Heera 4>BRRI hybrid dhan2>BR 16> BRRI dhan50>BRRI dhan29. Biswas *et al.* (2013) also observed that BRRI dhan50 produced higher number of ineffective tillers hill^{-1} than BRRI dhan29.



V_1 = BR 16, V_2 = BRRI dhan29, V_3 = BRRI dhan50, V_4 = BRRI hybrid dhan2, V_5 = Heera 4

Figure 20. Effect of variety on effective tillers hill^{-1} of inbred and hybrid *boro* rice ($LSD_{0.05}$ = 4.897)

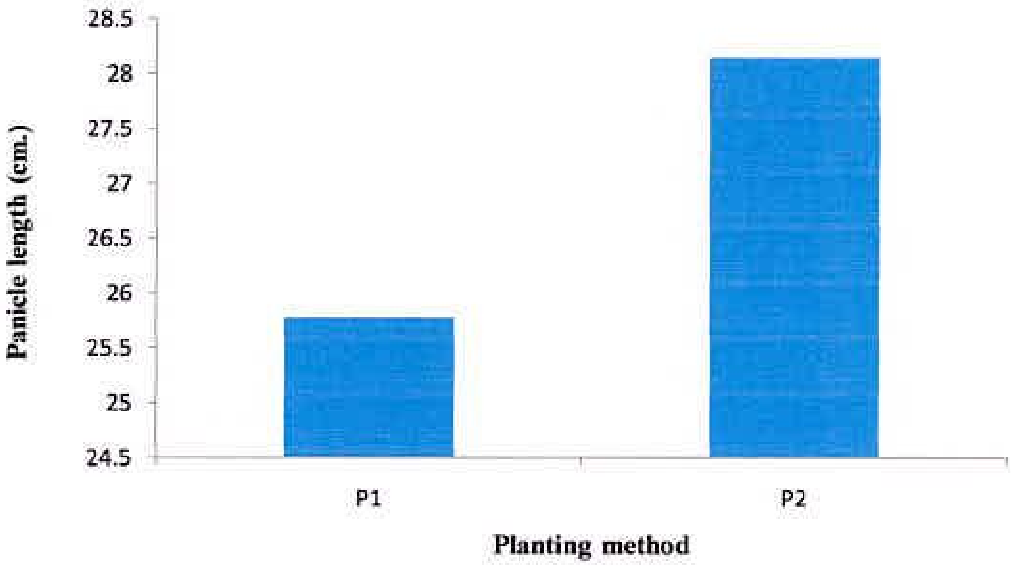
4.2.2.2 Interaction effect of planting method and variety

The number of ineffective tillers ware significantly influenced by the interaction effect of planting method and variety (Appendix XII and Table 9). The highest number of ineffective tillers hill^{-1} was produced in the interaction of planting method of SRI and variety of Heera 4 (24.67) and the lowest number of ineffective tillers was produced in the interaction of conventional method and variety of BRRI dhan29 (0.67) which was statistically similar to the interaction of conventional planting method and variety BR 16 (3.67), conventional planting method and variety of BRRI hybrid dhan2 (3.67), conventional planting method and variety of Heera 4(5.67) and SRI and variety of BRRI dhan50 (4.00). Descending order for ineffective tillers hill^{-1} was $P_2V_5 > P_2V_4 > P_2V_1 > P_1V_3 > P_2V_2 > P_1V_5 > P_2V_3 > P_1V_4 = P_1V_1 > P_1V_2$. These results revealed that irrespective of variety SRI produced higher number of ineffective tillers hill^{-1} than the conventional method. Chakrabortty (2012) also observed that combination of younger seedling with wider plant spacing gave the highest number of ineffective tillers hill^{-1} than the combination of older seedling with closer spacing.

4.2.3 Panicle length (cm)

4.2.3.1 Effect of planting method

Panicle length was significantly influenced by planting method (Appendix XIII and Figure 21).The longest panicle was observed in SRI (28.15 cm) than the conventional method (25.77 cm). Panicle was 9.25% longer in SRI than the conventional system. Longer panicle was in SRI might be due to higher dry matter accumulation in the plant, higher photosynthetic rate and better utilization of the nutrients. Thakur *et al.* (2011) found that SRI produced panicles with higher length than in standard management practices. Biswas *et al.* (2013) also observed that SRI produced longer panicle than the conventional method.



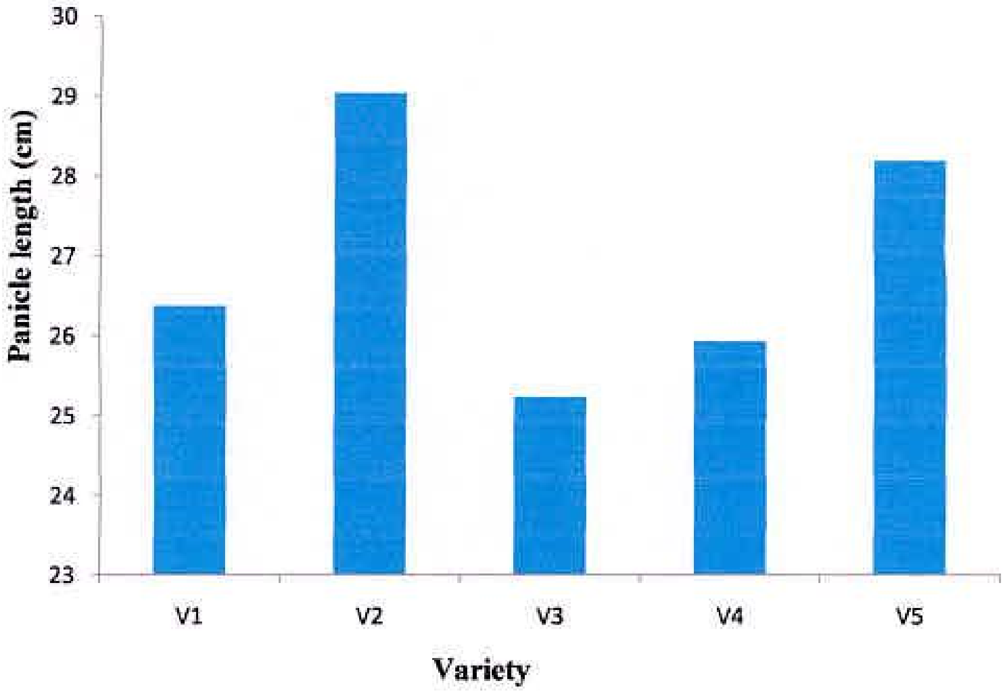
P_1 = Conventional method, P_2 = SRI

Figure 21. Effect of planting method on panicle length (cm) of inbred and hybrid *boro* rice ($LSD_{0.05}$ = 0.4)

4.2.3.2 Effect of variety

Panicle length was significantly influenced by the variety (Appendix XIII and Figure 22). The longest panicle was produced in BRRI dhan29 (29.05 cm) which was statistically similar with the variety of Heera 4 (28.20 cm) followed by variety of BR 16 (26.38 cm). The shortest panicle was produced in variety of BRRI dhan50 (25.24 cm) that were statistically similar with the variety BRRI hybrid dhan2 (25.94 cm).

The descending order of panicle length was BRRI dhan29>Heera 4> BR 16>BRRI hybrid dhan2>BRRI dhan50.



V_1 = BR 16, V_2 = BRRI dhan29, V_3 = BRRI dhan50, V_4 = BRRI hybrid dhan2, V_5 = Heera 4

Figure 22. Effect of variety on panicle length (cm) of inbred and hybrid *boro* rice ($LSD_{0.05}$ = 0.5307)

4.2.3.3 Interaction effect of planting method and variety

Panicle length was significantly influenced by the interaction of the planting method and variety (Appendix XIII and Table 10). The longest panicle was observed in the interaction of SRI and variety BRRI dhan29 (30.53 cm) and the shortest panicle was recorded in the interaction of conventional planting method and variety BRRI dhan50 (23.52 cm). The descending order of interaction was P_2V_2> P_2V_5> P_1V_2> P_1V_5> P_2V_4> P_2V_1> P_2V_3> P_1V_1> P_1V_4> P_1V_3). BR 16 produced 5.32% longer, BRRI dhan29 produced 10.74% longer, BRRI dhan50 produced 14.63% longer, BRRI hybrid dhan2 produced 9.45% longer and Heera produced 6.78% longer panicle in SRI than the conventional method of those varieties, respectively. Latif *et al.* (2005) found that BRRI dhan29 had 24.48 cm panicle length in SRI, 24.12 cm in BRRI recommended practice and 22.32 cm in farmers practice in Vagurapara, Chandina. Thakur *et al.* (2010) observed measurable changes in longer panicles with transplanting single, young (10 days old) seedlings. Chakrabortty (2012) was also in the agreement with this result that younger seedling with wider spacing produced longer panicle than the older seedling with closer spacing.

Table 10. Interaction effect of planting method and variety on different crop characters of inbred and hybrid *boro* rice

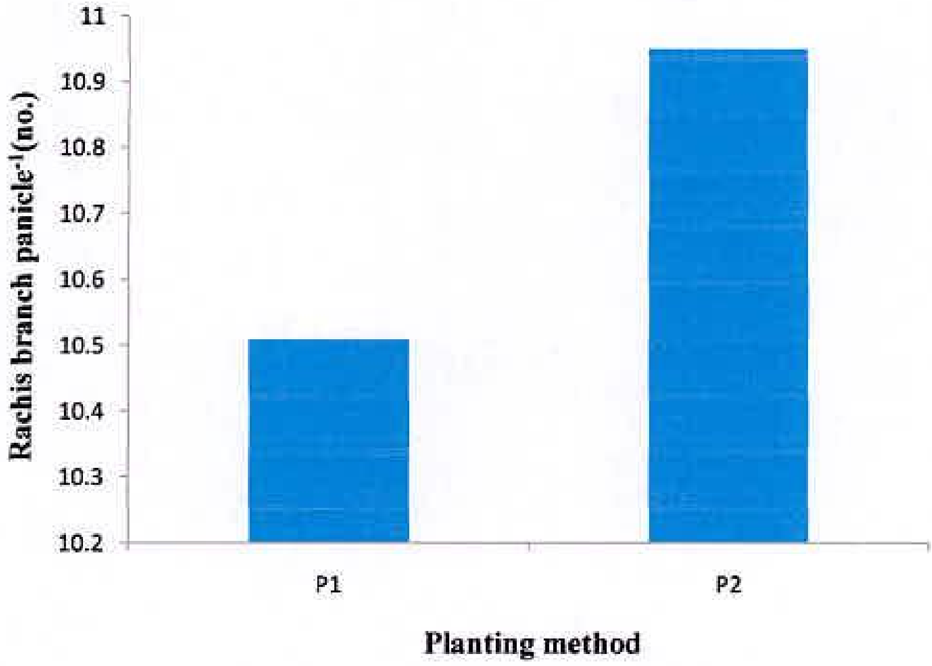
Treatments	Panicle length (cm)	Rachis branches panicle^{-1} (no.)	Total grains panicle^{-1} (no.)	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1} (no.)	1000-grains weight (g)
P_1V_1	25.72e	9.23f	150.60ef	120.87d	29.73c	26.77c
P_1V_2	27.57c	11.10bc	203.30c	157.70bc	45.60b	22.16d
P_1V_3	23.52f	10.10de	145.80f	92.37e	53.47b	19.83e
P_1V_4	24.77e	10.97bc	170.10ef	117.37de	52.73b	28.64b
P_1V_5	27.27c	11.13bc	193.10d	133.77cd	59.30b	30.58a
P_2V_1	27.04c	9.80ef	176.50d	125.73d	50.77b	25.17c
P_2V_2	30.53a	11.60ab	255.40a	166.80ab	88.60a	20.67e
P_2V_3	26.96d	10.53ce	200.20c	172.23ab	27.93c	19.69e
P_2V_4	27.11c	10.73cd	208.30b	182.97ab	25.37c	25.86c
P_2V_5	29.12b	12.10 a	244.00 a	186.37a	57.67b	29.24b
$LSD_{(0.005)}$	1.242	0.7505	26.85	26.228	16.679	1.861
CV (%)	2.66	4.05	7.97	10.41	19.6	4.30

P_1 = Conventional method, P_2 = SRI, V_1 = BR 16, V_2 = BRRI dhan29, V_3 = BRRI dhan50, V_4 = BRRI hybrid dhan2, V_5 = Heera 4

4.2.4 Rachis branches panicle^{-1}

4.2.4.1 Effect of planting method

There was no significant difference among the planting methods for number of rachis branches panicle^{-1} (Appendix XIII and Figure 23). Numerically higher rachis branches panicle^{-1} was produced in SRI (10.95) than conventional method (10.51). Rachis branches panicle^{-1} was 4% higher in SRI than conventional method. Higher number of rachis branch panicle^{-1} was produced in SRI than conventional method might be due to longer panicle in SRI than conventional method.

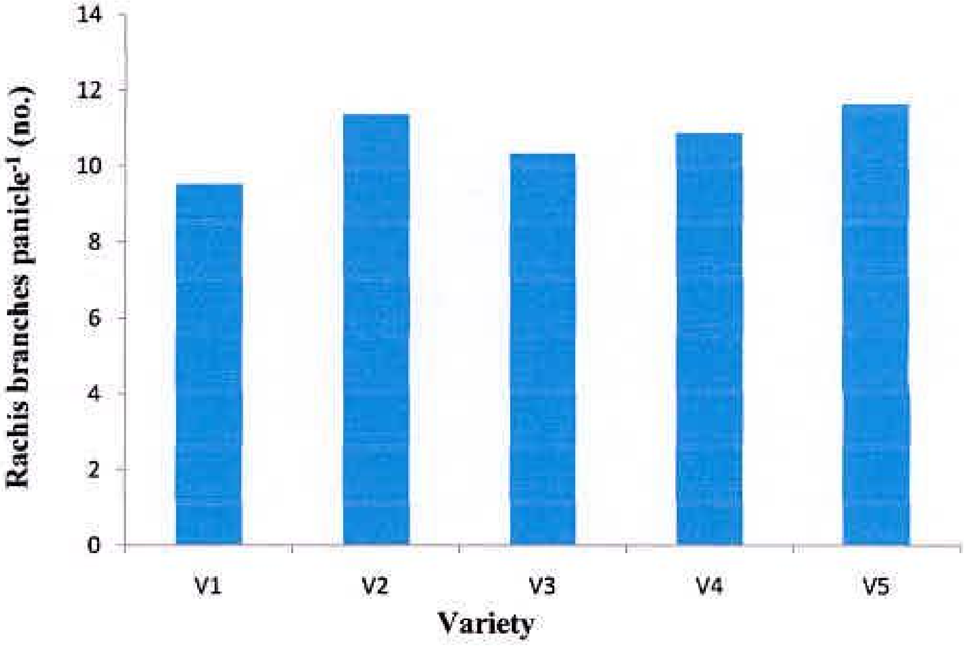


P_1 = Conventional method, P_2 = SRI

Figure 23. Effect of planting method on rachis branches panicl^{-1} of inbred and hybrid *boro* rice ($LSD_{0.05}$ = 1.67)

4.2.4.2 Effect of variety

Rachis branches panicle^{-1} was significantly influenced by the variety (Appendix XIII and Figure 24). Heera 4 (11.62) produced the highest number of rachis branches panicle^{-1} which was statistically similar in the variety BRRI dhan29 (11.35) followed by variety BRRI hybrid dhan2 (10.85) and the lowest rachis branches panicle was in BR 16 (9.52). Descending order for rachis branches panicle^{-1} was Heera 4 >BRRI dhan29>BRRI hybrid dhan2>BRRI dhan50>BR 16.



V_1 = BR 16, V_2 = BRRI dhan29, V_3 = BRRI dhan50, V_4 = BRRI hybrid dhan2, V_5 = Heera 4

Figure 24. Effect of variety on rachis branches of inbred and hybrid *boro* rice ($LSD_{0.05}$ = 0.5307)

4.2.4.3 Interaction effect of planting method and variety

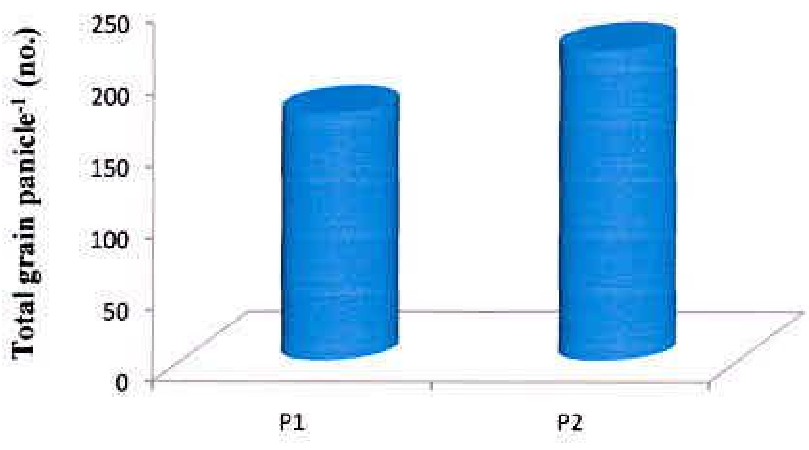
Rachis branches panicle^{-1} was significantly influenced by the interaction effect of planting methods and variety (Appendix XIII and Table 10).The highest number of rachis branches panicle^{-1} was produced in the combination of planting method of P_2 and variety V_5 which was statistically similar in the combination of planting method of P_2 with the variety V_2. The lowest number of rachis branches panicle^{-1} was produced in the planting method of P_2 and variety V_1 that was statistically similar with the planting method of P_1 and variety V_1. BR 16 produced 6.17% higher, BRRI dhan29 produced 4.50% higher, BRRI dhan50 produced 4.26% higher, BRRI hybrid dhan2 produced 2.19% lower and Heera 4 produced 8.72% higher rachis branches panicle^{-1} in SRI than conventional method.

4.2.5 Total number of grains panicle^{-1}

Total number of grains panicle^{-1} is an important factor which determines the grain yield. There was a significant variation for planting method and variety on total number of grains panicle^{-1}.

4.2.5.1 Effect of planting method

Total number of grains panicle^{-1} was significantly influenced by the planting methods (Appendix XIII and Figure 25). Higher number of grains panicle^{-1} was produced in the planting method of SRI (216.89) than the conational method. It was 25.67% higher in SRI than the conventional method (172.58). Husain *et al.* (2004) also observed higher number of grains panicle^{-1} under SRI compared to the farmers' practice. Thakur *et al.* (2011) agreed that SRI produced higher number of total grains panicle^{-1} than standard management practice.

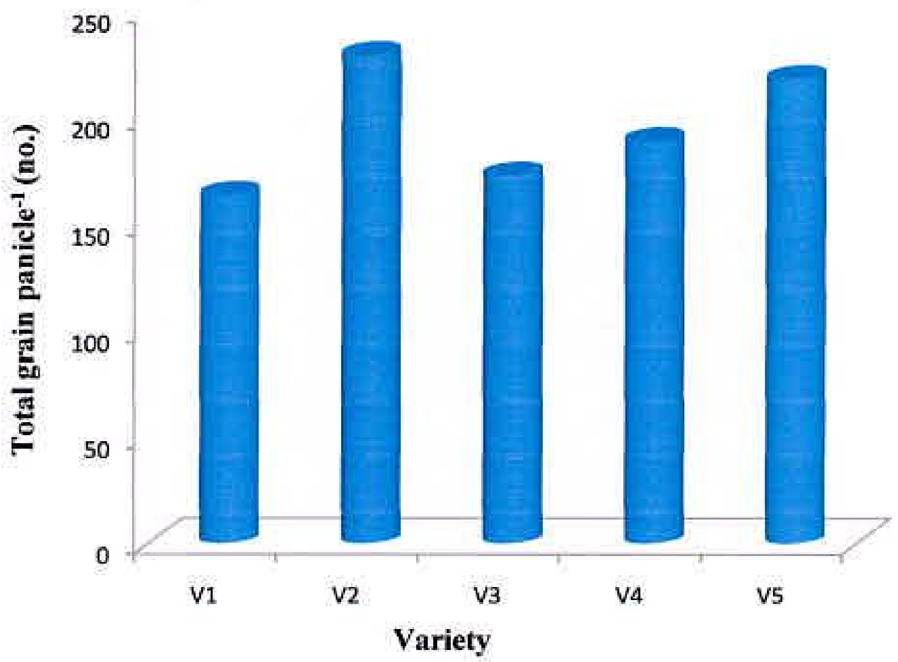


P_1 = Conventional method, P_2 = SRI

Figure 25. Effect of planting method on total grains panicle^{-1} of inbred and hybrid *boro* rice ($LSD_{0.05}$ = 15.98)

4.2.5.2 Effect of variety

The number of total grains panicle^{-1} was influenced by the variety (Appendix XIII and Figure 26).The highest number of grains panicle^{-1} was produced in the variety BRRI dhan29 (229.40) which was statistically similar with the variety Heera 4 (218.60) followed by BRRI hybrid dhan2 (189.20) and the lowest grains panicle was produced in variety BR 16 (163.60) that was statistically similar in BRRI dhan50 (173.00). The descending order of the five varieties for total grains panicle^{-1} was BRRI dhan29> Heera 4>BRRI hybrid dhan2> BRRI dhan 50>BR 16.



V_1 = BR 16, V_2 = BRRI dhan29, V_3 = BRRI dhan50, V_4 = BRRI hybrid dhan2, V_5 = Heera 4

Figure 26. Effect of variety on total grain panicle^{-1} of inbred and hybrid *boro* rice ($LSD_{0.05}$ = 18.99)

4.2.5.3 Interaction effect of planting method and variety

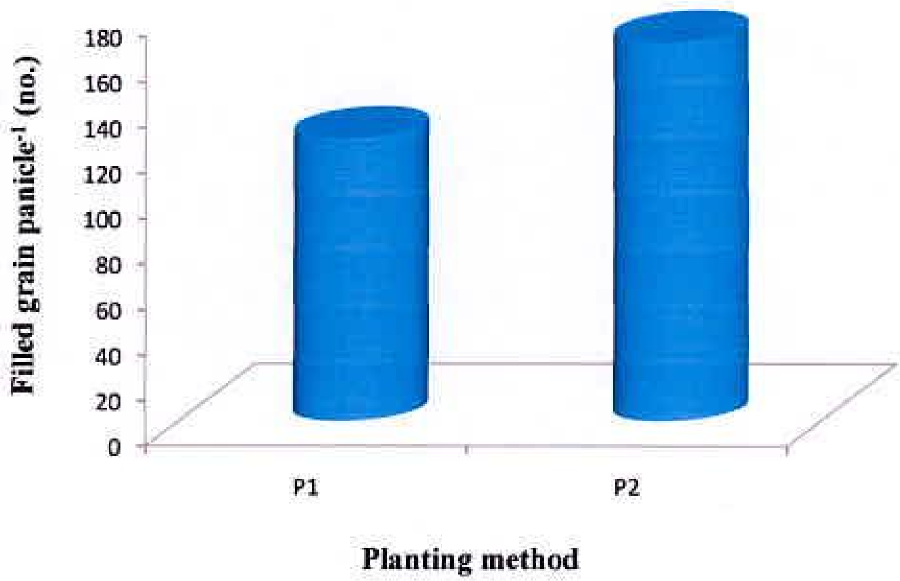
Total number of grains panicle $^{-1}$ was significantly influenced by the interaction effect of planting method and variety (Appendix XIII and Table 10). The highest number of grains was produced in the interaction of planting method of SRI and the variety of

BRRI dhan29 (255.40) which were statistically similar with the planting method of SRI and variety Heera 4 (244.00). The lowest number of grains panicle^{-1} was produced in conventional planting method with the variety BRRI dhan50 (145.80) which was statistically similar with conventional planting method and variety BR 16 (150.60) and conventional method and variety BRRI hybrid dhan2 (170.10).The BR 16 produced 17.19 % higher, BRRI dhan29 produced 25.63% higher, BRRI dhan50 produced 37.31% higher, BRRI hybrid dhan2 produced 22.24% higher and Heera 4 produced 26.25% higher grain panicle^{-1} in SRI than the conventional method. Descending order for total grain panicle^{-1} was $P_2V_2>P_2V_5>P_2V_4> P_1V_2>P_2V_3>P_1V_5> P_2V_1> P_1V_4>P_1V_1>P_1V_3$. Biswas *et al.* (2013) also found in SRI that BRRI dhan29 Produced higher total grains panicle^{-1} than the BRRI hybrid dhan2, BRRI dhan50 and BR 16.

4.2.6 Filled grains panicle^{-1}

4.2.6.1 Effect of planting method

There was significant influence of planting method on filled grains panicle^{-1} (Appendix XIII and Figure 27). These result revealed that SRI (166.82) produced higher number of filled grains panicle^{-1} than the conventional method (124.41). It was 34.09% higher in SRI than the conventional method. Higher number of filled grains in SRI might be due to higher nutrient, better utilization of nutrients, and higher rate of photosynthesis. Ali, *et al.* (2013) also support by their research findings that 15 days old seedlings with intermittent irrigated plots produced higher grains panicle^{-1} than 30 days old seedlings with continuous flooded plots. Thakur *et al.* (2010) also observed higher percentage of grain-filling in SRI.

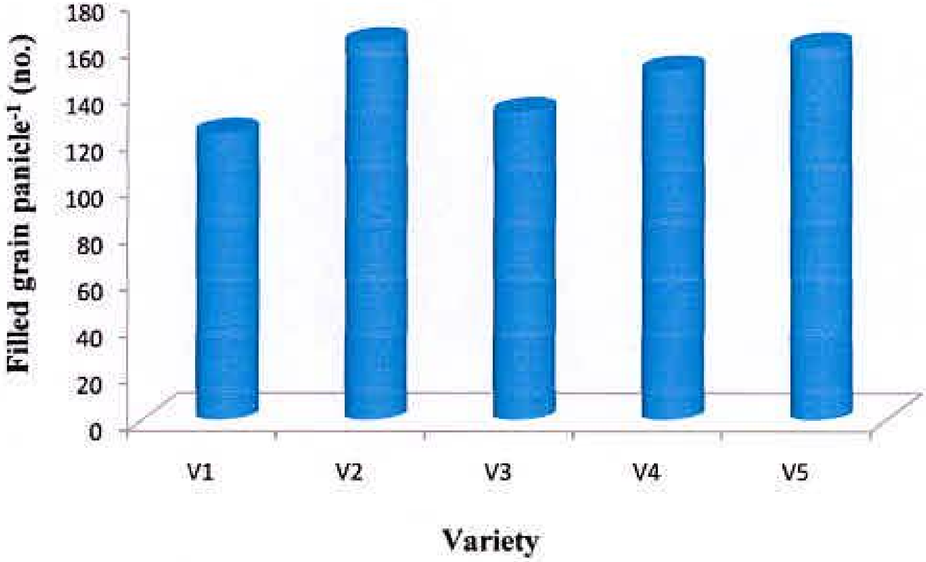


P_1 = Conventional method, P_2 = SRI

Figure 27. Effect of planting method on filled grain panicle^{-1} of inbred and hybrid *boro* rice ($LSD_{0.05}$ = 9.751)

4.2.6.2 Effect of variety

The number of filled grains panicle^{-1} was significantly influenced by the variety (Appendix XIII and Figure 28).The highest number of filled grain panicle^{-1} was found in BRRI dhan29 (162.25) which was statistically similar in BRRI hybrid dhan2 (150.17) and Heera 4 (160.07) and followed by BRRI dhan50 (132.30) and the lowest grain panicle^{-1} was found in BR 16 (123.30). Descending order of filled grains panicle^{-1} was as BRRI dhan129>Heera 4>BRRI hybrid dhan2>BRRI dhan50>BR 16.



V_1 = BR 16, V_2 = BRRI dhan29, V_3 = BRRI dhan50, V_4 = BRRI hybrid dhan2, V_5 = Heera 4

Figure 28. Effect of variety on filled grain panicle^{-1} of inbred and hybrid *boro* rice ($LSD_{0.05}$ = 8.546)

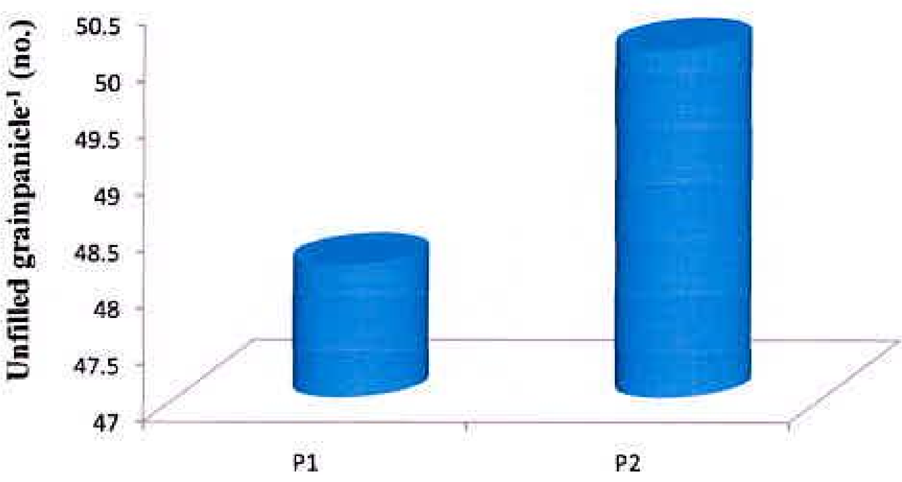
4.2.6.3 Interaction effect of planting method and variety

Interaction of planting method and variety greatly affect the filled grains panicle^{-1} (Appendix XIII and Table 10). The highest number of filled grains panicle^{-1} was produced in the planting method P_2 with the variety V_5 (186.37) which was statistically similar to the planting method P_2 with the variety V_2 (166.80), the planting method of P_2 with the variety V_3 (172.23) and the planting method of P_2 with the variety V_4 (182.97). The lowest numbers of filled grains were produced in the planting method of P_2 with the variety V_3 (92.37) which were statistically similar to the planting method of P_1 with the variety V_4 (117.37). The BR 16 produced 4.03%, BRRI dhan29 produced 5.80%, BRRI dhan50 produced 5.93%, BRRI hybrid dhan2 produced 55.89% and Heera 4 produced 39.32% higher filled grains in SRI than the conventional method.

4.2.7 Unfilled grains panicle^{-1}

4.2.7.1 Effect of planting method

Unfilled grains panicle^{-1} was not statistically differed due to the different cultivation method (Appendix X III and Figure 29). Numerically higher numbers of unfilled grains were higher produced in SRI (50.07) than the conventional method (48.17).

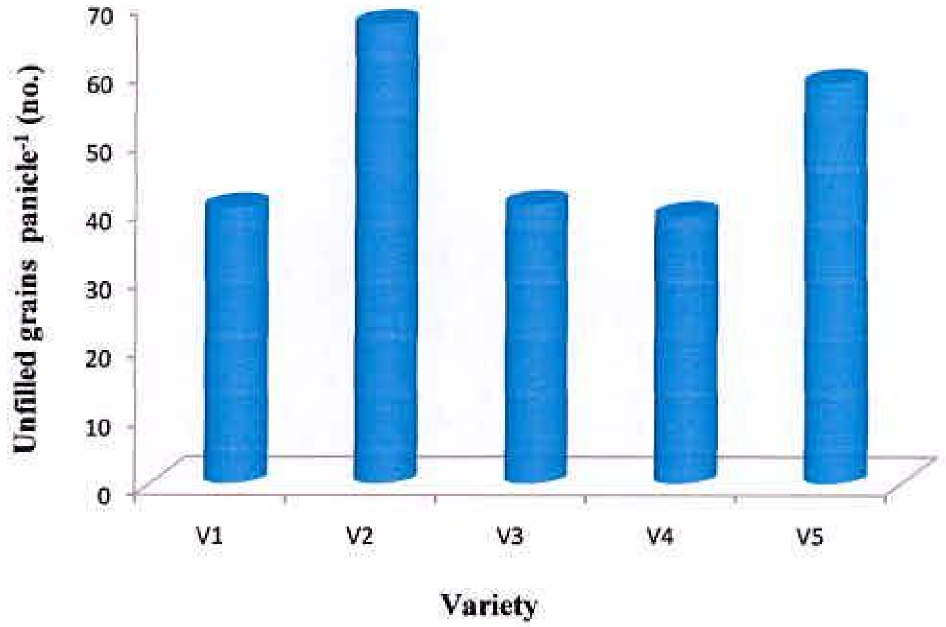


P_1 = Conventional method, P_2 = SRI

Figure 29. Effect of planting method on unfilled grains panicle^{-1} of inbred and hybrid rice ($LSD_{0.05}$ = NS)

4.2.7.2 Effect of variety

Numbers of unfilled grains were significantly influenced by the variety (Appendix XIII and Figure 30). The highest number of unfilled grains were produced in BRRI dhan29 (67.10) which was statistically similar in hybrid variety Heera 4 (58.48) and the lowest number of unfilled grains was obtained from BRRI hybrid dhan2 (39.05) that was statistically similar to BR 16 (40.25) and BRRI dhan50 (40.70). This finding agreed with Debnath (2010) who obtained the highest number of unfilled grains panicle^{-1} from the inbred variety BRRI dhan29 than hybrid variety BRRI hybrid dhan2.



V_1 = BR 16, V_2 = BRRI dhan29, V_3 = BRRI dhan50, V_4 = BRRI hybrid dhan2, V_5 = Heera 4

Figure 30. Effect of variety on unfilled grain panicle^{-1} of inbred and hybrid *boro* rice ($LSD_{0.05}$ = 11.794)

4.2.7.3 Interaction effect of planting method and variety

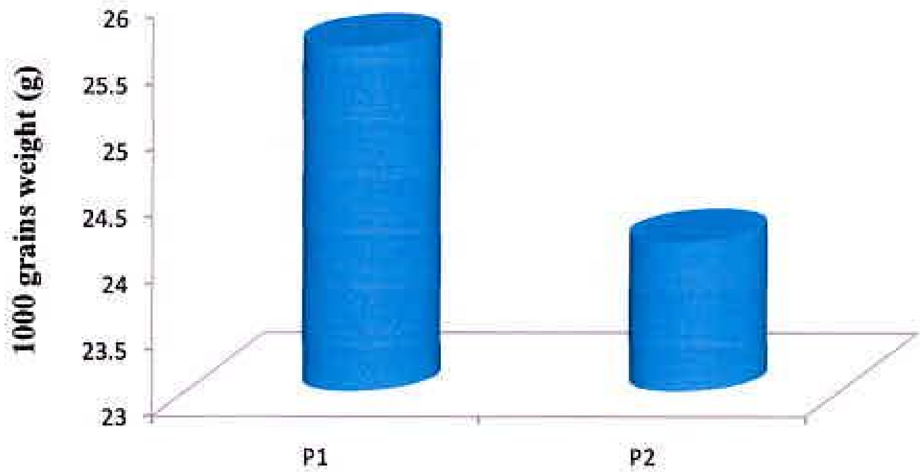
The number of unfilled grains was significantly influenced by the interaction effect of planting method and variety (Appendix X III and Table 10). The highest number of unfilled grains were obtained from the planting method of P_2 and the variety V_2 (88.60) and the lowest number of unfilled grains were obtained from the planting method of P_2 with the variety V_4 (25.37) which was statistically similar with the planting method of P_1 with V_1 (29.73) and planting method of P_2 and variety V_3 (27.93).

4.2.8 Weight of 1000 grains

4.2.8.1 Effect of planting method

The weight of 1000-grains was significantly influenced by the variety (Appendix XIII and Figure 31). The higher weight of 1000-grains (25.60 g) was obtained from conventional method and lower (24.13 g) was obtained from SRI. Mannan *et al.*

(2009) opposed the result that heavier grain weight was found in early planted crop and grain weight decreased with the delayed transplanting.

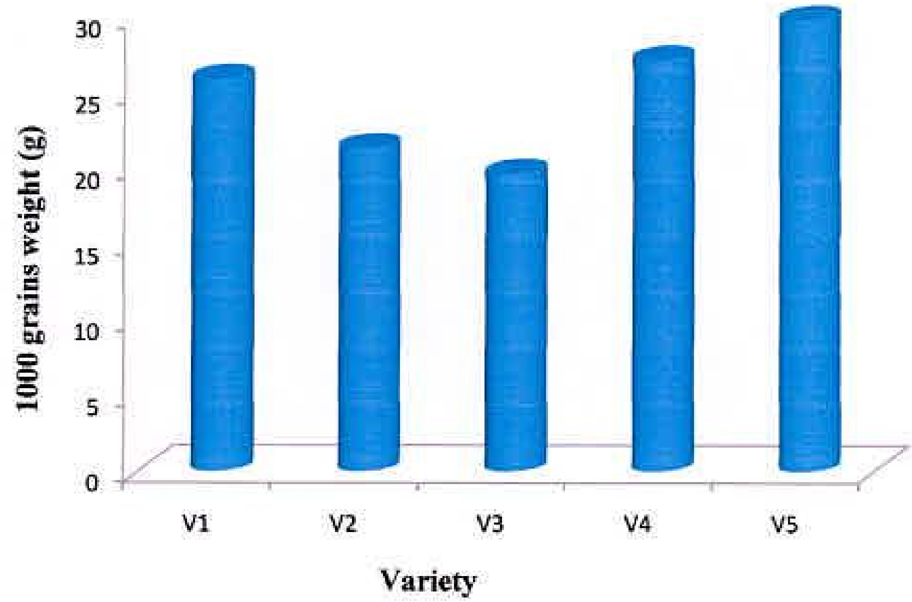


P_1 = Conventional method, P_2 = SRI

Figure 31. Effect of planting method on 1000 grain weight of inbred and hybrid *boro* rice ($LSD_{0.05}$ = 0.889)

4.2.8.2 Effect of variety

The weight of 1000-grains was significantly influenced by the variety (Appendix X III and Figure 32). The highest weight of 1000-grains (29.91 g) was obtained from the hybrid variety of Heera 4 followed by the BRRI hybrid dhan2 (27.25 g) and the lowest weight of 1000-grains was obtained from the inbreed variety of BRRI dhan50 (19.76 g). The variation of 1000-grain weight between varieties might be due to the difference in their genetic makeup. The result also supports the findings of Obaidullah (2007), Ashrafuzzaman (2006) and Debnath (2010) who found the highest weight of 1000-grains in hybrid variety than the inbred variety BRRI dhan29.



V_1 = BR 16, V_2 = BRRI dhan29, V_3 = BRRI dhan50, V_4 = BRRI hybrid dhan2, V_5 = Heera 4

Figure 32. Effect of variety on 1000 grain weight (g) of inbred and hybrid *boro* rice ($LSD_{0.05}$ = 1.303)

4.2.8.3 Interaction effect of planting method and variety

Interaction effect between variety and planting method was found significant in respect of weight of 1000-grains (Appendix XIII and Figure 10). The highest weight of 1000-grains was obtained from the conventional method P_1 of the hybrid variety Heera 4 V_5 (30.58 g) that was statistically similar with SRI of the hybrid variety Heera 4 (29.24 g). The lowest 1000-grains weight was obtained from the conventional method P_1 of the inbred variety V_3 (19.83 g) which was statistically similar from SRI (P_2) of the variety V_2 and from P_2 (20.67 g) of the variety of V_3 (19.69 g).

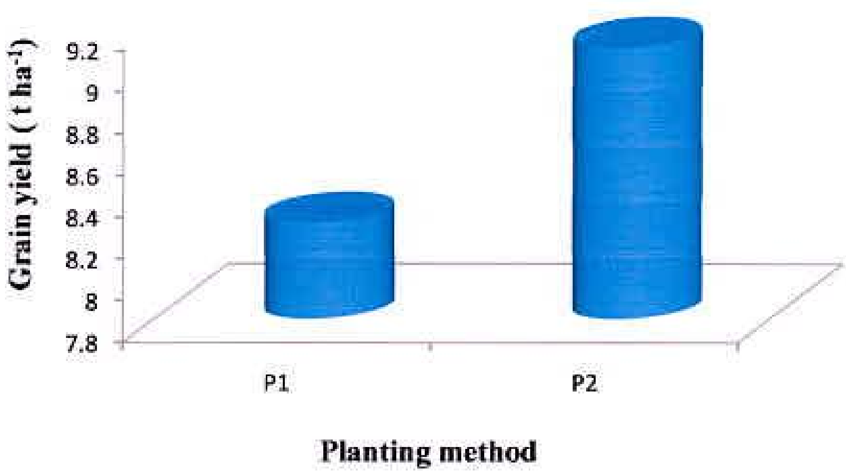
4.3 Yield

4.3.1 Grain yield

4.3.1.1 Effect of planting method

Grain yield was significantly influenced by the planting method (Appendix XIV and Figure 33). Higher grain yield was obtained from the planting method of SRI (9.10 t ha^{-1}) and the lower grain yield from conventional method (8.26 t ha^{-1}). SRI produced

10.17% higher grain yield than conventional method. Krishna *et al.* (2008) also observed that SRI produced 15.65% higher grain yield over traditional method. But Mazid *et al.* (2003) opposed the result that conventional practices of rice cultivation gave significantly higher grain yield compared to the SRI method. Nissanka and Bandara (2004) were agreed to the result that System of Rice Intensification (SRI) method produced higher (9%) over the conventional transplanting. Thakur *et al.* (2010) stated that the decreased plant density with SRI management was compensated for by increased per plant productivity. Karmakar *et al.* (2004) also opposed the result that conventional practice gave higher yield than the SRI practices with wider spacing. Song chen *et al.* (2013) supposed that SRI produced significantly higher yield than the conventional management might be due to the net photosynthetic rate of the recent fully expanded leaf at mid-tillering stage was significantly higher in SRI and improved utilization of photosynthates in the grain-filling stage.



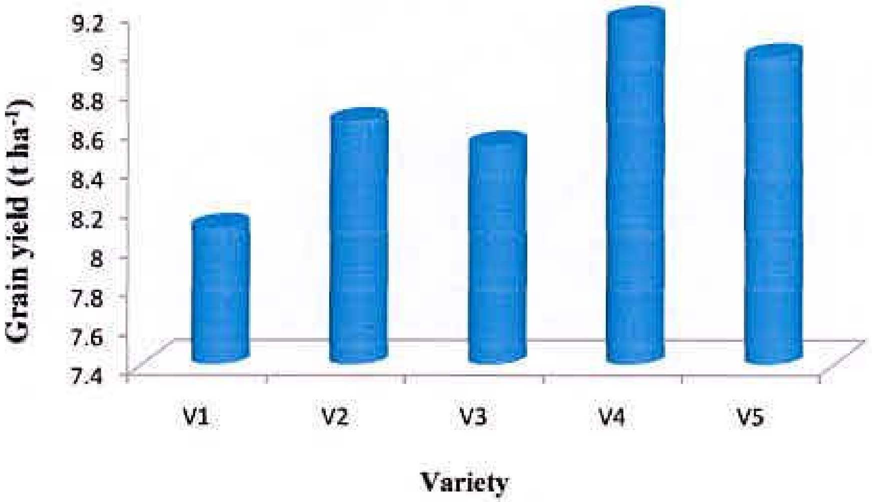
P_1 = Conventional method, P_2 = SRI

Figure 33. Effect of planting method on grains yield (t ha^{-1}) of inbred and hybrid *boro* rice ($LSD_{0.05}$ = 0.619)

4.3.1.2 Effect of variety

Grain yield was significantly influenced by the variety (Appendix XIV and Figure 34). The highest yield was produced in the variety of BRRI hybrid dhan2 (9.16 t ha^{-1}) which was statistically similar in the variety of BRRI dhan29 (8.64 t ha^{-1}) and Heera 4 (8.97 t ha^{-1}) followed by BRRI dhan50 (8.52 t ha^{-1}) and the lowest was produced in

BR 16 (8.10 t ha^{-1}). Descending order for the grain yield was BRRI hybrid dhan2> Heera 4>BRRI dhan29>BRRI dhan50>BR 16. The variation for the grain yield among the varieties might be due to genetic character.



V_1 = BR 16, V_2 = BRRI dhan29, V_3 = BRRI dhan50, V_4 = BRRI hybrid dhan2, V_5 = Heera 4

Figure 34. Effect of variety on grains yield (t ha^{-1}) of inbred and hybrid *boro* rice ($LSD_{0.05}$ = 0.41)

4.3.1.3 Interaction effect of planting method and variety

Interaction between planting method and variety had an important role for promoting the yield. Grain yield was significantly influenced by the interaction effect of variety and planting method (Appendix XIV and Table 11). The highest amount of grain yield was obtained from the planting method of P_2 and variety V_4 (9.60 t ha^{-1}) that was statistically similar with the planting method of P_2 and variety V_5 (9.39 t ha^{-1}). The lowest amount of grain yield was obtained from planting method of P_1 and variety V_1 (7.56 t ha^{-1}). This result revealed that higher amount of gain yield was obtained from the SRI method than the conventional method.The BR 16 produced 14.29%, BRRI dhan29 produced 8.31% higher, BRRI dhan50 produced 8.57%, BRRI hybrid dhan2 produced 10.22% higher and Heera 4 produced 9.70% higher grain yield in SRI than the conventional method. Thakur *et al.* (2011) observed that SRI gave 6.51 t ha^{-1} grain yield over 4.40 t ha^{-1} of grain yield in SMP (standard management practices). Chapagain and Yamaji (2010) found in an experiment that SRI practice increased the yields of irrigated rice by 25–50%. Krishna *et al.* (2008)

reported that treatment combination of 12 days old seedling with wider spacing recorded maximum seed yield. But Ahmed (2007) opposed the result that, the lowest grain yields was obtained from the SRI, which might be due to the wider spacing of 40 cm × 40 cm.

Table 11. Interaction effect of planting method and variety on yield and other contributing characters of inbred and hybrid *boro* rice

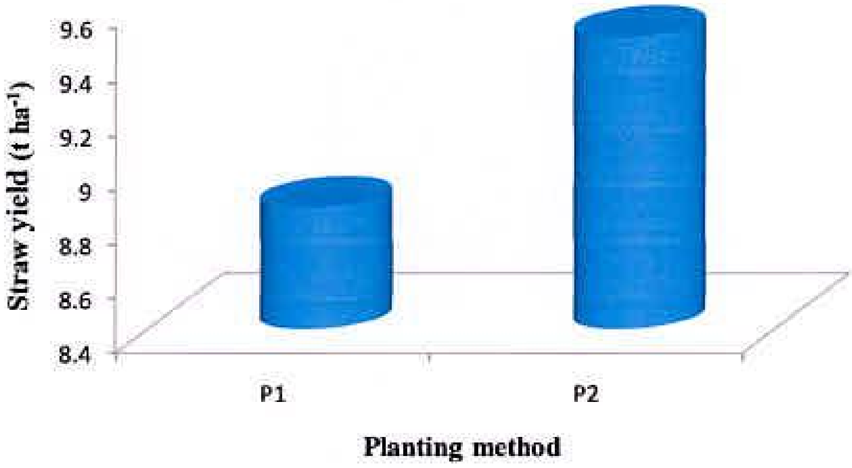
Treatments	Grain yield ($t\ ha^{-1}$)	Straw yield ($t\ ha^{-1}$)	Biological yield ($t\ ha^{-1}$)	Harvest index (%)
P_1V_1	7.56f	8.64ef	16.20e	46.64d
P_1V_2	8.30de	9.53abc	17.83bc	46.52d
P_1V_3	8.17e	8.38f	16.55de	49.32ab
P_1V_4	8.71cde	8.83def	17.54cd	49.67ab
P_1V_5	8.56cde	8.85def	17.41cd	49.13ab
P_2V_1	8.64cde	9.10cde	17.74bc	48.71bc
P_2V_2	8.99bc	9.80ab	18.79ab	47.83c
P_2V_3	8.87bcd	9.12cde	17.99bc	49.27ab
P_2V_4	9.60a	10.02a	19.61a	48.97b
P_2V_5	9.39ab	9.36bcd	18.75ab	50.07a
LSD $_{(0.05)}$	0.58	0.65	1.171	1.066
CV (%)	3.86	4.10	3.79	1.27

P_1 = Conventional method, P_2 = SRI, V_1 = BR 16, V_2 = BRRI dhan29, V_3 = BRRI dhan50, V_4 = BRRI hybrid dhan2, V_5 = heera 4

4.3.2 Straw yield

4.3.2.1 Effect of planting method

Straw yield was significantly influenced by the planting method (Appendix XIV and Figure 35). Higher amount of Straw yield was produced in the planting method of SRI (9.48 tha^{-1}) and lower amount of straw yield was produced in conventional method (8.85 tha^{-1}). The 12.19% higher straw yield was produced in SRI than conventional method. Das (2003) also support that SRI produced higher (12%) amount of straw than conventional method. Husain *et al.* (2004) found SRI produced 39% higher straw yield compared to traditional methods. But Thakur *et al.* (2011) opposed the result that the straw yield was much higher in standard management practices compared to SRI.

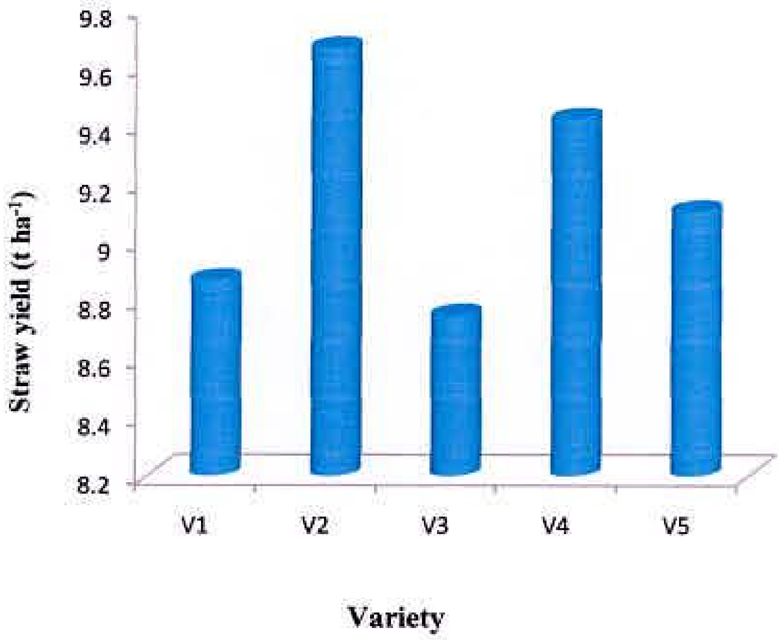


P_1 = Conventional method, P_2 = SRI

Figure 35. Effect of planting method on straw yield (t ha^{-1}) of inbred and hybrid *boro* rice ($LSD_{0.05}$ = 0.25)

4.3.2.2 Effect of variety

Straw yield was significantly influenced by variety (Appendix XIV and Figure 36).The highest amount of straw yield was produced in the variety of BRRI dhan29 (9.67 tha^{-1}) that was statistically similar to the variety BRRI hybrid dhan2 (9.42 tha^{-1}) and the lowest straw was produced in BR 16 (8.87 tha^{-1}) that was statistically similar to the variety of BRRI dhan50 (8.75 tha^{-1}) and Heera 4 (9.11 tha^{-1}). The descending order of varieties for straw yield was BRRI dhan29> BRRI hybrid dhan2>Heera 4>BR 16>BRRI dhan50. Tohiduzzaman (2011) also found that BRRI dhan29 produced higher straw yield than BR 16 and BRRI dhan50.



V_1 = BR 16, V_2 = BRRI dhan29, V_3 = BRRI dhan50, V_4 = BRRI hybrid dhan2, V_5 = Heera 4

Figure 36. Effect of variety on straw yield (t ha^{-1}) of inbred and hybrid *boro* rice ($LSD_{0.05}$ = 0.4596)

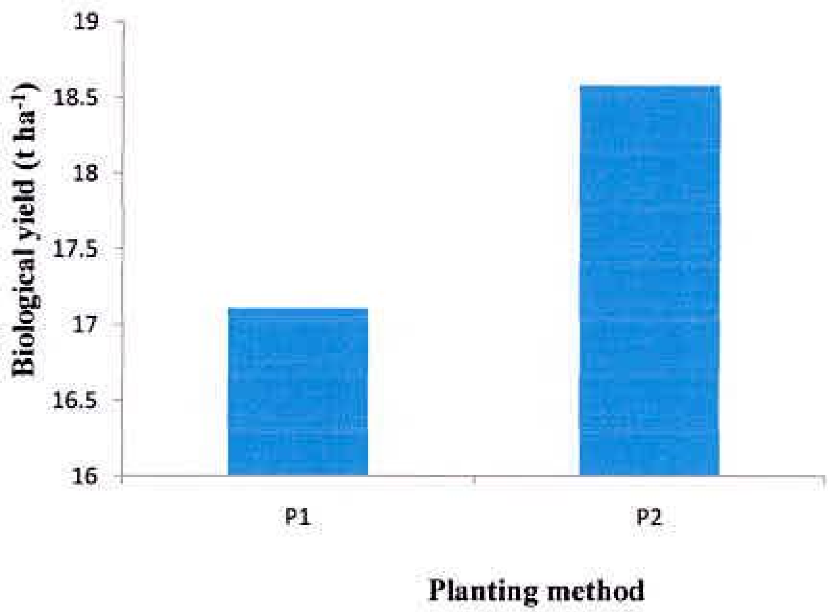
4.3.2.3 Interaction effect of planting method and variety

Straw yield was significantly influenced by the interaction of planting method and variety (Appendix XIV and Table 11). The highest straw yield was obtained from the planting method of P_2 and variety V_4 (10.02 t ha^{-1}) which was statistically similar to the planting method of P_2 and variety V_2 (9.80 t ha^{-1}) and planting method of P_1 and variety V_2 (9.53 t ha^{-1}). The lowest straw yield was obtained from the planting method of P_1 and variety V_3 (8.38 t ha^{-1}) which was statistically similar to the planting method of P1 and variety V_1 (8.64 t ha^{-1}), planting method of P_1 and variety V_4 (8.83 t ha^{-1}), and planting method of P_1 and variety V_5 (8.85 t ha^{-1}). These result revealed that SRI produced higher straw yield than conventional method. Das (2003) reported that the System of Rice Intensification (SRI) gave more straw (12%) compared to the hay produced in the FP plot. Thakur *et al.* (2011) also found that SRI produced 7.28 t ha^{-1} straw yield compared to the 9.17 t ha^{-1} straw yield produced in standard management practices.

4.3.3 Biological yield

4.3.3.1 Effect of planting method

Planting method influenced the biological yield (Appendix XIV and Figure 37). Higher amount of biological yield was produced in the planting method of SRI (18.58 tha^{-1}) and lower amount of biological yield was produced in conventional method (17.11 tha^{-1}). SRI produced 8.59% higher biological yield than the conventional method. Haque (2002) and Hossain *et al.* (2003) found highest biological yield in the SRI compared to the conventional planting method.

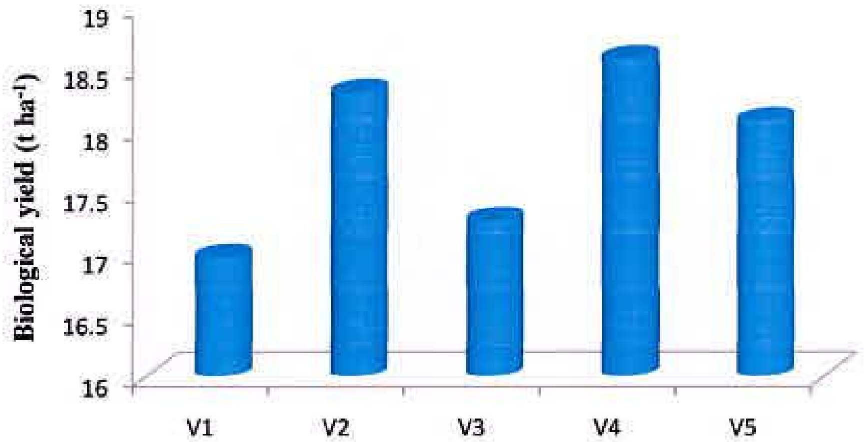


P_1 = Conventional method, P_2 = SRI

Figure 37. Effect of planting method on biological yield (t ha^{-1}) of inbred and hybrid *boro* rice (LSD$_{0.05}$ = 0.856)

4.3.3.2 Effect of variety

Biological yield was significantly influenced by variety (Appendix XIV and Figure 38). The highest amount of biological yield was obtained from BRRI hybrid dhan2 (18.58 tha^{-1}) which was statistically similar to BRRI dhan29 (18.31 tha^{-1}) and Heera 4 (18.08 tha^{-1}). The lowest biological yield was obtained from BR 16 (16.97 tha^{-1}) that was statistically similar to BRRI dhan50 (17.27 tha^{-1}). Biswas *et. al.* (2013) also agreed that BRRI hybrid dhan2 produced the highest biological yield from BRRI dhan29, BRRI dhan50 and BR 16.



V_1 = BR 16, V2 = BRRI dhan29, V_3 = BRRI dhan50, V_4 = BRRI hybrid dhan2, V_5 = Heera 4

Figure 38. Effect of variety on biological yield (t ha^{-1}) of inbred and hybrid *boro* rice ($LSD_{0.05}$ = 0.8283)

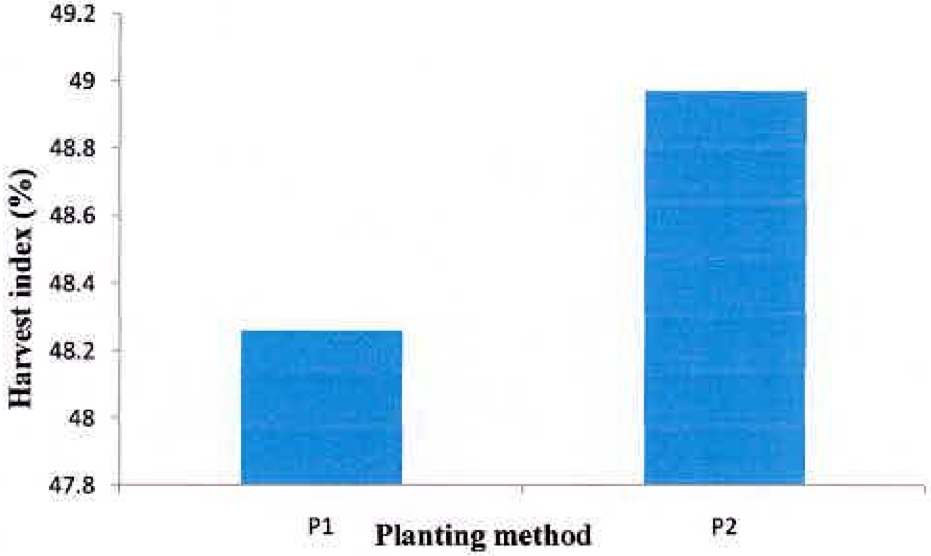
4.3.3.3 Interaction effect of planting method and variety

Interaction effect between planting method and variety was significant in respect of biological yield (Appendix XIV and Table 11). The highest biological yield was obtained from the planting method of P_2 and variety V_4 (19.61 t ha^{-1}) which was statistically similar with the planting method of P_2 and variety V_2 (18.79 t ha^{-1}) and planting method of P_2 and variety V_5 (18.75 t ha^{-1}). The lowest biological yield was obtained from the planting method of P_1 and variety V_1 (16.20 t ha^{-1}) that was statistically similar with the planting method of P_1 and variety V_3 (16.55 t ha^{-1}). These result revealed that SRI produced higher biological yield than conventional method. Thakur *et al.* (2011) also found in an experiment that, SRI produced 13.79 t ha^{-1} biological yield compared to 13.57 t ha^{-1} of biological yield produced in standard management practices (SMP).

4.3.4 Harvest index (%)

4.3.4.1 Effect of planting method

Harvest index (%) was not significantly different for planting method (Appendix XIV and Figure 39). Numerically higher harvest index was obtained from SRI (48.97%) and the lower harvest index was obtained from conventional method (48.26%). Barison (2003) also found no difference for harvest index between SRI and conventional method though Ahmed (2007) found the higher harvest index from the SRI than conventional method.

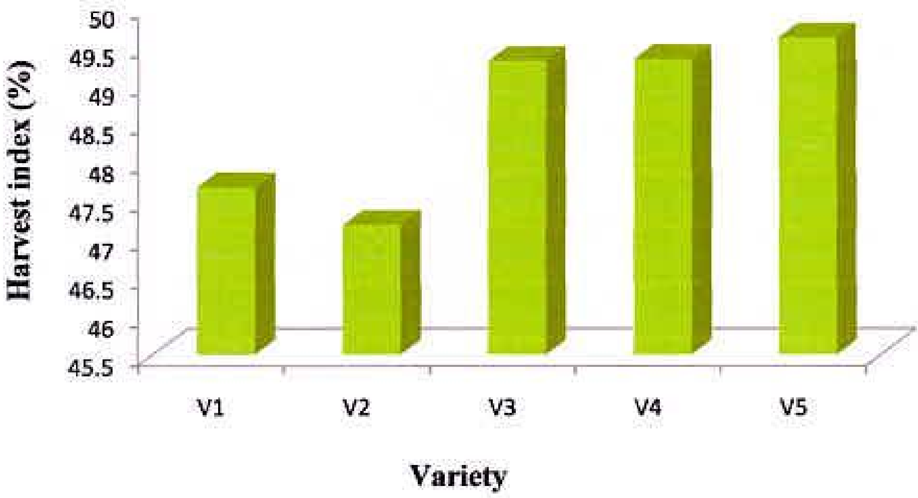


P_1 = Conventional method, P_2 = SRI

Figure 39. Effect of planting method on harvest index (%) of inbred and hybrid *boro* rice ($LSD_{0.05}$ = 1.12)

4.2.12.2 Effect of variety

Variety produced significant differences in respect of harvest index (Appendix XIV and Figure 40). The highest harvest index was obtained from Heera 4 (49.60%) that was statistically similar to BRRI dhan50 (49.30%) and BRRI hybrid dhan2 (49.32%) and the lowest harvest index was obtained from BRRI dhan29 (47.18%) that was statistically similar to BR 16 (47.67%).



V_1 = BR 16, V2 = BRRI dhan29, V_3 = BRRI dhan50, V_4 = BRRI hybrid dhan2, V_5 = Heera

Figure 40. Effect of variety on harvest index (%) of inbred and hybrid *boro* rice ($LSD_{0.05}$ = 0.7535)

4.3.4.3 Interaction effect of planting method and variety

Interaction effect between planting method and variety was significant in respect of harvest index (Appendix XIV and Table 11). The highest harvest index was observed in the planting method SRI and variety Heera 4 (50.07 %) which was statistically similar with conventional planting method and of variety BRRI dhan50 (49.32%), conventional planting method and of variety BRRI hybrid dhan2 (49.67%), conventional planting method and of variety Heera 4 (49.13%) and planting method SRI and of variety BRRI dhan50 (49.27%). The lowest harvest index was observed from the conventional planting method with the variety BR 16 (46.64%).

4.4. Economics analysis

Assuming selling rate of grain 13.44 Tk. kg^{-1} and of straw 2.69 Tk. kg^{-1} total selling prices in SRI for grain was 11289.60 Tk. ha^{-1}, 1694.70 Tk. ha^{-1} higher than conventional method respectively.

In case of seed requirement 4.58 times higher seed was required for conventional method. Considering the required seed rate for conventional method 20 kg ha^{-1}, SRI required seed 4.37 kg ha^{-1}. If the average cost of seed 40 Tk. kg^{-1}, SRI saved 625.20 Tk. ha^{-1}. In accordance with the labor wage 250 Tk. day^{-1} and working hours 8 day^{-1}

total cost required for transplanting in conventional method was 13020.75 Tk. ha^{-1} and in SRI was 7378.47 Tk. ha^{-1} Due to practicing AWD in SRI; it saved 33.33% water than conventional method. Assuming the total cost of irrigation conventional method required 20000 Tk. ha^{-1} where SRI required 13334 Tk. ha^{-1} that save 6666 Tk. ha^{-1}. For weeding 870.82 Tk. ha^{-1} more was required in conventional method than SRI. From the above analysis net profit in SRI than conventional method was 26788.60 Tk. ha^{-1}.

Table 12. Economic analysis of conventional method with SRI

Items of costing	Conventional method (Tk. ha^{-1})	SRI (Tk. ha^{-1})	Difference (SRI-Conventional method) (Tk. ha^{-1})
Seed	800	174.80	625.20
Transplanting	13020.75	7378.47	5642.28
Irrigation	20000.00	13334.00	6666.00
Weeding (2 times)	13020.82	12150.00	870.82
Grain	111014.40	122304,00	11289.60
Straw	23806.50	25501.20	1694.70
Net profit for SRI over conventional method			26788.60

*Labor wage = 250 TK. day^{-1}, *No. labor for transplanting in conventional method = 52.08 ha^{-1}, *No of labor for transplanting in SRI = 29.51 ha^{-1}, *No of labors for two times weeding in conventional method = 52.08 ha^{-1}, *No of labors for two times weeding in SRI = 48.60 ha^{-1}, Grain selling rate = 13.44 TK. kg^{-1}, Straw selling rate = 2.69 TK. kg^{-1}. Grain = 8.26 t ha^{-1}, Straw = 8.85 t ha^{-1} in conventional method and grain = 9.10 t ha^{-1}, Straw = 9.48 t ha^{-1} in SRI.

CHAPTER 5

SUMMARY AND CONCLUSION

The field experiment was conducted at the Agronomy field of Sher-e-Bangla Agricultural University (SAU), Dhaka, during the period from November 2012 to July 2013 to assess the performance of SRI with conventional method of rice cultivation in *boro* season under the Modhupur Tract (AEZ-28). The experiment was comprised of two sets of treatments viz. A. Planting method (SRI and conventional) B. Variety (BR 16, BRRI dhan29, BRRI dhan50, BRRI hybrid dhan2 and Heera 4). The experiment was laid out in split-plot design with three replications having planting method in the main plots and variety in the sub plots.

The data on crop growth were recorded in the field and yield as other crop characters were recorded after harvest and analyzed using the MSTAT-C package. The mean differences among the treatments were compared by least significant difference test at 5% level of significance.

Results showed that planting method had significant effect on growth and yield attributes except leaf area index (LAI), total dry weight (g m^{-2}), number of rachis branches panicle^{-1}, number of unfilled grains panicle^{-1} and harvest index. It revealed that conventional method produced higher plant height at 25, 50 and 75 DAT than SRI but finally at harvest SRI produced longer plant than conventional method. Initially the number of tillers hill^{-1} was not significantly different but gradually the number was higher in conventional method than SRI and at last it was higher in SRI. For the number of tiller m^{-2} was higher in conventional method than SRI. Root length was not significantly different for both of the cultivation method at the early stage of transplanting but at harvest longest root was recorded in SRI than conventional method. Number of effective tillers and ineffective tillers hill^{-1} was higher in SRI than conventional method. Longer panicle (28.15 cm) was found in SRI than conventional method (25.77 cm). Total number of grains panicle was also higher (216.89) in SRI. Number of filled grain and weight of 1000 grains was higher in SRI than conventional method. Grain and straw yield was (9.10 t ha^{-1} and 9.48 t ha^{-1}) higher in SRI than conventional method (8.26 t ha^{-1} and 8.85 t ha^{-1}). Higher amount of biological yield

(18.58 t ha^{-1}) was obtained from SRI and lower biological yield (17.11 t ha^{-1}) was obtained from conventional method.

The variety showed significant effect on all the agronomic parameters except root length. Among the five varieties (BR 16, BRRI dhan29, BRRI dhan50, BRRI hybrid dhan2 and Heera 4) Heera 4 produced the longest (119.10 cm) plant and BR 16 produced the shortest plant (101.6 cm). The highest (34.77) number of tillers hill^{-1} was obtained from BR 16 and the lowest (21.33) number of tillers hill^{-1} was obtained from hybrid variety of Heera 4. The highest number of leaves hill^{-1} was produced in BR 16 and the lowest number was obtained from Heera 4. The highest leaf area index (LAI) was observed in BRRI dhan29 from all other varieties where there was no significant difference at 25 DAT. Heera 4 produced the highest amount of dry weight among the fives varieties. BR 16 produced the highest number (33.43) of effective tillers hill^{-1} where Heera 4 produced the lowest (18.30). But BRRI dhan29 was the lowest variety producing lowest number of ineffective tillers hill^{-1}. BRRI dhan29 showed the longest panicle length (29.05 cm), highest total number grains panicle^{-1} (229.40), number of filled grains panicle^{-1} (162.25) and number of unfilled grains panicle^{-1} (67.10) but the highest rachis branches panicle^{-1} (11.62) and number of unfilled grains panicle^{-1} (29.91) was produced in Heera 4. In case of grain yield (9.16 t ha^{-1}) and biological yield (18.58t ha^{-1}) BRRI hybrid dhan2 produced the highest but the lowest harvest index was obtained from Heera 4.

Interaction effect of planting method and variety also significantly influenced all the growth as well as yield and other crop characters. These result revealed that at the early stage the longest plant was obtained from conventional planting method with the variety of Heera 4 but finally at harvest the longest plant was obtained from the planting method of SRI with variety Heera 4. All the five the tested varieties showed longer plant at early stage growth with the combination of conventional planting method but in case of harvesting longer plant was produced in SRI. The similar trend was observed for number of tillers hill^{-1}, number of leaves hill^{-1} and root length in SRI than conventional method. But in consideration of tiller number m^{-2} and leaf number m^{-2} all of the five varieties showed better result in combination of conventional method than SRI. Total dry weight m^{-2} was not statistically different among the interaction of planting method and variety. The highest number (52.47) of effective tiller was produced in the interaction of inbred variety of BR 16 with the planting method of SRI and ineffective tiller was in Heera 4 with SRI compared to other treatments. Panicle length, total grains panicle^{-1}, number of unfilled grains panicle^{-1} was significantly affected by the interaction of planting method and variety. BRRI dhan29 produced longest panicle length (30.53 cm), highest total grains panicle^{-1} (255.40) and highest number of unfilled grains panicle^{-1} (88.60) in SRI among the all other treatments. BRRI dhan50 produced the shortest panicle length (23.52 cm) and the lowest number of total grains panicle^{-1} (145.80) in the conventional practice. The lowest number of unfilled grains panicle^{-1} (25.37) was produced in SRI for BRRI hybrid dhan2. The highest number of rachis branches panicle^{-1} (12.10) and number of filled grains panicle^{-1} (186.37) was produced in combination of SRI with Heera 4 among the treatments. The lowest number of rachis branches panicle^{-1} (9.23) in the conventional planting method with the variety BR 16 and the lowest number of filled grains panicle^{-1} (92.37) was obtained from the conventional method with variety of BRRI dhan50. The highest 1000 grain weight was recorded in the conventional method for Heera 4 (30.58 g) and the lowest was in SRI with the variety of BRRI han50 (19.69 g). Considering the grain yield (9.60 t h^{-1}), straw yield (10.02 t ha^{-1}) and biological yield (19.61 t ha^{-1}) the highest performance was found in BRRI hybrid dhan2 with the method of SRI. Heera 4 in SRI produced the highest harvest index (50.07 t ha^{-1}). All the treatments of SRI produced better performance for grain yield, straw yield, biological yield and harvest index than the conventional method.

Based on the result of the present study the following conclusion may be drawn –

- SRI produced better performance (10.17 % grain yield) on the most of the growth and yield attributes that contributed to the net profit Tk. 26788.60 ha^{-1}.
- SRI produced longer root than conventional method as a result better utilization of nutrients.
- In SRI practice it improved the soil status as organic manure was used and no need of extra preparation for seedbed as it was grown in tray.
- BRRI hybrid dhan2, and Heera 4 performed better which was followed by BBRI dhan29.

However, to reach a specific conclusion and recommendation the experiments with SRI need to be conducted with more varieties and in different agro-ecological zones.

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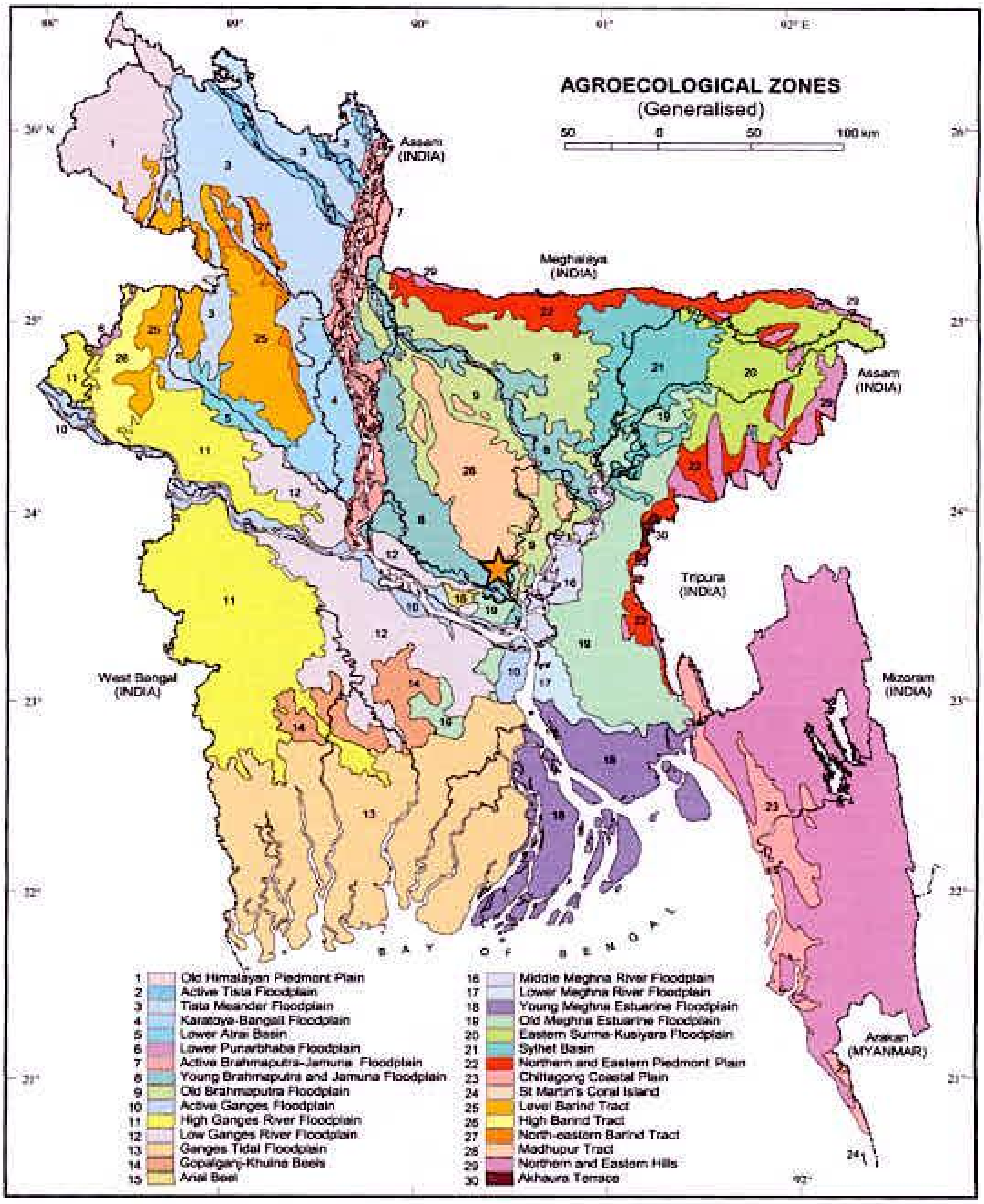
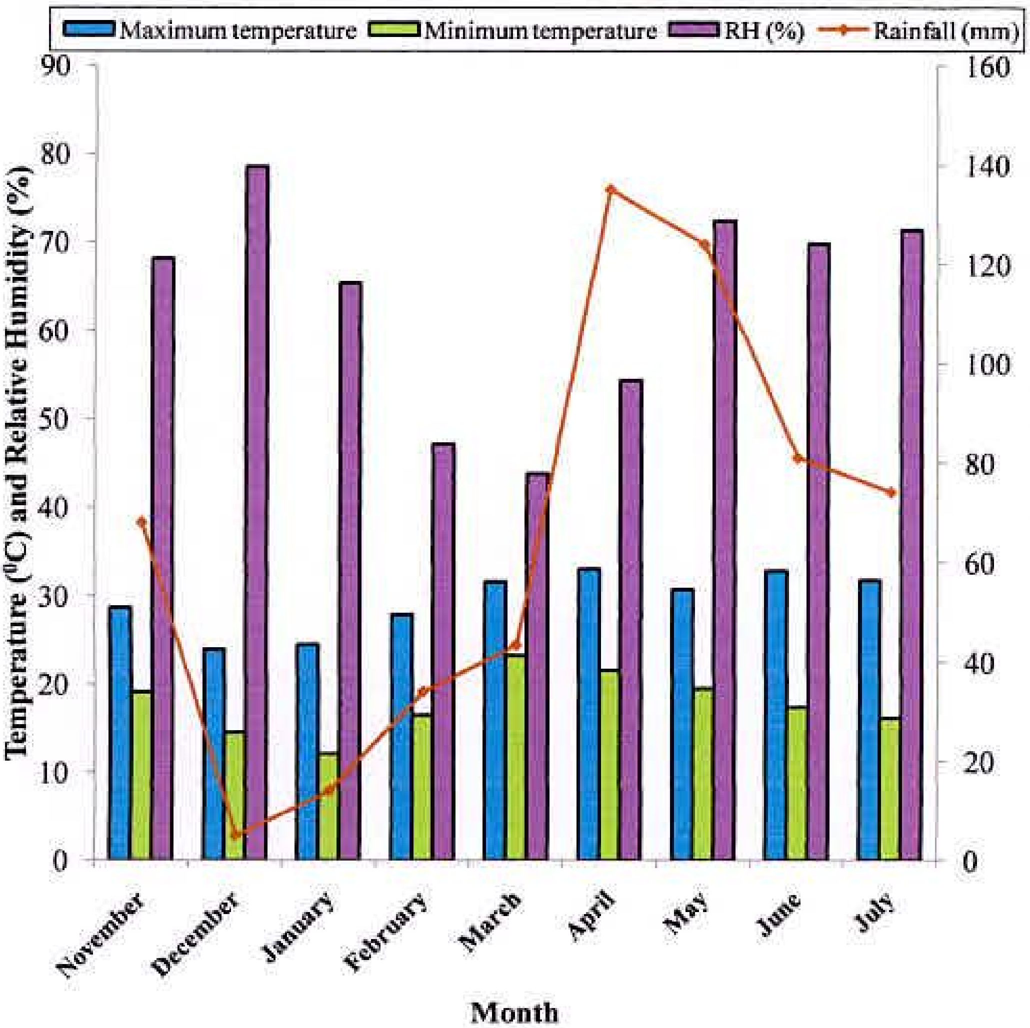
APPENDICES

Appendix I. Map showing the experimental sites under study



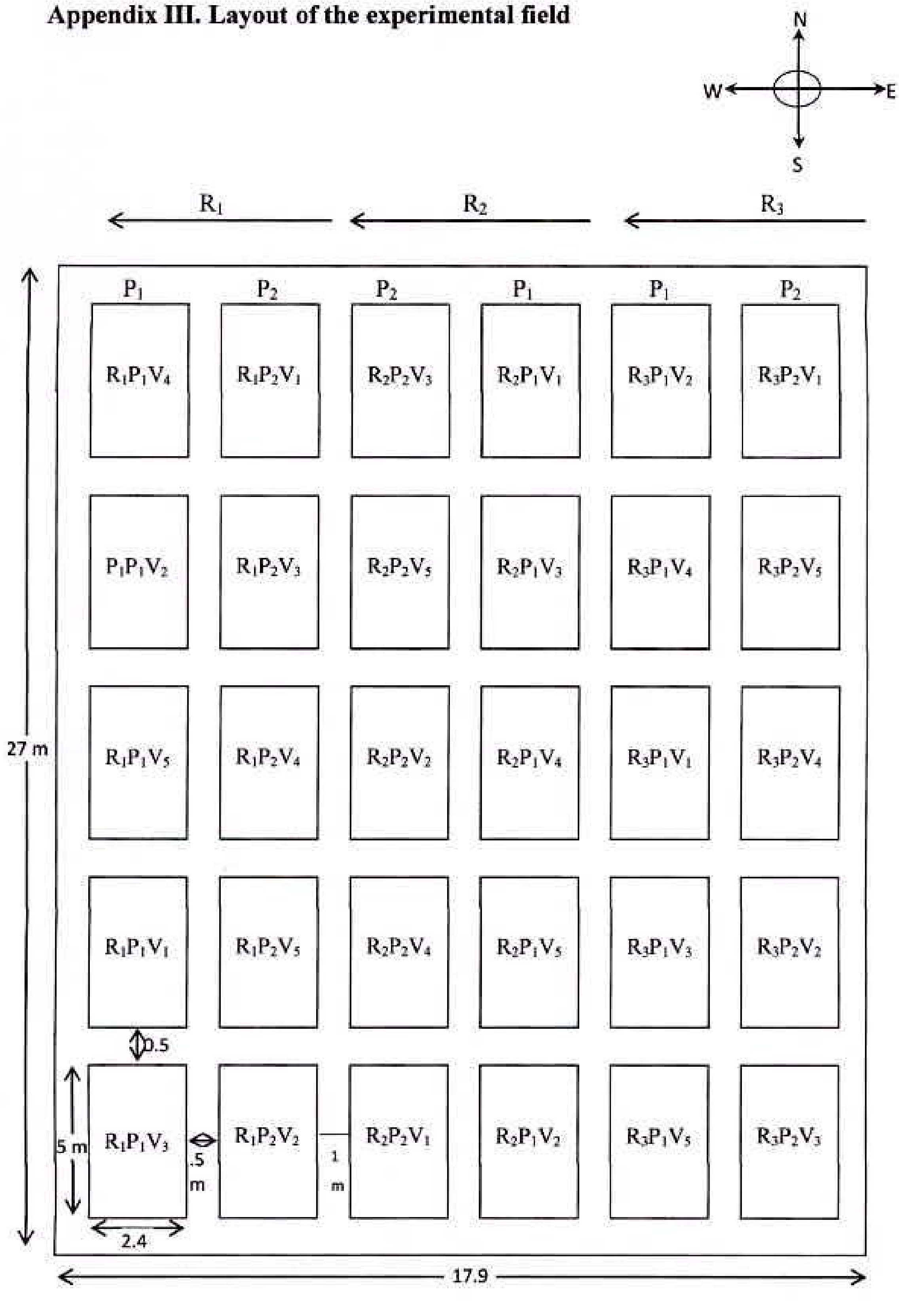
★ **The experimental site under study**

Appendix II. Monthly record of average air temperature, relative humidity and total rainfall of the experimental site during the period from November 2012 to July 2013



Source: Weather station, Sher-e-Bangla Agricultural University, Dhaka-1207.

Appendix III. Layout of the experimental field



Appendix IV. Mean square values for plant height at different days after transplanting *boro* rice

Sources of variation	Degrees of freedom	Mean square values for plant height at different days after transplanting			
		25	50	75	At harvest
Replication	2	3.043	2.681	7.144	7.651
Planting method	1	106.484*	280.602*	27.418	479.20*
Error (a)	2	0.757	15.133	18.113	20.442
Variety	4	34.952*	289.871*	850.309*	403.044*
Planting method × Variety	4	11.38*	9.317*	6.404*	11.341*
Error (b)	16	4.416	14.439	22.723	7.792

* Significant at 5% level

Appendix V. Mean square values for tiller number hill^{-1} at different days after transplanting *boro* rice

Sources of variation	Degrees of freedom	Mean square values for tiller number hill^{-1} at different days after transplanting			
		25	50	75	At harvest
Replication	2	0.041	2.236	1.477	0.177
Planting method	1	4.332	32.865*	8758.626*	7133.292*
Error (a)	2	0.364	3.537	18.581	3.724
Variety	4	0.370*	16.595*	403.070*	174.973*
Planting method × Variety	4	0.675*	14.189*	137.562*	57.852*
Error (b)	16	0.183	9.910	13.461	4.076

* Significant at 5% level

Appendix VI. Mean square values for tiller number m^{-2} at different days after transplanting *boro* rice

Sources of variation	Degrees of freedom	Mean square values for tiller number m^{-2} at different days after transplanting			
		25	50	75	At harvest
Replication	2	21.970	1901.861	681.457	233.782
Planting method	1	27676.181*	795636.25*	130838.45*	55659.364*
Error (a)	2	75.210	2116.581	3503.617	818.982
Variety	4	280.285*	4572.388*	46171.391*	22142.003*
Planting method × Variety	4	330.666 *	4175.288*	2362.572*	2816.983*
Error (b)	16	67.077	2121.613	1480.222	848.968

* Significant at 5% level

Appendix VII. Mean square values for leaf number $hill^{-1}$ at different days after transplanting *boro* rice

Sources of variation	Degrees of freedom	Mean square values for leaf number $hill^{-1}$ at different days after transplanting			
		25	50	75	At harvest
Replication	2	0.252	39.845	43.433	20.908
Planting method	1	41.772	502.661	218453.333*	170373.888*
Error (a)	2	2.604	56.709	443.633	96.148
Variety	4	3.212*	263.725*	10038.717*	7260.528*
Planting method × Variety	4	4.699*	225.581*	3465.250*	2406.621*
Error (b)	16	1.451	156.537	337.408	85.870

* Significant at 5% level

Appendix VIII. Mean square values for leaf number m^{-2} at different days after transplanting *boro* rice

Sources of variation	Degrees of freedom	Mean square values for leaf number m^{-2} at different days after transplanting			
		25	50	75	At harvest
Replication	2	99.37	31957.04	13851.93	2978.33
Planting method	1	294624.3*	12763293.*	3325671.08*	1227758.7*
Error (a)	2	487.452	34739.595	79884.925	15392.925
Variety	4	2347.590*	76281.368*	1144511.05*	828794.03*
Planting method × Variety	4	2592.89*	69987.61*	59889.05*	27899.43*
Error (b)	16	564.35	32434.41	37673.56	21759.95

* Significant at 5% level

Appendix IX. Mean square values for root length at different days after transplanting *boro* rice

Sources of variation	Degrees of freedom	Mean square values for root length at different days after transplanting			
		30	60	90	At harvest
Replication	2	10.598	4.419	10.581	18.10
Planting method	1	9.976	3.745	658.018*	433.20*
Error (a)	2	2.315	1.517	6.640	1.900
Variety	4	3.070*	16.420*	15.628*	9.669
Planting method × Variety	4	5.023*	9.828*	13.420*	0.815*
Error (b)	16	1.878	3.389	5.910	6.979

* Significant at 5% level

Appendix X. Mean square values for leaf area index at different days after transplanting *boro* rice

Sources of variation	Degrees of freedom	Mean square values for leaf area index at different days after transplanting			
		25	50	75	100
Replication	2	0.001	0.023	0.595	0.132
Planting method	1	0.119*	35.554*	35.297	2.216
Error (a)	2	0.001	0.071	2.202	0.099
Variety	4	0.001	0.312*	2.387	3.095*
Planting method × Variety	4	0.001	0.497*	1.427*	1.019*
Error (b)	16	0.000	0.205	1.565	0.461

* Significant at 5% level

Appendix XI. Mean square values for total dry weight m^{-2} at different days after transplanting *boro* rice

Sources of variation	Degrees of freedom	Mean square values for total dry weight m^{-2} at different days after transplanting			
		30	60	90	At harvest
Replication	2	17.790	17459.447	76186.734	70015.471
Planting method	1	974.301*	917506.174*	626424.88*	248912.04
Error (a)	2	18.236	21760.689	28607.546	19698.320
Variety	4	9.012	17748.077*	33652.006	90470.70*
Planting method × Variety	4	10.447*	18979.535*	29720.76*	80503.13*
Error (b)	16	8.312	13466.502	24179.105	51664.206

* Significant at 5% level

Appendix XII. Mean square values for effective and ineffective tillers hill^{-1} of inbred and hybrid *boro* rice

Sources of variation	Degrees of freedom	Mean square values for effective and ineffective tillers hill^{-1} of inbred and hybrid	
		Effective tillers hill^{-1}	Ineffective tillers hill^{-1}
Replication	2	0.515997	3.63333
Planting method	1	6476.82*	396.033*
Error (a)	2	2.08134	11.6333
Variety	4	218.355*	107.783*
Planting method × Variety	4	78.3680*	100.283*
Error (b)	16	3.14033	16.0083

* Significant at 5% level

Appendix XIII. Mean square values for different crop characters of inbred and hybrid *boro* rice

Sources of variation	Degrees of freedom	Mean square values for different crop characters					
		Panicle length (cm)	Rachis branches panicle^{-1} (no.)	Total grains panicle^{-1} (no.)	Filled grains panicle^{-1} (no)	Unfilled grains panicle^{-1} (no.)	1000-grains weight (g)
Replication	2	0.70	0.70	71.95	676.47	523.93	.646
Planting method	1	42.43*	1.50	14723.1*	13487.4*	27.08	16.25*
Error (a)	2	0.07	1.14	103.48	38.51	243.52	.32
Variety	4	15.38*	4.25*	4861.08*	1772.31*	992.90*	105.5*
Planting method × Variety	4	1.08*	0.28*	218.0*	1711.38*	1378.8*	1.33*
Error (b)	16	0.52	0.19	240.72	229.60	92.85	1.14

* Significant at 5% level

Appendix XIV. Mean square values for yield and other crop characters of inbred and hybrid *boro* rice

Sources of variation	Degrees of freedom	Mean square values for yield and other crop characters			
		Grain yield	Straw yield	Biological yield	Harvest index
Replication	2	.939463	0.286	2.239	1.839
Planting method	1	5.27521*	2.970*	16.163*	3.809
Error (a)	2	.155103	0.025	0.297	0.507
Variety	4	1.01636*	0.872*	2.863*	7.319*
Planting method × Variety	4	.383633*	0.187*	0.242*	1.808*
Error (b)	16	.112108	0.141	0.458	0.379

* Significant at 5% level

PLATES

Seed sown in tray for SRI seedling

Seed sown in wet seedbed for conventional method

Seedlings of BR 16 for SRI transplanting

Seedlings of BR 16 for conventional transplanting

Plate 1. Information of the seed sowing and seedlings before transplanting

Seedlings of BRRI dhan 50 for SRI transplanting

Seedlings of BRRI dhan 50 for conventional transplanting

Seedlings of BRRI dhan 29 for SRI transplanting

Seedlings of BRRI dhan 29 for conventional transplanting

Plate 2. Seedlings before transplanting

Seedlings in transplanted SRI plot

Seedlings in transplanted conventional plot

AWD practice in SRI plot

Mechanical weeding in SRI plot

Plate 3. Plot information and practice used after transplanting

Plot of SRI at 47 DAT

Plot of convention method at 47 DAT

Plot of SRI at 60 DAT

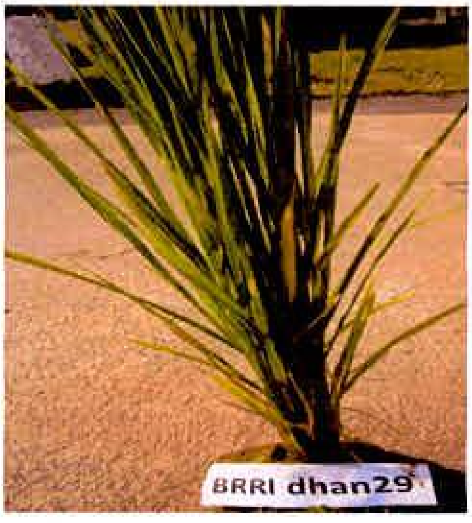
Plot of convention method at 60 DAT

Plate 4. Plot information at different DAT

Hill of BRRI dhan50 in SRI at 100 DAT

Hill of BRRI dhan50 in conventional method at 100 DAT

Hill of BRRI dhan29 in SRI at 100 DAT



Hill of BRRI dhan29 in conventional method at 100 DAT

Plate 5. Hill information at 100 DAT