IMPACT OF THE SYSTEM OF RICE INTENSIFICATION (SRI) ON MORPHO-PHYSIOLOGICAL CHARACTERISTICS AND PRODUCTIVITY OF HYBRID RICE VARIETIES

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CERTIFICATE

This is to certify that the thesis entitled “Impact of the System of Rice Intensification (SRI) on morpho-physiological characteristics and productivity of hybrid rice varieties” submitted to the Department of Agricultural Botany, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE in Agricultural Botany, embodies the result of a piece of bonafide research work carried out by MD. HAZRAT ALI, Registration No. 10-03806 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.

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MY

BELOVED PARENTS

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IMPACT OF THE SYSTEM OF RICE INTENSIFICATION (SRI) ON MORPHO-PHYSIOLOGICAL CHARACTERISTICS AND PRODUCTIVITY OF HYBRID RICE VARIETIES

ABSTRACT

An experiment was carried at the Sher-e-Bangla Agricultural University Farm, Dhaka, Bangladesh from December 2015 to May 2016 to study the impact of the system of rice intensification (SRI) on morpho-physiological characteristics and productivity of hybrid rice varieties. Two cultivation methods *viz.* a) Traditional method (15 cm × 25 cm spacing + regular irrigation) and b) SRI method (20 cm × 20 cm spacing + alternate wetting and drying), and eight hybrid varieties *viz.* BRRI hybrid dhan2, BRRI hybrid dhan3, Heera1, Bolaka, Tia, ACI Sampod, Moyna and one inbred rice variety, BRRI dhan45 were used for this experiment. The experiment was laid out in a randomized Complete Block Design (RCBD) and replicated thrice. Among eight rice varieties, BRRI hybrid dhan3 exhibits the best performance in relation to its morpho-physiological characteristics and yield attributes. Consequently the highest yield (8.52 t ha^{-1}) was obtained from BRRI hybrid dhan3 followed by Tia (8.14 t ha^{-1}) and Heera1 (8.03 t ha^{-1}). Under SRI method, all the studied hybrids had higher yield. BRRI hybrid dhan3 with SRI method produced highest dry weight $plant^{-1}$ for leaves (9.67g), panicle (48.83g), calm (19.17g) and root (8.33g) at harvest and also provided the significantly higher number of effective tillers $hill^{-1}$ (19.67), highest filled grains $panicle^{-1}$ (204), 1000 grain weight (28.77 g), grain yield (9.77 t ha^{-1}), stover yield (8.46 t ha^{-1}) and harvest index (45.06) whereas under Traditional method, higher grain yield (7.85 t ha^{-1}) was recorded from the hybrid Tia. Among hybrid and inbred varieties, BRRI dhan45 showed the lowest performance under traditional method in term of all the studied parameters. So, SRI method appeared better for cultivation of the hybrid rice varieties compared to traditional method.

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ABBREVIATIONS AND ACRONYMS

AEZ	=	Agro-Ecological Zone
BBS	=	Bangladesh Bureau of Statistics
BCSRI	=	Bangladesh Council of Scientific Research Institute
cm	=	Centimeter
CV %	=	Percent Coefficient of Variation
DAS	=	Days After Sowing
DMRT	=	Duncan’s Multiple Range Test
et al.,	=	And others
e.g.	=	exempli gratia (L), for example
etc.	=	Etcetera
FAO	=	Food and Agricultural Organization
g	=	Gram
i.e.	=	id est (L), that is
Kg	=	Kilogram
LSD	=	Least Significant Difference
m^2	=	Meter squares
ml	=	MiliLitre
M.S.	=	Master of Science
No.	=	Number
SAU	=	Sher-e-Bangla Agricultural University
var.	=	Variety
^oC	=	Degree Celceous
%	=	Percentage
NaOH	=	Sodium hydroxide
GM	=	Geometric mean
mg	=	Miligram
P	=	Phosphorus
K	=	Potassium
Ca	=	Calcium
L	=	Litre
µg	=	Microgram
USA	=	United States of America
WHO	=	World Health Organization

Chapter 1

Introduction

CHAPTER I

INTRODUCTION

Rice is the foremost staple food for more than 50% of the world's population (Thakur *et al*., 2011). There is an upward shift in demand for rice worldwide due to population increase and urbanization, as people change their eating habits (Mishra, 2009), leading to high shelf prices. Between 2006 and 2008, average world prices for rice grew by 217%, compared to wheat which increased by 136%, corn by 125%, and soybeans by 107%. (FAO, 2010; Mittal, 2009).

Bangladesh is one of the less developed countries of the world which is densely populated and threatened by floods and storms. About 75% of the total cropped area and more than 80% of the total irrigated area is planted to rice (Hossain and Deb, 2003).

The country is now producing about 42.3 million tons of clean rice @ 3.78 t ha^{-1} in 11.2 million ha of land. A conservative statistics given by Bhuiyan *et al*. (2002) indicates that about 21% higher amount of rice than the production of 2000 have to be produced to feed the population by the year 2025. There is no opportunity to increase rice area consequently; much of the additional rice required will have to come from higher average yield on existing land. Clearly, it will require adoption of new technology such as high management package, high yielding cultivar, higher input use etc. (Wang *et al*., 2002).

To be able to meet the world's food demand by 2025, it is estimated that rice production has to increase 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). Rice crop is also the largest consumer of water in the agricultural sector (Bera, 2009; Mishra, 2009; Prasad and Ravindra, 2009). Thus, innovative ways for reducing inputs like water, chemicals, fertilizers and labor while increasing yields on the same piece of land need to be put in place to ensure sustainable rice production (Bouman *et al*., 2005; Mati and Nyamai, 2009).

The System of Rice Intensification (SRI), offers an opportunity to improve food security through increased rice productivity by changing the management of plants, soil, water and nutrients while reducing external inputs like fertilizers and herbicides (Berkelaar, 2001; Thakur *et al*., 2009; Uphoff, 2003; Vermeule, 2009). The system proposes the use of single, very young seedlings with wider spacing, intermittent wetting and drying, use of a mechanical weeder which also aerates the soil, and enhanced soil organic matter (Uphoff and Kassam, 2009).

SRI is a technique that is a set of practices and a set of principles rather than as a "technology package" (Uphoff, 2004). SRI is not a technology like the seed of high-yielding varieties or like a chemical fertilizer or insecticide. It is a system for managing plants, soil, water or nutrient together in mutually beneficial ways, creating synergies (Laulanié, 1993). With SRI, management practices control or modify the microenvironment so that existing genetic potentials can be more fully expressed and realized.

The most obvious advantage from SRI appears to be the yield increase in farmers' field without any new seeds or chemical and mechanical inputs (Stoop *et al*., 2002) and that is reported to be from 50% to 200% (Uphoff, 2005; Deichert and Yang, 2002; Wang *et al*., 2002). According to proponents, SRI encompasses a set of principles, each of them fairly simple, but working synergistically with the others in order to achieve higher grain yield (Uphoff and Randriamiharisoa, 2002; Anon., 1992; Vallois, 1996).

The SRI is a production system that emphasize the use of younger seedlings (< 15 days) planted singly and at wider spacing, together with the adoption of intermittent irrigation, organic fertilization, and active soil aeration to the extent possible (Stoop *et al.*, 2002; Uphoff 2007). 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. SRI methods enable farmers to reduce their irrigation by 25-50% while realizing higher and more profitable production (Uphoff and Randriamiharisoa, 2002; Anthofer, 2004; Li, 2001; Sato, 2005; Uphoff, 2006).

Traditional flood irrigated rice ecosystem not only causes wastage of water but also leads to environmental degradation and reduces fertilizer use efficiency. During the last few decades, various new cultivation practices for growing rice have been tried worldwide. The different technologies developed so far to reduce water loss as well as increase water use efficiency of the rice crop are alternate wetting and drying, system of rice intensification, and saturated soil culture, which partially or totally suppress the need for water in rice field. All these systems have been reported to show high water productivity with no or little compromise on yield.

The study was therefore, undertaken to investigate the impact of SRI on productivity of hybrid rice varieties. The objectives of the study are as follows-

1. To study the growth and yield response of eight hybrid rice varieties grown under system of rice intensification (SRI).
2. To compare the productivity of the test hybrid rice varieties under system of rice intensification (SRI) and conventional method
3. To verify the effectiveness of the system of rice intensification (SRI) over traditional rice cultivation method.

Chapter 2
Review of literature

CHAPTER II

REVIEW OF LITERATURE

Rice is extensively adaptable crop in different environmental conditions. The growth and development of rice may be affected due to varietal performance and systems of cultivation. Productivity or yield potentiality also depends on physiological parameters like height, leaf area, dry matter accumulation, translocation of assimilate etc. Systematic research on 'System of Rice Intensification' (SRI) has started recently, and till date now hybrid rice seed production under SRI method has not been under taken, hence the literature available is scanty and not available. System of rice intensification (SRI) farming method is on practice in several countries as an alternative, sustainable, low-cost system to the conventional farming systems (Krishna *et al*., 2008)

2.1 Effect of varieties on morpho-physiological characters and productivity of rice

The successful production of any crop depends on manipulation of basic ingredients of crop culture. The variety of crop is one of the important basic ingredients. Some of the works related to different rice varieties with different systems of cultivations are cited below:

Yuni-Widyastuti *et al*. (2015) established an experiment on hybrid rice varieties in lowland rice fields in Sukamandi (West Java) and Batang (Central Java), Indosesia during the dry season and the rainy season of 2012. Randomized complete block design (RCBD) with three replications was used in each location. The results showed that grains yields were affected by locations, seasons, and genotypes. The genotypes x locations x seasons interaction effect was significant; therefore, the best hybrid was different for each location and season. A7/PK36 hybrid has the best performance in Batang during the dry season, while A7/PK40 and A7/PK32 are the best hybrids in the rainy season. In Sukamandi, nine hybrids were identified as better yielder than that of the check cultivar in the dry season, but not so in the rainy season.

An experiment was conducted by Bhuiyan *et al*. (2014) to determine the adaptability and performance of different hybrid rice varieties and to identify the best hybrid rice variety in terms of yield and recommend it to rice farmers. Based on the findings of the study, the different hybrid rice varieties evaluated had significant effects on plant height at maturity, number of days to maturity, number of tillers, number of productive tillers, number of filled and unfilled grains, length of panicle and yield. RGBU010A X SL8R is therefore recommended as planting material among hybrid rice varieties because it produced favorable yield, produced more productive tillers and filled grains, produced longer panicles, heavy seeds, high harvest index and are accepted by consumers. In the absence of this variety, RGBU02A × SL8R, RGBU003A × SL8R and RGBU0132A × SL8R may also be used as planting material.

An experiment was conducted during *Aus* season to observe the effect of transplanting dates on the yield and yield attributes of exotic hybrid rice varieties by Hosain *et al*. (2014) at the research farm of Sher-e-Bangla Agricultural University (SAU), Dhaka. The experiment comprised of three rice varieties (two hybrids-Heera2, Aloron and one inbred- BRRI dhan48). From the findings it was revealed that BRRI dhan48 produced the highest grain yield (3.51 t ha^{-1}) where as the hybrid varieties Heera2 (3.03 t ha^{-1}) and Aloron (2.77 t ha^{-1}) achieved lower grain yield due to higher spikelet sterility.

Sarker *et al*. (2013) and Bikash *et al*. (2002) conducted to study morphological, yield and yield contributing characters of four *Boro* rice varieties of which three were local viz., Bashful, Poshursail and Gosi; while another one was a high yielding variety (HYV) BRRI dhan28. The BRRI dhan8 were significantly superior to the cultivars studied. The BRRI dhan28 was shorter in plant height, having more tillering capacity, higher leaf number which in turn showed superior growth character and yielded more than those of the local cultivars. The HYV BRRI dhan28 produced higher number of grains panicle^{-1} and bolder grains resulted in higher grain yield over the local cultivars. Further, BRRI dhan28 had erect leaves and more total dry mass than those of local varieties. The BRRI dhan28 produced higher grain yield (7.41 t ha^{-1}) and Bashful, Poshurshail and Gosi yielded ha^{-1}, respectively. Among the local rice cultivars, Gosi showed the higher yielding ability than Bashful and Poshursail.

Haque *et al*. (2013) conducted in 2009 and 2010 to evaluate some physiological traits and yield of three hybrid rice varieties (BRRI hybrid dhan2, Heera2, and Tia) in comparison to BRRI dhan48 in *Aus* season. The experiments involved four planting dates (1 April, 16 April, 1 May and 16 May). Compared to BRRI dhan48, hybrid varieties accumulated greater shoot dry matter at anthesis, higher flag leaf chlorophyll at 2, 9, 16 and 23 days after flowering (DAF), flag leaf photosynthetic rate at 2 DAF and longer panicles. However, hybrid varieties demonstrated smaller remobilization of shoot reserve to grain and photosynthetic rate of its flag leaf at 9 and 16 DAF than BRRI dhan48. Heera2 and BRRI hybrid dhan2 maintained significantly higher chlorophyll a, b ratio over Tia and BRRI dhan48 at 2, 9, 16 and 23 DAF in their flag leaf. Shoot reserve remobilization to grain exhibited higher degree of sensitivity to rising of minimum temperature in the studied hybrids compared to the inbred. Inefficient photosynthetic activities of flag leaf and poor shoot reserve translocation to grain resulted poor grain filling percentage in the test hybrids. Consequently the studied hybrids showed significantly lower grain yield (ca. 36.7%) as compared to inbred BRRI dhan48, irrespective of planting date in *Aus* season.

Tabien *et al*. (2012) reported that two newly released high yielding rice varieties, Antonio and Colorado would be the new choices for rice farmers in Texas for commercial production in the future. Both inbred varieties show great promise of high yields. These could also be good recipients of important traits needed in future climate or environment. The screening and yield performance trials identified donors for tolerance to higher rate of herbicide. Mallikarjuna *et al*. (2012) were mapped in 2 mapping populations derived from *Oryza sativa* cv Swarna in a Quantitative trait loci (QTLs) for 12 grain quality traits nivara. QTLs for 4 quality traits were associated with 5 of the 7 major yield QTLs reported in the same 2 mapping populations. Useful introgression lines have been developed for several agronomic traits.

Samonte *et al*. (2011) reported that the two elite lines recommended for release are high yielding in Texas. RU0703190 is also a very early maturing conventional long grain rice. The high yield potential newly released varieties will increase the production of rice and the income of the farmers. The germination and seedling cold tolerant donors that were identified will be useful in developing variety for early plantings. Forty five aromatic rice genotypes were evaluated by Kaniz *et al*. (2011) to assess the genetic variability and diversity on the basis of nine characters. Significant variations were observed among the genotypes for all the characters. Thousand grain weights have been found to contribute maximum towards genetic diversity in 45 genotypes of aromatic rice.

Abou-Khalif (2009) conducted in the experimental farm of Rice Research and Training Center (RRTC)- Sakha, Kafr- El Sheikh Governorate, and Egypt during rice season in 2008 for physiological evaluation of some hybrid rice varieties in different sowing dates. Four hybrid rice H1, H2, GZ 6522 and GZ 6903 were used. Seeds were sown on six different sowing dates April 10th, April 20th, May 1st, May 10th, May 20th and June 1st; and seedlings of 26 days old were transplanted at 20×20 cm spacing. All agricultural practices recommended for each cultivar were applied. Nitrogen fertilizer was used as urea (46.5% N) in two splits; that is, 2/3 were added and mixed in dry soil before flooding of irrigation water and the other 1/3 was added at panicle initiation stage. Experimental design was spilt plot design, with sowing dates as main and varieties as sub plot treatments. Results indicated that early date of sowing (April 20th) was superior to other dates of sowing for MT, PI, HD, number of tillers m^{-2}, (plant height and root length) at PI and HD stage, chlorophyll content, number of days up to PI and HD, leaf area index, sink capacity , number of grains $panicle^{-1}$, panicle length(cm), 1000-grain weight (g), number of $paniclesm^{-2}$, panicle weight (g) and grain yield (ton ha^{-1}). Sterility percentage was the lowest in sowing 20th April. 1st of June, sowing gave the lowest with all traits under study. H1 hybrid rice variety surpassed other varieties for all characters studied except for number of days to PI and HD.

Islam *et al*. (2009) conducted pot experiments during *T. Aman* 2001 and 2002 (wet season) at Bangladesh Rice Research Institute (BRRI) in net house. Hybrid variety $Sonarbangla^{-1}$ and inbred modern variety BRRI dhan31 were used in both the seasons and BRRI hybrid dhan-l was used in 2002. The main objective of the experiments was to compare the growth and yield behavior of hybrid and inbred rice varieties under controlled condition. In 2001, BRRI dhan3l had about 10-15% higher plant height, very similar tillers/plant, 15-25% higher leaf area at all days after transplanting (DAT) compared to Sonarbangla-1. Sonarbangla-1 had about 40% higher dry matter production at 25 DAT but had very similar dry matter production at 50 and 75 DAT, 4-11% higher rooting depth at all DATs, about 22% higher root dry weight at 25 DAT, but 5-10% lower root dry weight at 50 and 75 DAT compared to BRRI dhan31. The photosynthetic rate was higher (20 µ mol m^{-2} sec^{-1}) in BRRI dhan3l at 35 DAT (maximum tillering stage) but at 65 DAT, Sonarbangla-l had higher photosynthetic rate of 19.5 µ mol m^{-2} sec^{-1}. BRRI dhan3l had higher panicles $plant^{-1}$ than Sonarbangla-1, but Sonarbangla-1 had higher number of grains $panicle^{-1}$, 1000-grain weight and grain yield than BRRI dhan31. In 2002, BRRI dhan31 had the highest plant height at 25 DAT, but at 75 DAT, BRRI hybrid dhanl had the highest plant height. Sonarbangla-1 had the largest leaf area at 25 and 50 DAT followed by BRRI dhan31, but at 75 DAT, BRRI dhan31 had the largest leaf area. The highest shoot dry matter was observed in BRRI dhan31 followed by Sonarbangla-1 at all DATs. Sonarbangla-1 had the highest rooting depth and root dry weight at all DATs. BRRI dhan31 gave the highest number of panicles plant^{-1} followed by Sonarbangla-1, BRRI hybrid dhan-l had the highest grains panicle^{-1} followed by BRRI dhan31 and Sonarbangla-1 had the highest 1000-grain weight followed by BRRI dhan31. The highest amount of grains plant^{-1} (34.6 g) was obtained from BRRI dhan31.

Obaidullah *et al*. (2009) conducted a field experiment at Sher-e-Bangla Agricultural University, Dhaka during the period from November 2006 to April 2007 to study the growth and yield of inbred and hybrid rice with clonal tillers different of age. They found highest grain yield (5.10 t ha^{-1}) from the clonal tiller of 25 days old and the lowest grain yield (4.31 t ha^{-1}) from 40 days old clonal tillers. Irrespective of variety 25 to 35 days old clonal tiller showed superior performance. Hybrid variety transplanted with 25 days old clonal tiller gave significantly higher grain yield.

Ashrafuzzaman *et al*. (2008) conducted a field experiment at the Agronomy field, Sher-e-Bangla Agricultural University, Dhaka during the period from June 2006 to November 2006 to study the growth and yield of inbred and hybrid rice with tiller separation at different growth periods. The experiment was conducted with two levels of treatments viz.a) Variety: BRRI dhan32 and Sonarbangla-1; and b) tiller separation days: 20, 25, 30, 35 and 40 days after mother plant transplantation. Maximum filled grains panicle^{-1} (144.28) was observed from the tiller separation at 20 DAT. Total and effective tillers hill^{-1} was affected by tiller separation beyond 30 DAT. Delayed tiller separation extended the flowering and maturity duration. Therefore, it was concluded that earlier tiller separation (20-30 DAT) resulted higher grain yield in hybrid variety but no such variations was observed in inbred variety.

Nitrogen fertilizer was used as urea form (46.5% N) in two splits; 2/3 were added and mixed in dry soil before flooding irrigation water and the other 1/3 was added at panicle initiation. Three hybrid rice H1 (SK-2034H), H4 (IR96258/Giza181) and H5 (IR70368A/Giza178) were used with three irrigation intervals every 4, 7 and 10 days. Three sowing dates 1st May, 15th May and 30th May with seedling age transplanted at 26 days by 20X20 cm planting spacing. All agricultural practices were applied as recommended for each cultivar. As split, split plot design with four replications was used, three sowing dates were allocated in the main plots, three irrigation intervals were allocated in sub-plots and three rice cultivars were allocated in the sub-sub plots. Main results indicated that maximum tillering, panicle initiation, heading dates, crop growth rates (CGR), Leaf area index, straw yield, harvest index and grain yield (t ha^{-1}) were decreased by increased irrigation intervals up to 10 days. While roots length was increased by increase irrigation intervals up to 10 days. Also sowing dates at 1st May gave the highest value to all studied characters. While 30th May date of sowing gave the lowest value with all traits under study. Also hybrid rice variety surpassed other varieties for studied characters. The interaction between H1 hybrid rice varieties with 4 days irrigation interval gave the highest value for leaf area index, Leaf area- ratio and the interaction between May 1st with irrigation interval every 10 days gave the highest value of roots length (Abou-Khalif, 2009).

Ahmed *et al*. (2007) conducted a field experiment at Agronomy field, Sher-e-Bangla Agricultural University, Dhaka during December 2005 to May 2006 to study the influence of cultivation methods on inbred and hybrid rice in *Boro* season. The experiment consisted of two levels of treatment *viz.* variety and cultivation method and was laid out in a split plot design with four replications. Interaction of variety and cultivation method revealed that nursery seedlings of the inbred variety produced the highest grain yield (8.88t ha^{-1}) and sprouted seeds broadcast of the inbred variety gave the lowest grain yield (6.35 t ha^{-1}).

Main *et al*. (2007) stated that in South and Southeast Asia, floodwater may remain for more than a month during the period of *Aman* rice grown with maximum submergence reaching to about 50-400 cm in depth. Comparative submergence by flash floods has been reported as a major production constraint in about 25 million ha of low land in this region. Although rice is adapted to lowland, complete submergence for more than 2-3 days killed most of the rice cultivars. This type of damage would be rather serious for dwarf and semi dwarf varieties, which cause total crop losses. Horizontal expansion of *Aman* rice area is not possible due to high human population pressure on land. Therefore, it is an urgent need of the time to increase rice production through increasing the yield of *Aman* rice at farmers level using inbreed and hybrid varieties. There are different methods of planting such as direct seedlings (haphazard and line sowing), transplanting of seedlings (haphazard and line sowing), transplanting of clonal tillers. The vegetative propagation of using clonal tillers separated from previously established transplanted crop was beneficial for restoration of a damaged crop of *Aman* rice where maximum number of filled grain per panicle (173.67), the highest grain yield (4.96 t ha^{-1}) was obtained with the clonal tillers followed by nursery seedlings the highest harvest index (49.04%) was found from the clonal tillers those were statistically similar with nursery seedlings.

Xia *et al*. (2007) in experiment found that Shanyou63 variety gave the higher yield (12 t ha^{-1}) compared to Xieyou46 variety (10 t ha^{-1}).

AEF (2006) stated that planting 2 clonal tillers $hill^{-1}$ showed significantly higher grain yield (4.24 t ha^{-1}) compared two other plant densities along with nursery seedlings. The higher yield in clonal tillers compared to nursery seedlings might be due to the higher filled grains per panicle. Clonal tillers gave significantly higher number of filled grains per panicle than nursery seedlings irrespective of variety.

Amin *et al.* (2006) conducted a field experiment to find out the influence of variable doses of N fertilizer on growth, tillering and yield of three traditional rice varieties (*viz.* Jharapajam, Lalmota, Bansful Chikon) with that of a modern variety (viz. KK-4) and reported that traditional varieties accumulated higher amount of vegetative dry matter than the modern variety.

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

Swain *et al*. (2006) evaluated in a field experiment the performance of rice hybrids NRH1, NRH3, NRH4, NRH5, PA6111, PA6201, DRRH1, IR64, CR749-20-2 and Lalat conducted in Orissa, India during 1999-2000. Among the hybrids tested, PA 6201 recorded the highest leaf area index.

Chowdhury *et al*. (2005) conducted an experiment with 2, 4 and 6 seedlings hill^{-1} to study their effect on the yield and yield components of rice varieties BR23 and Pajam during the *Aman* season. They reported that the cv. BR23 showed superior performance over Pajam in respect of yield and yield contributing characters i.e. number of productive tillers hill^{-1}, length of panicle, l000-grain weight, grain yield and straw yield. On the other hand, the cultivar Pajam produced significantly the tallest plant, total number of grains panicle^{-1}, number of filled grains panicle^{-1} and number of unfilled grains panicle^{-1}.

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

Akbar (2004) reported that variety, seedling age and their interaction exerted significant influence on almost all the crop characters. Among the varieties, BRRI dhan41 performed the best in respect of number of bearing tillers hill^{-1}, panicle length, total spikelet‟s panicle^{-1} and number of grains panicle^{-1}. BRRI dhan41 also produced the maximum grain and straw yields. Sonarbangla-1 ranked first in respect of total tillers hill^{-1} and 1000-grain weight but produced highest number of non-bearing tillers hill^{-1} and sterile spikelet‟s panicle^{-1}. Grain, straw and biological yields were found highest in the combination of BRRI dhan41 with 15 day-old seedlings. Therefore, BRRI dhan4l may be cultivated using 15 day-old seedlings in *Aman* season following the SRI technique to have better grain and straw yields.

Murthy *et al*. (2004) conducted an experiment with six varieties of rice genotypes Mangala, Madhu, J-13, Sattari, CR 666-16 and Mukti and observed that Mukti (5268 kg ha^{-1}) out yielded the other genotypes and recorded the maximum number of filled grains and had lower spikelet sterility (25.85%) compared to the others.

Anwar and Begum (2004) reported that time of tiller separation of rice significantly influenced plant height, total number of tiller hill^{-1}, number of bearing tillers and panicle length but grain and straw yields were unaffected. Therefore, Sonarbangla^{-1} appeared to be tolerant to tiller separation and separation should be done between 20 to 40 DAT without hampering grain yield.

Sumit *et al*. (2004) worked with newly released four commercial rice hybrids (DRRH 1, PHB 71, Pro-Agro 6201, KHR 2, ADTHR 1, UPHR 1010 and Pant Sankar dhan1) and two high yielding cultivars (HYV) as controls (Pant dhan4 and Pant dhan12) and reported that KHR 2 gave the best yield (7.0 t ha^{-1}) among them.

Bokyeong *et al*. (2003) reported that applied with same nitrogen dose Sindongjinbyeo and Iksan467 gave high primary rachis branches than Sindongjinbyeo and Dongjin No. 1 varieties.

Dongarwar *et al*. (2003) carried out an experiment to compare the response of hybrid rice KJTRH-1 combination with 2 traditional cultivars, Jaya and Swarna, with 4 fertilizer rates, i.e. 100:50:50, 75:37.5:37.5, 125:62.5:62.5 and 150:75:75 kg NPK ha^{-1} and reported that KJTRH-1 produced significantly higher yield (49.24 q ha^{-1}) than Jaya (39.64 q ha^{-1}) and Swarna (46.06 q ha^{-1}).

Siddiquee *et al*. (2002) conducted a study to evaluate the difference between hybrid and inbred rice in respect of their growth duration, yield and quality in *Boro* season, 1999. Among the varieties, Aalok 6201 had the highest grain yield followed by BRRI dhan29 and IR68877H but statistically they were similar. BRRI dhan28 had the lowest grain yield, which was statistically similar to Loknath503. BRRI dhan28 and the tested hybrid rice had lower growth duration than BRRI dhan29. Milling out turn varied from 67 to 70% among the tested varieties. Loknath 503 had the lowest milling out turn (70%) and, BRRI dhan28 and BRRI dhan29 had the highest milling out turn (70%) for unparboiled but parboiled rice the highest milling out turn(73%) were found in BRRI dhan28 and IR68877H . All tested hybrid rice were medium bold, whereas BRRI dhan29 and BRRI dhan28 were medium slender and long slender, respectively in both parboiled and unparboiled condition. Among the varieties, amylose content (%) was higher in BRRI dhan29 and protein content (%) was higher in IR68877H for both under parboiled and unparboiled condition.

Rahman *et al*. (2002) carried out an experiment with 4 varieties of transplant *Aman* rice *viz.*, BR1l, BR22, BR23 and Tuishimala and 6 structural arrangement of rows viz., 25 cm + 25 cm, 30 cm + 20 cm, 35 cm + 1 5 cm, 40 cm + 10 cm) 45 cm + 05 cm and haphazard planting at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh. Thousand grains weight and grain yield were highest in BR23 and these were lowest in Tulshirnaia.

Obulamma *et al*. (2002) performed an experiment with hybrid rice DRRHI and APHR-2 at Andhra Pradesh, India. The treatments were 4 spacing (15x10, 2U x10, 15x15 and 20cm x15 cm) and 3 seedling densities (1, 2 and 3 seedlings hill^{-1}). APHR-2 was found to produce higher yield than DRRH-l. The clonal tillers produced higher yields than the nursery seedlings, and transplanting 2 clonal tillers hill^{-1} resulted in almost the same yield as 3 clonal tillers and 4 clonal tillers hill^{-1}.A single clonal tiller had the capacity to produce 4.5 t ha^{-1} grain yields. Yield components of clonal tillers, i. e. panicle number and grain weight, had no influence due to variations of N and light intensity of the mother crop, but higher densities of clonal tillers transplanted per hill gave lower panicle number and grain weight.

Xu and Wang (2001) evaluated ten restorer and ten maintainer lines. They observed that the restorer lines showed more spikelet fertility than maintainer lines. They studied growth duration, number of effective tillers, number of spikelet‟s panicle^{-1} and adaptability.

Dwarfness may be one of the most important agronomic characters, because it is often accompanied by lodging resistance and thereby adapts well to heavy fertilizer application (Futsuhara and Kikuchi, 1984).

Prasad *et al*. (2001) observed that days to flowering are negatively correlated with plant height. Grain yield is negatively correlated with plant height.

Patnaik *et al*. (1990) found that hybrids with intermediate to tall plant height having non-lodging habit could be developed gave more than 20% grain yield than the standard checks.

Bhowmick and Nayak (2000) conducted an experiment with two hybrids (CNHR2 and CNHR3) and two high yielding varieties (IR36 and IR64) of rice and five levels of nitrogenous fertilizers. They observed that CNHR2 produced more number of productive tillers (413.4 m^{-2}) and filled grains panicle^{-1} (111.0) than other varieties, whereas IR36 gave the highest 1000-grain weight (21.07 g) and number of panicles m^{-2} than other tested varieties. In a trial, varietal differences in harvest index and yield examined using 60 Japanese varieties and 20 high yielding varieties bred in Asian countries. It was reported that harvest index varied from 36.8 to 53.4%. Mean values of harvest index were 43.5% in the Japanese group and 48.8% in high yielding group. Yield ranged from 22.6g $plant^{-1}$ to 40.0g $plant^{-1}$.

2.3 Influence of SRI on the growth and yield of rice

2.3.1 Plant height

A field experiment was carried out by Tohiduzzaman (2011) 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 (V1), BR14 (V2) BR16 (V3), BRRI dhan28 (V4), BRRI dhan29 (V5), BRRI dhan36 (V6), BRRI dhan45 (V7), BRRI dhan50 (V8), Binadhan-6 (V9), Bina new line (V10), BRRI hybrid dhan1 (V11), BRRI hybrid dhan2 (V12), BRRI hybrid dhan3 (V13), Chamak (V14), Hira1 (V15) and Bhajan (V16). Experimental results showed that the sixteen varieties cultivated in *Boro* season had significant difference among them in all agronomic parameters including plant height in SRI system.

Nissanka and Bandara (2004) evaluated the productivity of System of Rice Intensification (SRI) method with 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.

Sarkar *et al*. (2003) reported that compared with transplanting, the crops from anaerobic direct sowing had greater plant height. Sarker *et al*. (2002) investigated the effect of row arrangement, time of tiller separation on growth of transplant *Aman* rice (cv. BR23). The experiment comprised of three row arrangement *viz*., single, double and triple row; two times of tiller separation *viz.*, 25 days after transplanting (DAT) and 35 DAT; and three levels of number of tillers kept hill^{-1} viz., 2,4 and intact hills. The tallest plant was recorded in single row, intact hills and when row and intact hills.

Goel and Verma (2000) investigated 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.

Reddy *et al*. (1987) conducted an experiment in India in which rice cv. Tellahamsa seedling were transplanted in lines or at random. They found that plant height (78.1-78.01 cm) did not differ significantly for the planting methods.

2.3.2 Tillers hill^{-1}

A field experiment was carried out by Tohiduzzaman (2011) 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.

Krishna *et al*. (2008) conducted an investigation 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. SRI method of cultivation, application of FYM and RDF significantly increased the number of tillers. The treatment combinations with SRI method showed more number of productive tillers. Chakrabarty *et al.* (1993) reported that chemical fertilizer performed the highest number of total tillers hill^{-1} with organic manure.

Akbar (2004) reported that hybrid variety Sonarbangla-1 ranked first in respect of total tillers hill^{-1} among the varieties studied. Sarker *et al*. (2002) investigated the effect of row arrangement, time of tiller separation on growth of transplant *Aman* rice (cv. BR23). Experimental result showed that in single row tillers could be separated at 25 DAT without hampering tiller reduction hill^{-1}.

Nissanka and Bandara (2004) evaluated the productivity of System of Rice Intensification (SRI) method with conventional rice farming systems in Sri Lanka. Dry weight 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.

Saina (2001) reported that fifty tillers per plant in SRI practice 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.

2.3.3 Leaf area index

Thakur *et al*. (2011) conducted a field experiment in Bhu-baneswar, Orissa, India, during the dry season (January– May) in 2008 and 2009 to investigate whether practices of the System of Rice Intensification (SRI), including alternate wetting and drying (AWD) during the vegetative stage of plant growth, could improve rice plants' morphology compared with currently recommended scientific management practices (SMP), including continuous flooding (CF) of paddies. Significant improvements were observed in SRI over SMP in case of leaf number (55.39%), leaf size (26.22% increase in leaf length and 26.37% increase in leaf width) and leaf area index (34.18%).Dobermann and Fairhurst (2000)reported that application of chemical fertilizer with cow dung produced higher LAI.

Sarker *et al*. (2002) investigated the effect of row arrangement, time of tiller separation on growth of transplant *Aman* rice (cv. BR23). Growing of transplant *Aman* rice in triple rows with intact hills appears as the promising practice in respect of highest leaf area index.

Hoon and Kim (1997) compared the physiological and ecological characteristics of rice cv. Whasungbyeo in direct sown and transplanted crops in Japan. The specific leaf area was higher in mechanically transplanted crop (MTC) than in direct sown crop (DSC) from the tillering stage to 15 days before heading, and was lower in MTC from the heading stage to 15 days after heading.

2.3.4 Dry matter production

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.

Nissanka and Bandara (2004) evaluated 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, during the growing period were significantly higher in SRI compared to other treatments.

Paul *et al*. (2003) investigated leaf production, leaf and culm dry matter yield of transplant *Aman* rice as affected by row arrangement and tiller separation in this study. The maximum culm dry matter yield was recorded in triple row (4.14 t ha^{-1}, 85 DAT). But the lowest dry matter of culm was recorded in single row (0.42 t ha^{-1} 25 DAT). Closer row spacing significantly reduced the leaf production ability $hill^{-1}$ but increase leaf and culm production per unit area and hence, dry matter yield increased. To enhance leaf production $hill^{-1}$, transplant *Aman* rice cv. BR 23 (Dishari) could be grown in single row but to increase dry matter yield it could be grown in triple or double row arrangement.

Sarkar *et al*. (2003) conducted an experiment at Cuttack, Orissa, India where seeds of 6 rice cultivars (Tulasi, FR 13A, T 1471, Sabita, Kolasali and CH 19) were sown in moistened soil and maintained after 5 days under 5 cm of water were compared with 30-day-old seedlings transplanted in the normal way. Compared with transplanting, the crops from anaerobic direct sowing had greater above-ground dry matter.

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 large individual plants, and dry matter 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.

Sarker *et al*. (2002) investigated the effect of row arrangement, time of tiller separation on growth of transplant *Aman* rice (*cv.* BR23). Growing of transplant *Aman* rice in triple rows with intact hills appears as the promising practice in respect of highest total dry matter production.

2.3.5 Days to flowering and maturity

Ali *et al*. (2006) mentioned that shortage of labor and water are forcing farmers to explore the alternatives of transplanting. They further concluded that direct-seeded rice had shorter crop duration. Anon. (2004) reported that the cultivation of *Boro* rice by direct seeding using the drum seeder had created a sensation among farmers wherever it was tested. Earlier harvest could result in another crop being accommodated. The choice of appropriate variety and cropping system would be important.

Karmakar *et al*. (2004) conducted two experiments in *Boro* 2002 and 2003 at the Bangladesh Rice Research Station, Rajshahi, Bangladesh to validate the SRI practice through spacing, seedling age and water movement comparing with conventional practice and bed planting on BRRI dhan29. In general, growth duration increased by 7-10 days in the treatments where wider spacing and younger seedlings were used.

Valarmathi and Leenakumary (1998) carried out a field experiment in Kerala, India to evaluate the suitability of *Aman* rice cultivars under direct sown conditions because of scarcity of labor for transplanting. Shorter duration in time to maturity was observed in all the cultivars under direct sowing, upland situation than under lowland transplanted conditions.

2.3.6 Effective tillers m^{-2}

A field experiment was carried out by Tohiduzzaman (2011) 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).

Akbar (2004) reported that inbred variety BRRI dhan 41 performed the best in respect of number of bearing tillers $hill^{-1}$ in comparison with hybrid variety Sonarbangla-1.

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.

Maqsood *et al*. (1997) grown rice cv. Basmati-385 grown at Faisalabad during 1994 and 1995 established by transplanting or direct sowing and reported that number of productive tillers $hill^{-1}$ was significantly higher from transplanting than direct sowing for both the years.

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

Tohiduzzaman (2011) found from an experiment conducted at Agronomy research field, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh, for the screening of rice varieties responsive to SRI in *Boro* season and reported that Binadhan-6 had the highest number of total grains $panicle^{-1}$ (222.70) in SRI system.

Akbar (2004) reported that inbred variety BRRI dhan 41 produced the highest number of grains $panicle^{-1}$ than the hybrid variety $Sonarbangla^{-1}$. Biswas and Salokhe (2001) observed that grains $panicle^{-1}$ showed better responses with early transplanting of the photo periodically sensitive KDML 105 in the mother crop and vegetative tillers. Rahman (2001) observed that the maximum number of grains $panicle^{-1}$ was found in the intact crop.

2.3.8 Filled grains panicle^{-1}

Tohiduzzaman (2011) observed for the screening of rice varieties responsive to SRI in *Boro* season and reported that BR16 had the highest number of filled grains panicle^{-1} (191.00) in SRI system.

Biswas and Salokhe (2001) observed that percent filled grains showed better responses with early transplanting of the photo periodically sensitive KDML 105 in the mother crop and vegetative tillers. Rahman (2001) observed that the maximum number of filled grains panicle^{-1} was found in the intact crop.

Aziz and Hasan (2000) reported that in SRI practice, at Kishoregonj the average number of filled grains panicle^{-1} with 35 cm × 35 cm spacing was found more promising, which was 173 panicle^{-1} and unfilled grains was 42 panicle^{-1}. At Rajshahi the average number of filled grains panicle^{-1} was 106 in case of SRI practice and 70 in case of farmers practice.

2.3.9 Weight of 1000-grains

A field experiment was carried out by Tohiduzzaman (2011) 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 BR3 and BR14 both had the highest 1000-grain weight (30.63 g) in SRI system.

Biswas and Salokhe (2001) observed that weight of 1000-grains showed better responses with early transplanting of the photo periodically sensitive KDML 105 in the mother crop and vegetative tillers.

Aziz and Hasan (2000) reported that in SRI practice, the grain weight was found 12% higher with SRI practice over farmers practice. The weight of 1000-grains was the lowest (18.75 g) with 20 cm × 15 cm spacing in case of farmers practice and the highest (28 g) with 40 cm × 40 cm spacing in case of SRI.

Goel and Verma (2000) investigated the effects of 2 sowing methods, direct sowing and transplanting, on the yield and yield components of 2 rice cultivars, and observed weight of 1000-grains (25.0 g) was higher in direct sowing.

2.3.10 Grain yield

A field study was conducted by Hameed *et al*. (2011) at Al-Mishkhab Rice Research Station (MRRS) during the summer season 2009 to evaluate irrigation water use efficiency (IWUE) using Anbar 33 variety with the System of Rice Intensification compared to traditional methods. During the growth phase, the number of leaves, stems, and roots, and the average plant height were measured every 15 days for the two sets of methods. At maturity, the depth and length of plant roots was assessed, along with leaf area index (LAI) of the flag leaf and plant height. The amount of irrigation water applied was measured by water meter for both methods. SRI principles for plant age, spacing, etc., were implemented in the SRI plots. The results indicated more vigorous growth of roots under SRI methods, reaching 13,004 cm plant^{-1} compared with non-SRI results of 4,722 cm plant^{-1}. There was 42% increase in grain yield when SRI methods were used.

A field experiment was carried out by Tohiduzzaman (2011) 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 grain yield (6.86 t ha^{-1}) in SRI system.

The work was developed at Los Palacios Rice Research Station by Martin *et al*. (2010) for three years and later at small-scale producers' areas belonging to a non-specialized system (popular rice) as an agricultural extension. The study consisted of determining the effect of seedling age, plant spacing and seedling number per site on agricultural yield. Results showed a seed amount reduction in the nursery, to the value of 5 kg ha^{-1} year^{-1}, which represent between 35 and 40% of that used in the traditional transplanting system. In addition, agricultural yields increased up to 2.0 t ha^{-1}; there was a greater tillering and root system development per plant compared to the check control. On the other hand, when crop irrigation was discontinued for 21 days, 3 300 m3 ha^{-1} $year^{-1}$ of water were saved.

Ali *et al*. (2006) mentioned that crop-establishment method did not influence grain yield during the wet or dry seasons, indicating the potential of the three variants of direct seeding as alternative methods of establishing lowland rice. Satu (2006) reported that comparison trials had an average SRI yield is 7.23 t ha^{-1} compared to 3.92 t ha^{-1} with conventional methods, an 84% increase.

Devarajan (2005) reported that SRI (System of Rice Intensification) method produced rice yields of 7 to 8 t ha^{-1} against the normal 3 to 4 tons. Reddy (2005) conducted a field experiment where SRI was compared with existing traditional cultivation methodology. In both systems (traditional and SRI), it was found that SRI could produce similar yield with less inputs.

Anonymous (2005) summarized the speech of a workshop on drum seeding held at Bangladesh Rice Research Institute (BRRI) in Gazipur on June 20, that it was possible to produce 10-20 percent higher yield than the traditional transplanting method. Latif *et al*. (2005) reported that in comparison of short- and long-duration varieties, the long-duration variety BRRI dhan29 yielded highest with SRI practices.

McDonald *et al*. (2005) assembled 40 site-years of 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-years demonstrating inferior yields to best management and a mean performance of -11%.

Paris and Chi (2005) reported that the promotion of plastic row/drum seeder technology was on the yield increase in Vietnam, particularly in the southern part of the country, and in other Southeast Asian countries due to its advantages over the traditional transplanting or broadcast method of rice production. Uphoff (2005) reported that System of Rice Intensification (SRI) had 1.6-2.5 t ha^{-1} yield advantage over more input-intensive rice-growing practices.

Anonymous (2004) 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.

Bari (2004) reported the grain yield from direct wet seeded line sowing method was significantly higher than those from transplanted method. In *Boro* season with the planting methods of transplanting, seedling throwing/broadcasting with normal seedlings, direct seeding and seedling throwing with young seedling, the highest grain yield (5.4 t ha^{-1}) of BRRI dhan29 was obtained from transplanting method and direct seeding method gave the lowest grain yield (4.73 t ha^{-1}). Seedling throwing method gave little bit lower yield than transplanting method but higher than direct seeding method.

Horie (2004) reported some of the ways to increase yields might include components of the system of rice intensification (SRI). The extremely high yields in SRI were incredible but its elements, which had been studied and practiced in Japan for the past 50 years, might lead to yield increases. The practice of transplanting one or two young seedlings hill^{-1} had advantages in reducing transplanting injury and increasing tiller and root numbers on lower nodes. Such advantages could be realized under direct-seeding systems, where they were applicable.

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 spacings. Number of tillers and panicle per unit area were higher in closer spacing that contributed to obtain higher yield.

Nissanka and Bandara (2004) evaluated the productivity of System of Rice Intensification (SRI) method with conventional rice farming systems in Sri Lanka. 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.

Rajkhowa and Gogoi (2004) conducted a field experiment at Jorhat, Assam, India, during the 1999 and 2000 in summer seasons to determine the effect of planting methods on transplanted summer rice cv. Luit. The treatments comprised 3 planting methods, namely closer (10 □10 cm), normal (15 □ 15 cm) and farmers' practice (haphazard planting). Normal planting showed significantly higher yield than the other planting methods in 1999, while closer planting recorded the highest grain yield in 2000.

Sheehy *et al*. (2004) reported that the combination of natural resources, genes, weather and management systems largely determines maximum crop yields. Recently, one of those elements was portrayed as the key to releasing hitherto unrecognized, but significant, untapped growth potential in rice. That element, the system of rice intensification (SRI), was an unconventional management system developed in Madagascar, where it was reported to increase rice yields to 'fantastic' levels. They further reported that the SRI had no inherent advantage over the conventional system and that the original reports of extraordinary high yields were likely to be the consequence of error.

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.

Akanda (2003) presented results of 232 SRI demonstration plots from *Aman* 2003 season, conducted in 15 districts under DAE, and the results of 386 demonstration plots of boro 2002-2003 season conducted in 8 districts. In most of the cases, the result showed a significant yield increase in SRI practice.

Chowhan (2003) reported that farmers were able to achieve on average, 30% higher production from SRI practice than traditional practice (SRI = 75.75 Mds $acre^{-1}$, traditional practice = 58.04 Mds $acre^{-1}$).

Das (2003) reported that the System of Rice Intensification (SRI) gave more rice yield compared to the farmers‟ practice (FP). The farmers from their SRI plots received 19% higher yield compared to their FP plot during the *Boro* season in 2003.

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. The highest grain yield of SRI planting method 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*. (2003) 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. 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.

Mazid *et al*. (2003) found that conventional practice of rice cultivation gave significantly higher grain yield compared to the SRI method of crop establishment. SRI method with 30×30 cm and 40×40 cm spacing and younger seedlings increased number of panicles hill^{-1} but total number of panicles per unit area was found to be low. They further 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 rice cultivation.

Deichert and Yang (2002) discussed the experiences of 400 Cambodian farmers in adapting on how many elements of SRI were applied. The majority of 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. So far these achievements result mainly from small plot sizes, but importantly also with traditional crop varieties and without chemical fertilizers.

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 spacing respectively.

Hirsch (2000) reported that on the rice sector in Madagascar SRI yields in the Antsirable and Amhositra areas ranged between 6.7 and 10.2 t ha^{-1} and 7.7 and 11.2 t ha^{-1}, 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}.

2.3.11 Straw yield

A field experiment was carried out by Tohiduzzaman (2011) 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 BRRI hybrid dhan2 had the highest straw yield (7.70 t ha^{-1}) in SRI system.

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

Hossain *et al*. (2003) conducted an experiment to study the performance of BRRI dhan 32 in SRI and conventional methods and their technology mixes and reported that conventional planting method produced the lowest straw yield (4.29 t ha^{-1}).

Budhar and Tamilselvan (2001) conducted an experiment to evaluate the feasibility of different stand establishment techniques such as transplanting, seedling throwing, direct sowing by manual broadcasting and wet sowing by a drum seeder. The various stand establishment techniques showed no significant difference in straw yield in both seasons.

Ganajaxi and Rajkumara (2000) studied the performance of various methods of sowing with different agronomic practices for growing direct seeded rice an experiment conducted in Karnataka, India during wet season of 1999. They reported that fodder yield was highest in transplanting (farmer.s practice; 5483 kg ha^{-1}).

Roknuzzaman (1997) conducted an experiment with rice cultivar BR11 where seedlings transplanted in haphazard and row arrangements and observed that straw yield was highest in row planting.

2.3.12 Biological yield

Tohiduzzaman (2011) carried out an experiment and observed that rice varieties were responsive to SRI in *Boro* season and reported that BRRI hybrid dhan2 had the highest biological yield (13.24 t ha^{-1}) in SRI system.

Bari (2004) reported that all the yield contributing characters studied were significantly affected by method of planting except panicle length, 1000-grains weight and straw yield. The biological yield from direct wet seeded line sowing method was significantly higher than those from transplanted method.

Rahman (2001) observed that the highest biological yield was found in the intact crop. Garcia *et al*. (1995) found that uninhibited growth of direct seeded rice during the vegetative stage led to superior biological yield than that of transplanted rice.

2.3.13 Harvest index

Tohiduzzaman (2011) conducted a research at Sher-e-Bangla Agricultural University, Dhaka, Bangladesh, and reported that BRRI dhan50 had the highest harvest index (49.30) in SRI system.

Hoon and Kim (1997) compared the physiological and ecological characteristics of rice cv. Whasungbyeo in direct sown and transplanted crops in Japan. The harvest index was higher in direct sown crop (DSC) than in mechanically transplanted crop (MTC).

Roknuzzaman (1997) conducted an experiment with rice cultivar BR11, where seedlings transplanted in haphazard and row arrangements and observed that the harvest index was highest in haphazard planting.

Rao (1990) conducted an experiment with plant derived from primary, secondary and tertiary tillers and transplanted at 20 ×10 cm spacing produced harvest index which were 45.3, 45.3, 9.1 and 45.1% for plants derived from primary, secondary and tertiary tillers and control plants respectively.

Chapter 3

Materials and Methods

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted at the Sher-e-Bangla Agricultural University Farm, Dhaka, Bangladesh during the period from December 2015 to May 2016 to study the impact of the system of rice intensification (SRI) on morpho-physiological characteristics and productivity of hybrid rice varieties. The details of the materials and methods have been presented below:

3.1 Description of the experimental site

3.1.1 Location

The present piece of research work was conducted in the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka. The location of the site was 23°07′04″N latitude and 90°03′05″E longitude with an elevation of 8.2 meter from sea level.

3.1.2 Soil

The soil of the experimental area that used in the plot for rice cultivation belongs to “The Modhupur Tract”, AEZ – 28 (FAO, 1988). Top soil was silty clay in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. Soil pH was 5.6 and has organic carbon 0.45%. The experimental area was flat having available irrigation and drainage system. The details of the plot soil have been presented in Appendix I.

3.1.3 Climate

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

3.2 Experimental details

3.2.1 Treatments

The experiment comprised of two factors.

Factor A: Cultivation methods

i) T_1 = Traditional method; Plant spacing, S_1 (15 cm × 25 cm) + Regular irrigation, I_1

ii) T_2 = SRI method; Plant spacing, S_2 (20 cm × 20 cm) + Controlled irrigation, I_2

Factor B: Variety – 8 varieties

i) V_1 = BRRI hybrid dhan2

ii) V_2 = BRRI hybrid dhan3

iii) V_3 = Heera1

iv) V_4 = Bolaka

v) V_5 = Tia

vi) V_6 = ACI Sampod

vii) V_7 = Moyna

viii) V_8 = BRRI dhan45

Combine effect of Plant spacing with irrigation × Variety

i) T_1V_1 = Traditional method × V_1 (BRRI hybrid 2)

ii) T_1V_2 = Traditional method ×V_2 (BRRI hybrid 3)

iii) T_1V_3 = Traditional method ×V_3 (Heera1)

iv) T_1V_4 = Traditional method ×V_4 (Bolaka)

v) T_1V_5 = Traditional method ×V_5 (Tia)

vi) T_1V_6 = Traditional method ×V_6 (ACI Sampod)

vii) T_1V_7 = Traditional method ×V_7 (Moyna)

viii) T_1V_8 = Traditional method $_1$ ×V_8 (BRRI dhan45)

ix) T_2V_1 = SRI method ×V_1 (BRRI hybrid 2)

x) T_2V_2 = SRI method ×V_2 (BRRI hybrid 3)

xi) T_2V_3 = SRI method ×V_3 (Heera1)

xii) T_2V_4 = SRI method ×V_4 (Bolaka)

xiii) T_2V_5 = SRI method ×V_5 (Tia)

xiv) T_2V_6 = SRI method ×V_6 (ACI Sampod)

xv) T_2V_7 = SRI method ×V_7 (Moyna)

xvi) T_2V_8 = SRI method ×V_8 (BRRI dhan45)

3.2.2 Experimental design

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. There were 16 treatment combinations. The total numbers of unit plots were 48. The size of unit plot was 3 m × 1.5 m. The distances between each plots and replications were 1 m. The layout of the experiment has been shown in Appendix II.

3.3 Growing of crops

3.3.1 Raising seedlings

3.3.1.1 Seed collection

The seeds of the test crop *i.e* BRRI hybrid 2, BRRI hybrid 3 were collected from Bangladesh Rice Research Institute (BRRI), Joydebpur, Gazipur and the other seeds were collected from local market.

3.3.1.2 Seed sprouting

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

3.4.1.3 Preparation of seedling nursery

As per BRRI recommendation seedbed was prepared with 1 m wide adding nutrients as per the requirements of soil. Seed were sown in the seed bed @ 70 g m^{-2} on 5 December, 2015.

3.4.1.4 Seed Sowing

Seeds were sown in the seed bed on December 28, 2015. Sprouted seeds were sown uniformly as possible.

3.6.2 Preparation of the main field

The plot selected for the experiment was opened in 20 December 2015 with a power tiller, and was exposed to the sun for a week, after which the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain a good tilth. Weeds and stubble were removed, and finally obtained a desirable tilth of soil for transplanting of seedlings.

3.3.3 Fertilizers and manure application

The fertilizers N, P, K, S, Zn and B in the form of urea, TSP, MP, gypsum, zinc sulphate and borax, respectively were applied. The entire amount of TSP, MP, gypsum, zinc sulphate and borax were applied during the final preparation of plot land. Mixture of cowdung and compost was applied @ 10 t/ha during 15 days before transplantation. Urea was applied in three equal installments at after recovery, tillering and before panicle initiation. The dose and method of application of fertilizers are shown in Table 1.

Table 1. Dose and method of fertilizers application

Fertilizers	Dose (kg ha^{-1})	Application (%)			
		Basal	1st installment	2nd installment	3rd installment
Urea	150	--	33.33	33.33	33.33
TSP	100	100	--	--	--
MP	100	100	--	--	--
Zinc sulphate	10	100	--	--	--
Gypsum	60	100	--	--	--
Borax	10	100	--	--	--

3.6.4 Uprooting seedlings

The nursery bed was made wet by application of water one day before uprooting the seedlings. The seedlings were uprooted on January 13, 2016 without causing much mechanical injury to the roots.

3.6.5 Transplanting of seedlings in the field

The seedlings were transplanted in the main field on January 14, 2016 and the rice seedlings were transplanted in lines. Spacing of plantation was maintained as per treatment. Two types of spacing were used as 15 cm × 25 cm and 20 cm × 20 cm.

3.3.6 After care

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

3.4.6.3 Application of irrigation water and drainage

Level of irrigation was done as per treatment. Two water regimes namely, controlled irrigation and regular irrigation were used for the experiment.

Controlled irrigation: Water was applied just to saturate the soil (no flood) throughout the growing period of the crop. Irrigation was done when it is needed.

Regular irrigation: Flood irrigation was done. Irrigation was provided to maintain a constant level of standing water upto 6 cm. Plots were equipped with drainage irrigation system for continuous flood irrigation (up to 5-6 cm depth) throughout the rice-growing season.

3.3.6.2 Gap filling

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

3.3.6.3 Weeding

Weeding was done to keep the plots free from weeds, which ultimately ensured better growth and development. The newly emerged weeds were uprooted carefully at 30 DAT and 60 DAT by mechanical means.

3.3.6.4 Top dressing

First dose after recovery, the remaining doses of urea were top-dressed in 2 equal installments at tillering and before panicle initiation.

3.3.6.5 Plant protection

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

3.4 Harvesting, threshing and cleaning

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

3.5 Data recording

3.5.1 Plant height

The height of plant was recorded in centimeter (cm) at the time of 30, 60, 90 and 110 DAT (Days after transplanting). The height was measured from the ground level to the tip of the plant of five hills and finally averaged.

3.10.2.3 Leaves hill^{-1}

Leaves hill^{-1} in each plot was counted at the time of 50 (vegetative stage), 70 and 90 DAT (reproductive stage) and at harvesting.

3.5.2 Tillers hill^{-1}

The number of tillers hill^{-1} was recorded at the time of 30, 60, 90 and 110 DAT by counting total tillers of five respective hills and finally averaged to hill^{-1} basis.

3.5.3 Leaf area index

Leaf area index measured manually at the time of 30, 60, 90 and 110 DAT. Data were recorded as the average of 05 plants selected at random the inner rows of each plots. The final data calculated multiplying by a correction factor 0.75 as per Yoshida (1981).

3.5.4 Dry matter hill^{-1}

Dry matter was recorded at 40, 70 and 100 DAT from 2 randomly collected hills of each plot from inner rows leaving the boarder row. Collected plants including roots, leaves, grain and straw were oven dried at 70°C for 72 hours then transferred into desiccator and allowed to cool down at room temperature, final weight was taken and converted into dry matter content hill^{-1}.

3.5.5 Effective tillers hill^{-1}

The total number of effective tillers hill^{-1} was counted as the number of panicle bearing tillers hill^{-1}. Data on effective tiller hill^{-1} from five hills were counted and value was recorded and averaged to hill^{-1} basis.

3.5.6 Ineffective tillers hill^{-1}

The total number of ineffective tillers hill^{-1} was counted as the number of no panicle bearing tillers hill^{-1}. Data on in effective tillers hill^{-1} were counted at harvest and value was recorded.

3.5.7 Panicle length

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

3.5.8 Filled grains panicle^{-1}

The total number of filled grains was counted randomly from selected 10 panicles of a plot on the basis of grain in the spikelet and then average number of filled grains panicle^{-1} was recorded.

3.5.8 Filled grains panicle^{-1}

The total number of filled grains was counted randomly from selected 10 panicles of a plot on the basis of grain in the spikelet and then average number of filled grains panicle^{-1} was recorded.

3.5.9 Unfilled grains panicle^{-1}

The total number of unfilled grains was counted randomly from the same 10 panicles where filled grains were counted of a plot on the basis of no grain in the spikelet and then average number of unfilled grains panicle^{-1} was recorded.

3.5.10 Weight of 1000 grains

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

3.5.11 Grain yield

Grains obtained from each unit plot were sun-dried and weighed carefully and finally adjusted to 14% moisture basis using a digital moisture meter. The dry weight of grains of each plot from harvested area was measured and converted to t ha^{-1}.

3.5.12 Straw yield

Straw obtained from each unit plot were sun-dried and weighed carefully. The sub-samples of the straw of each plot was oven dried and finally converted to t ha^{-1}.

3.5.13 Biological yield

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

Biological yield = Grain yield + Straw yield.

3.5.14 Harvest index

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

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

Where, HI = Harvest Index

Biological yield = Grain yield + Straw yield

3.6 Statistical Analysis

The data obtained for different parameters were statistically analyzed to obtain the level of significance using the computer MSTAT package program. The significance of the differences among the treatment means were estimated by the Duncan's Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

Chapter 4

Results and Discussion

CHAPTER IV

RESULTS AND DISCUSSION

Results obtained from the present study regarding the effects of cultivation methods under irrigation and plant spacing with varietal performance and their interactions on the yield and yield components of rice have been presented, discussed and compared in this chapter. The analytical results have been presented under the following headings:

4.1 Growth parameters

4.1.1 Plant height

Different cultivation methods affected the plant height of rice significantly at all crop duration (Fig. 1 and Appendix V). Results indicated that the tallest plant (18.93, 34.90, 47.16, 58.78, 72.62, 85.10, 100.68 and 101.75 cm at 20, 30, 40, 50, 60, 70, 80 DAT and at harvest, respectively) was recorded with traditional methods of cultivation. In contrast, the shortest plant (12.56, 26.94, 37.48, 47.26, 64.67, 78.09, 96.40 and 97.51 cm at 20, 30, 40, 50, 60, 70, 80 DAT and at harvest, respectively) was recorded from SRI cultivation system. The height of rice plant is directly related to the depth of water and generally increases with increasing water depth (Datta, 1981). Khaliq and Cheema, (2005) also observed tallest plant in the wager logged condition and shortest plant height in alternate wet and dry condition. With advancing plant age, water requirement increased and reducing water to field capacity condition significantly reduced plant height especially at maturity as well as tiller production during later growth stages. Beyrouty *et al*. (1994) also observed reduction in plant height but not tiller production when flood was delayed.

Plant height under the present study was significantly influenced by Varietal performance (Fig.2 and Appendix V). Results revealed that the highest plant height (17.00, 34.18, 48.07, 59.43, 74.82, 94.85, 103.0 and 104.1 cm at 20, 30, 40, 50, 60, 70, 80 DAT and at harvest, respectively) was found from hybrid variety Tia at all crop duration followed by hybrid variety Heera1 and BRRI hybrid 2 and also with check variety BRRI dhan45. Results also indicated that the shortest plant (14.97, 28.40, 36.62, 44.78, 60.32, 72.75, 95.50 and 96.62 cm at 20, 30, 40, 50, 60, 70, 80 DAT and at harvest, respectively) was found in ACI Sampod which was statistically identical with BRRI hybrid 3 at 80 DAT and at harvest. Wang, (2000) reported that plant height was 88-89 cm directly related to yields. The results corroborate with the findings of Islam *et al*. (2009), Bisne *et al*. (2006), Mishra and Pandey (1998), BINA (1993) and Hossain and Alam (1991) who observed various plant height due to different varieties.

The combined effect of cultivation methods and variety had significant effect on plant height at 20, 30, 40, 50, 60, 70, 80 DAT and at harvest (Table 1 and Appendix V). The tallest plant (21.53, 40.03, 55.97, 66.08, 77.20, 98.13, 106.0 and 107.5 cm at 20, 30, 40, 50, 60, 70, 80 DAT and at harvest) was obtained in Traditional × Tia treatment combination followed by Traditional × BRRI dhan45 and *SRI* × BRRI hybrid 2, whereas the shortest plant (13.93, 26.93, 34.13, 39.53, 55.17, 69.63, 92.33 and 93.37 cm at 20, 30, 40, 50, 60, 70, 80 DAT and at harvest) was observed in SRI × ACI Sampod treatment combination which was closely followed by SRI × BRRI hybrid 3 and SRI × Moyna treatment combination at harvest.

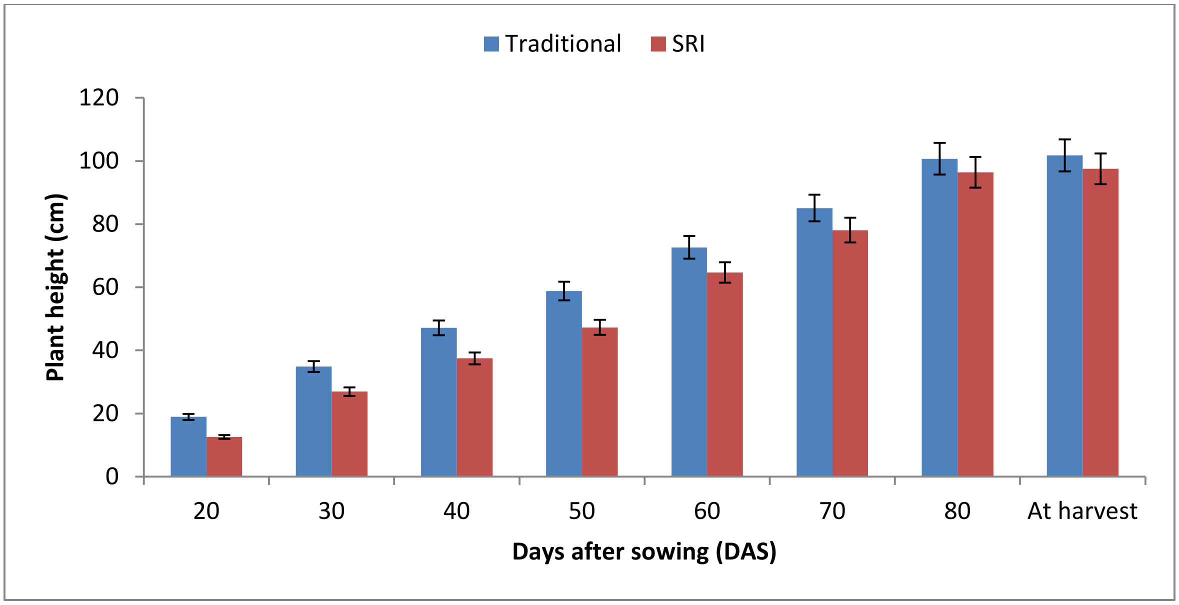

Fig. 1. Changes in cultivation method (the system of rice intensification; SRI and conventional method) on plant height

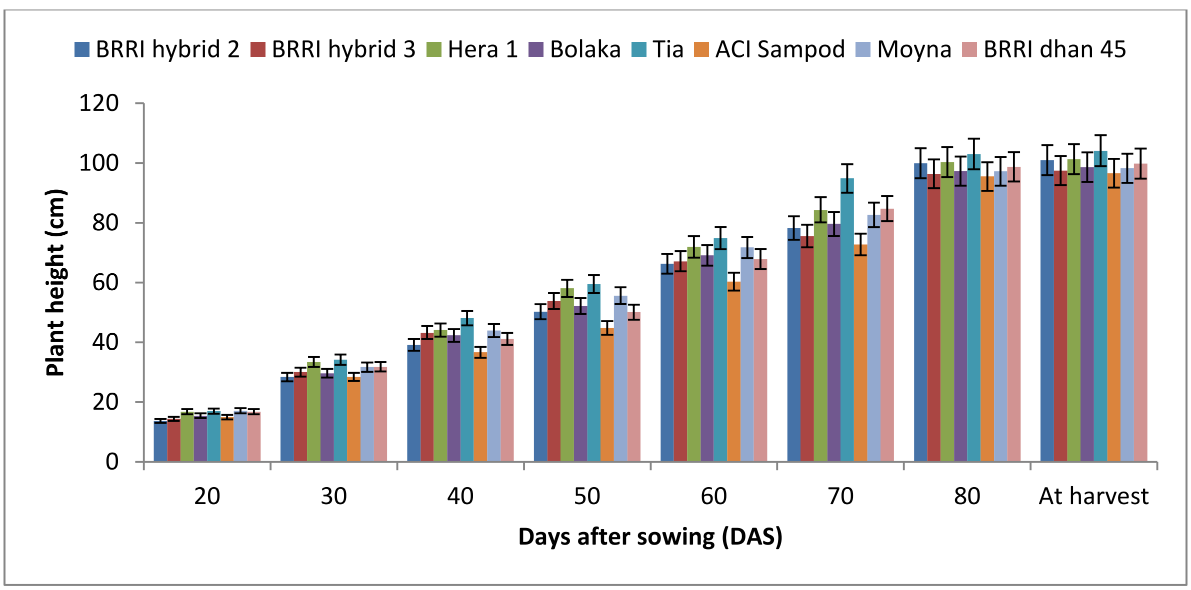

Fig. 2. Effect of variety under the system of rice intensification (SRI) and conventional method of cultivation on plant height

Table 1: Combined effect of the system of rice intensification (SRI) and traditional method on plant height of different rice varieties

Treatment	Plant height (cm)							
	20 DAS	30 DAS	40 DAS	50 DAS	60 DAS	70 DAS	80 DAS	At harvest
Traditional ×								
BRRI hybrid 2	15.90 c	30.30 e	39.77 de	51.37 cd	65.57 de	79.87 e	97.30 de	98.43 de
BRRI hybrid 3	16.50 c	32.87 d	46.90 c	59.04 b	70.43 c	78.57 efg	99.83 c	100.9 cd
Heera1	21.80 a	39.70 a	52.03 b	65.69 a	77.03 a	85.67 c	101.0 bc	102.0 bc
Bolaka	18.67 b	32.53 d	46.10 c	56.69 b	73.30 b	83.23 cd	99.33 cd	100.4 cd
Tia	21.53 a	40.03 a	55.97 a	66.08 a	77.20 a	98.13 a	106.0 a	107.5 a
ACI Sampod	16.00 c	29.87 e	39.10 de	50.02 cde	65.47 de	75.87 g	98.67 cd	99.87 cd
Moyna	22.23 a	38.50 b	51.47 b	63.63 a	78.43 a	89.00 b	100.7 bc	101.7 bc
BRRI dhan45	18.77 b	35.43 c	45.93 c	57.70 b	73.53 b	90.43 b	102.7 b	103.7 b
SRI ×								
BRRI hybrid 2	11.37 e	26.43 h	38.50 e	49.06 de	66.97 d	76.67 fg	102.5 b	103.5 b
BRRI hybrid 3	12.23 e	27.07 gh	39.53 de	48.57 de	63.77 ef	72.50 h	93.00 gh	94.03 gh
Heera1	11.70 e	27.00 gh	36.23 f	50.44 cde	66.87 d	82.97 d	99.50 cd	100.5 cd
Bolaka	12.13 e	26.73 h	38.50 e	47.59 e	64.90 de	76.03 g	95.33 ef	96.87 ef
Tia	12.47 e	28.33 f	40.17 d	52.77 c	72.43 bc	91.57 b	94.83 fg	95.87 fg
ACI Sampod	13.93 d	26.93 gh	34.13 g	39.53 g	55.17 g	69.63 i	92.33 h	93.37 h
Moyna	11.93 e	24.87 i	36.37 f	47.61 e	65.07 de	76.30 fg	93.77 fgh	94.80 fgh
BRRI dhan45	14.73 d	28.13 fg	36.38 f	42.54 f	62.17 f	79.03 ef	99.97 c	101.0 c
$LSD_{0.05}$	1.111	1.148	1.180	2.905	2.562	2.529	2.087	2.259
CV (%)	6.884	6.389	8.527	9.218	7.349	10.552	9.366	11.144

Values with common letter(s) within a column do not differ significantly at 5% level of probability analyzed by DMRT

4.1.2 Tillers plant^{-1}

Number of tillers plant^{-1} was significantly influenced by traditional cultivation method at different crop duration (Fig. 3 and Appendix VI). It was found that till 50 DAT, the highest number of tillers plant^{-1} was found in traditional cultivation methods but after 50 DAT to at harvest SRI method gave the highest number of tillers plant^{-1} (19.32, 16.09, 14.57 and 13.29 at 60, 70, 80 DAT and at harvest, respectively). The lowest number of tillers plant^{-1} was found by traditional cultivation methods at 60, 70, 80 DAT and at harvest. This finding is in agreement with Anwar and Begum (2004). Toung and Bouman (2001) also found the highest tillers hill-1 in the saturated condition.

The production of tillers plant^{-1} was significantly influenced by the tested different varieties (Fig.4 and Appendix VI). Rice variety of BRRI hybrid-3 showed the highest tillers plant^{-1} (11.09, 20.25, 15.75, 15.14 and 14.67 at 50, 60, 70, 80 DAT and at harvest, respectively), followed by hybrid variety Tia at harvest. The minimum tillers hill^{-1} found to be lowest at harvest (9.92) from BRRI dhan45 followed by BRRI hybrid 2 and Bolaka. Islam *et al*. (2009), Bisne *et al*. (2006), Chowdhury *et al*. (2005), Akbar (2004) and Bhowmick and Nayak (2000) reported similar trend of tillering habits with different varieties of rice.

The combined effect of cultivation methods and variety had significant effect on number of tillers plant^{-1} at 20, 30, 40, 50, 60, 70, 80 DAT and at harvest (Table 2 and Appendix VI). Results signified that *SRI* ×BRRI hybrid 3 treatment combination gave the highest number of tillers plant^{-1} (12.40, 23.60, 20.29, 20.27, 19.67 at 50, 60, 70, 80 DAT and at harvest, respectively) followed by *SRI* × Tia and *SRI* × BRRI dhan45 at harvest combinations. On the other hand, the lowest number of tillers plant^{-1} (8.43, 7.63 and 7.50 at 70, 80 DAT and at harvest, respectively) was found from *Traditional* × BRRI hybrid 3 treatment combination followed by *Traditional* × BRRI hybrid 2 and *Traditional* × Heera1 treatment combinations.

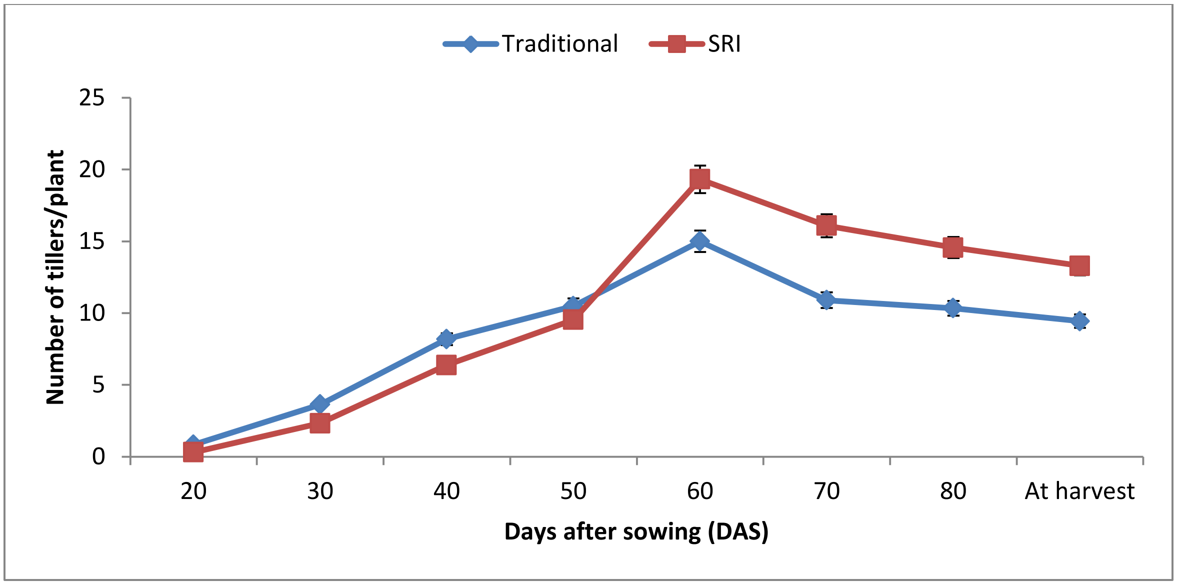

Fig. 3. Impact of system of rice intensification (SRI) and conventional cultivation method on number of tillers plant^{-1}

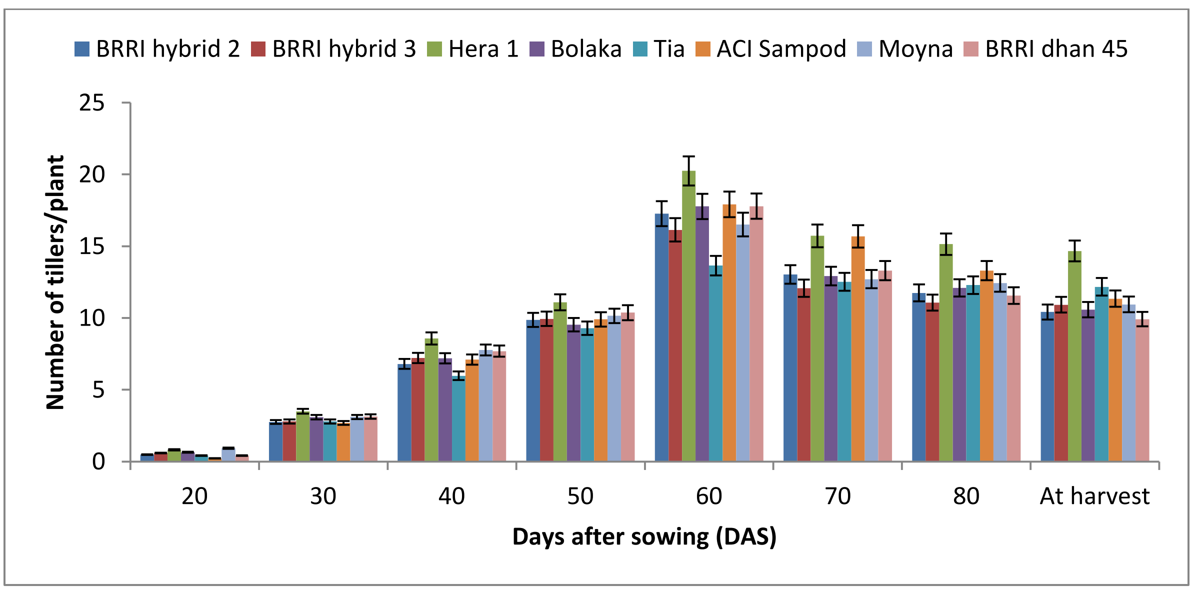

Fig. 4. Differences in tiller number per hill in rice varieties grown under the system of rice intensification (SRI) and conventional method of rice cultivation

Table 2: Influence of the system of rice intensification (SRI) and traditional method on number of tillers plant^{-1} of different rice varieties

Treatment	Number of tillers plant^{-1}							
	20 DAS	30 DAS	40 DAS	50 DAS	60 DAS	70 DAS	80 DAS	At harvest
Traditional ×								
BRRI hybrid 2	0.33 de	2.67 de	6.27 h	9.17 fg	13.43 h	9.630 i	9.43 g	8.67 h
BRRI hybrid 3	0.60 c	3.00 d	7.07 f	9.70 e	13.17 h	8.43 j	7.63 h	7.50 i
Heera1	1.37 a	4.43 ab	10.60 a	10.73 c	15.40 g	10.47 hi	9.97 fg	8.67 h
Bolaka	0.80 b	3.43 c	7.40 e	9.73 e	14.93 g	10.67 hi	10.63 f	9.83 g
Tia	0.83 b	4.20 b	7.73 d	9.83 de	11.83 i	11.00 h	10.90 ef	10.83 ef
ACI Sampod	0.33 de	3.33 c	8.27 c	11.67 b	17.33 e	13.57 e	12.00 de	10.17 fg
Moyna	1.50 a	4.57 a	9.77 b	11.43 b	17.00 ef	12.23 fg	11.87 e	10.20 fg
BRRI dhan45	0.87 b	3.37 c	8.47 c	10.00 de	16.90 ef	11.17 gh	20.00 a	9.67 g
SRI ×								
BRRI hybrid 2	0.63 c	2.83 de	7.33 e	10.57 c	21.10 b	16.43 c	14.07 bc	12.17 cd
BRRI hybrid 3	0.57 c	2.57 e	7.37 e	12.40 a	23.60 a	20.29 a	20.27 a	19.67 a
Heera1	0.27 e	2.57 e	6.57 g	9.77 e	20.17 bc	16.13 cd	13.17 c	11.17 e
Bolaka	0.47 cd	2.73 de	6.97 f	9.33 f	20.60 b	15.17 d	13.57 bc	11.33 de
Tia	0.00 f	1.37 g	4.20 j	8.73 h	15.47 g	14.03 e	13.67 bc	13.50 b
ACI Sampod	0.10 f	2.03 f	5.93 i	8.13 i	18.50 d	17.80 b	14.60 b	12.50 c
Moyna	0.33 de	1.63 g	5.77 i	8.87 gh	16.03 fg	13.17 ef	13.00 cd	11.67 cde
BRRI dhan45	0.10 f	2.90 de	6.90 f	10.17 d	19.10 cd	15.73 cd	14.50 b	14.33 b
$LSD_{0.05}$	0.1582	0.3029	0.2416	0.3653	1.088	1.111	1.073	0.9179
CV (%)	4.337	6.229	8.556	7.389	8.524	9.388	7.119	8.557

Values with common letter(s) within a column do not differ significantly at 5% level of probability analyzed by DMRT

4.2 Yield contributing parameters

4.2.1 Days to panicle initiation

Days to panicle initiation of different stages viz. first panicle initiation, 50% panicle initiation and 100% panicle initiation was greatly influenced by traditional cultivation methods (Fig. 5 and Appendix VII). Results denoted that the lowest days required for panicle initiation (71.71, 82.33 and 91.96 days for first panicle initiation, 50% panicle initiation and 100% panicle initiation, respectively) was done by traditional cultivation methods where the highest days required for panicle initiation (78.08, 88.83 and 98.33 days for first panicle initiation, 50% panicle initiation and 100% panicle initiation, respectively) was done by SRI methods.

Different rice variety had also significant influence on days to panicle initiation (Fig.6 and Appendix VII). It was found that the lowest days required for panicle initiation (65.67, 76.34 and 87.00 days for first panicle initiation, 50% panicle initiation and 100% panicle initiation, respectively) was by hybrid rice variety Tia where the highest days required for panicle initiation (83.33, 94.17 and 103.2 days for first panicle initiation, 50% panicle initiation and 100% panicle initiation, respectively) was by hybrid rice variety ACI Sampod.

In terms of combination with cultivation methods and variety, days to panicle initiation was found to be significant (Table 3 and Appendix VII). Results revealed that the lowest days required for panicle initiation (61.00, 73.00 and 85.00 days for first panicle initiation, 50% panicle initiation and 100% panicle initiation, respectively) was by *Traditional* × Tia followed by *Traditional* × Moyna, *Traditional* ×Heera1 and *SRI* × Tia where the highest days required for panicle initiation (86.33, 96.33 and 105.3 days for first panicle initiation, 50% panicle initiation and 100% panicle initiation, respectively) was by *SRI* × ACI Sampod followed by *Traditional* × ACI Sampod,

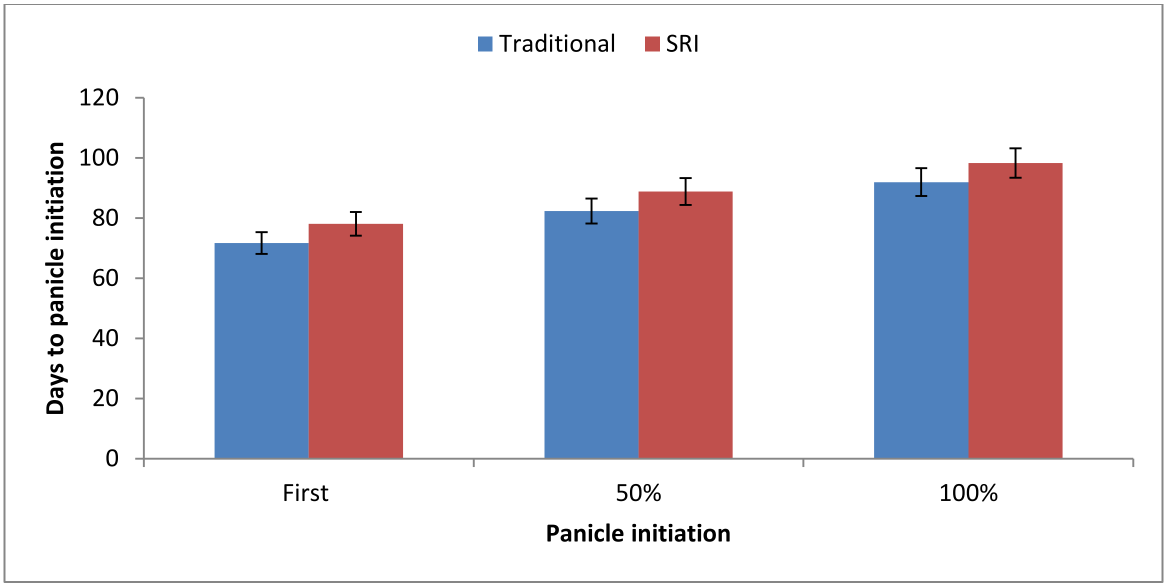

Fig. 5. Changes in cultivation method (the system of rice intensification; SRI and conventional method) on days to panicle initiation

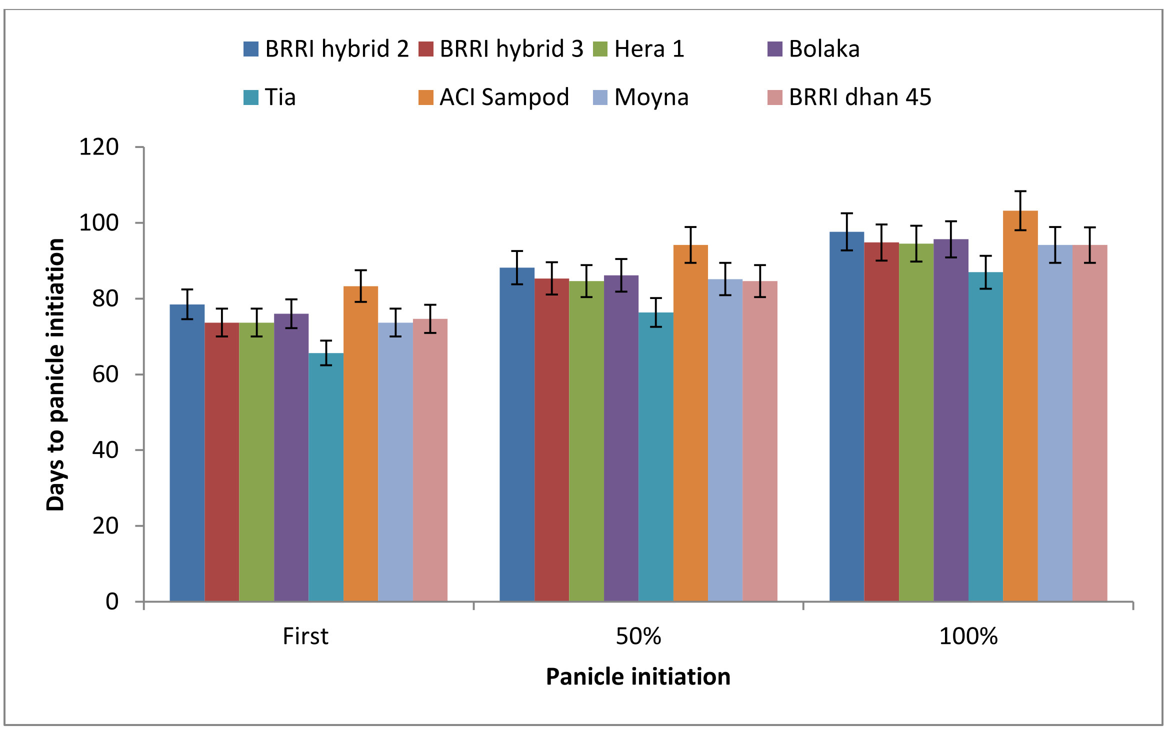

Fig. 6. Effect of variety under the system of rice intensification (SRI) and conventional method of cultivation on days to panicle initiation

Table 3: Influence of the system of rice intensification (SRI) and traditional method on days to panicle initiation of different rice varieties

Treatment	Days to panicle initiation		
	First panicle initiation	50% panicle initiation	100% panicle initiation
Traditional ×			
BRRI hybrid 2	76.00 e	85.33 e	95.00 d
BRRI hybrid 3	70.00 h	81.00 ghi	90.33 fg
Heera1	70.67 h	81.33 gh	90.67 efg
Bolaka	72.33 g	82.33 fg	92.00 ef
Tia	61.00 i	73.00 j	85.00 h
ACI Sampod	80.33 bc	92.00 b	101.0 b
Moyna	69.67 h	80.33 hi	89.33 g
BRRI dhan45	73.67 f	83.33 f	92.33 e
SRI ×			
BRRI hybrid 2	81.00 b	81.00 ghi	100.3 bc
BRRI hybrid 3	77.33 d	89.67 c	99.33 bc
Heera1	76.67 de	88.00 d	89.00 g
Bolaka	79.67 c	90.00 c	99.33 bc
Tia	70.33 h	79.67 i	89.00 g
ACI Sampod	86.33 a	96.33 a	105.3 a
Moyna	77.67 d	90.00 c	99.00 c
BRRI dhan45	75.67 e	86.00 e	96.00 d
$LSD_{0.05}$	1.107	1.327	1.611
CV (%)	7.544	9.389	10.712

Values with common letter(s) within a column do not differ significantly at 5% level of probability analyzed by DMRT

4.2.2 Tillers hill^{-1} at harvest

Significantly varied results were observed in case of effective tillers number hill^{-1} as influenced by cultivation method of Boro rice at harvest (Table 4 and Appendix VIII). Results showed that at harvest the highest number of effective tillers hill^{-1} (13.29) was recorded by SRI method where the lowest number of effective tillers hill^{-1} (9.44) was recorded by Traditional method. Similarly, Traditional cultivation method gave the lowest number of non-effective tiller hill^{-1} (5.56) where SRI method gave highest number of non-effective tiller hill^{-1} (5.78). Accordingly, in case of total tiller hill^{-1} SRI method gave highest result (19.32) where traditional cultivation method gave the lowest result (15.00). Rice growth low land transplant condition give higher tillers hill^{-1} than raised upland condition, comparable with raised transplant condition. This finding is in agreement with Anwar and Begum (2004). Toung and Bouman (2001) also found the highest tillers hill^{-1} in the saturated condition.

The production of effective tillers number hill^{-1} was significantly influenced by different rice varieties (Table 4 and Appendix VIII). Rice variety of BRRI hybrid-3 showed the highest number of effective tillers hill^{-1} (14.67), followed by hybrid rice variety Tia. The minimum effective tillers hill^{-1} (9.92) at harvest was found in hybrid rice variety Heera1 which was closely followed by BRRI hybrid2. Similarly, Rice variety of Tia showed the lowest number of non-effective tillers hill^{-1} (1.49) and rice variety Heera1 gave highest number of non-effective tillers hill^{-1} (7.87). In case of total tillers hill^{-1}, Rice variety of BRRI hybrid3 showed the highest total number of tillers hill^{-1} (20.25) and rice variety Tia gave lowest number of total tillers hill^{-1} (13.65). Islam *et al*. (2009), Bisne *et al*. (2006), Chowdhury *et al*. (2005), Akbar (2004) and Bhowmick and Nayak (2000) reported similar trend of tillering habits with different varieties of rice.

Interaction effect of cultivation system and variety significantly influenced the number of effective tillers hill^{-1} at harvest (Table 5 and Appendix VIII). Results indicated that the highest number of effective tillers hill^{-1} (19.67) was with *SRI* ×BRRI hybrid3 followed by *SRI* × BRRI dhan45. The results recorded from *Traditional* ×Heera1 showed the lowest number of effective tillers hill^{-1} (7.50) at harvest. In terms of number of non-effective tillers hill^{-1}, the highest was obtained from *SRI* × Bolaka (9.27) which was statistically identical with *SRI* ×Heera1 and *SRI* × BRRI hybrid2 where the lowest (1.00) was obtained from *Traditional* × Tia. Accordingly, the highest total number of tillers hill^{-1} (23.60) was obtained from *SRI* × BRRI hybrid3 where the lowest total number of tillers hill^{-1} (11.83) was obtained from *Traditional* ×Tia. The results obtained from all other treatments showed significantly different results compared to the highest and the lowest result on number of effective tillers hill^{-1}.

Table 4: Effect of the system of rice intensification (SRI) and traditional method on tiller number of different rice varieties

Treatment	Tillers hill^{-1}		
	Effective tillers hill^{-1}	Non-effective tillers hill^{-1}	Total tillers hill^{-1}
Cultivation methods			
Traditional	9.44 b	5.56	15.00 b
SRI	13.29 a	5.78	19.32 a
$LSD_{0.05}$	2.544	NS	2.599
CV (%)	5.389	5.076	7.338
Variety			
BRRI hybrid2	10.42 de	6.85 bc	17.27 b
BRRI hybrid3	14.67 a	5.59 d	20.25 a
Heera1	9.920 e	7.87 a	17.79 b
Bolaka	10.58 d	7.19 b	17.77 b
Tia	12.17 b	1.49 f	13.65 d
ACI Sampod	11.34 c	6.58 c	17.92 b
Moyna	10.94 cd	5.58 d	16.52 c
BRRI dhan45	10.92 cd	4.22 e	16.14 c
$LSD_{0.05}$	0.5596	0.3663	0.7327
CV (%)	5.389	5.076	7.338

Values with common letter(s) within a column do not differ significantly at 5% level of probability analyzed by DMRT

4.2.3 Grains panicle^{-1}

Cultivation system had significant effect on filled grains and un-filled grains panicle^{-1} (Table 6 and Appendix IX). Results showed that the highest filled grains panicle^{-1} was recorded by SRI system (160.67) while the lowest (144.90) was obtained from Traditional cultivation system. The highest un-filled grains panicle^{-1} was also recorded by SRI system (17.69) and the lowest (9.21) was obtained from raditional cultivation system. The result under the present study was similar with the findings of Bouman *et al*. (2005).

Table 5: Combined effect of the system of rice intensification (SRI) and traditional method on tiller number of different rice varieties

Treatment	Tillers hill^{-1}		
	Effective tillers hill^{-1}	Non-effective tillers hill^{-1}	Total tillers hill^{-1}
Traditional ×			
BRRI hybrid 2	8.67 h	4.76 de	13.43 h
BRRI hybrid3	8.67 h	6.73 b	15.40 fg
Heera1	7.50 i	5.67 c	13.17 h
Bolaka	9.83 g	5.10 d	14.93 g
Tia	10.83 ef	1.00 i	11.83 i
ACI Sampod	10.17 fg	7.16 b	17.33 e
Moyna	10.20 fg	6.80 b	17.00 e
BRRI dhan45	9.67 g	7.23 b	16.90 e
SRI ×			
BRRI hybrid 2	12.17 d	8.93 a	21.10 b
BRRI hybrid3	19.67 a	3.93 f	23.60 a
Heera1	11.17 e	9.00 a	20.17 c
Bolaka	11.33 e	9.27 a	20.60 bc
Tia	13.50 c	1.97 h	15.47 fg
ACI Sampod	12.50 d	6.00 c	18.50 d
Moyna	11.67 de	4.36 ef	16.03 f
BRRI dhan45	14.33 b	2.77 g	19.10 d
$LSD_{0.05}$	0.7962	0.5480	0.6328
CV (%)	5.389	5.076	7.338

Values with common letter(s) within a column do not differ significantly at 5% level of probability analyzed by DMRT

Performance of test varieties under the present study showed a significant difference in respect of grains panicle^{-1} (Table 6 and Appendix IX). The highest filled grains panicle^{-1} (179.30) was observed in variety of ACI Sampod where the lowest filled grains panicle^{-1} (118.20) was observed in variety of BRRI dhan45. Again, the highest un-filled grains panicle^{-1} (26.58) was observed in variety of ACI Sampod where the lowest un-filled grains panicle^{-1} (3.17) was observed in variety of BRRI dhan45. The results obtained by Chowdhury *et al*. (2005), Murthy *et al*. (2004), Bhowmick and Nayak (2000) and Patel (2000) was in agreement with findings of present study.

Combined effect of cultivation methods and variety under the present study showed a significant difference in respect of grains panicle^{-1} (Table 7 and Appendix IX). Results denoted that the highest filled grains panicle^{-1} (204.00) was observed in *SRI* × ACI Sampod followed by *SRI* ×BRRI hybrid3 where the lowest filled grains panicle^{-1} (112.00) was observed in *Traditional* × BRRI dhan45 followed by *SRI* × BRRI dhan45. Again, the highest un-filled grains panicle^{-1} (36.33) was observed in *SRI* × ACI Sampod followed by *SRI* ×BRRI hybrid3 where the lowest filled grains panicle^{-1} (112.00) was observed in *Traditional* ×Heera1 which was statistically similar with *Traditional* × BRRI hybrid 2.

Table 6: Effect of the system of rice intensification (SRI) and traditional method on number of grains panicle^{-1} in different rice varieties

Treatment	Grains panicle^{-1}	
	Filled grains panicle^{-1}	Unfilled grains panicle^{-1}
Effect of cultivation methods		
Traditional	144.90 b	9.21 b
SRI	160.67 a	17.69 a
$LSD_{0.05}$	4.229	3.846
CV (%)	11.267	8.319
Effect of variety		
BRRI hybrid 2	149.50 d	6.09 f
BRRI hybrid3	154.30 d	22.92 b
Heera1	142.50 e	8.67 e
Bolaka	151.30 d	10.17 d
Tia	159.80 c	12.35 c
ACI Sampod	179.30 a	26.58 a
Moyna	167.30 b	7.67 e
BRRI dhan45	118.20 f	3.17 g
$LSD_{0.05}$	5.230	1.149
CV (%)	11.267	8.319

Values with common letter(s) within a column do not differ significantly at 5% level of probability analyzed by DMRT

Table 7: Combined effect of the system of rice intensification (SRI) and traditional method on number of grains panicle^{-1} of different rice varieties

Treatment	Grains panicle^{-1}	
	Filled grains panicle^{-1}	Unfilled grains panicle^{-1}
Traditional ×		
BRRI hybrid 2	146.30 f	4.67 hi
BRRI hybrid3	134.70 g	6.50 ghi
Heera1	137.80 g	4.03 i
Bolaka	135.80 g	12.67 de
Tia	172.80 b	13.87 d
ACI Sampod	154.70 e	6.83 ghi
Moyna	165.00 d	6.00 ghi
BRRI dhan45	112.00 i	18.33 c
SRI ×		
BRRI hybrid 2	152.70 e	7.50 fghi
BRRI hybrid3	173.80 b	39.33 b
Heera1	147.20 f	12.50 de
Bolaka	166.80 cd	7.67 fgh
Tia	146.80 f	10.83 def
ACI Sampod	204.00 a	46.33 a
Moyna	169.70 c	9.33 efg
BRRI dhan45	124.30 h	8.00 fgh
$LSD_{0.05}$	3.093	3.182
CV (%)	11.267	8.319

Values with common letter(s) within a column do not differ significantly at 5% level of probability analyzed by DMRT

4.2.4 Dry weight plant^{-1}at harvest

Dry weight plant^{-1} at harvest was expressed as the total dry weight of leaves, panicle, calm and root weight plant^{-1}. Significantly varied results were observed in terms of dry weight plant^{-1} as influenced by different cultivation methods of Boro rice at harvest (Table 8 and Appendix X). Results showed that at harvest, the highest dry weight of leaves, panicle, calm and root weight plant^{-1} (8.00, 35.25, 16.47 and 5.24 g respectively) was obtained from SRI system where traditional system gave the lowest dry weight of leaves, panicle, calm and root weight plant^{-1} (6.96, 28.88, 14.18 and 5.24 g respectively).

Varietal performance had great influence on dry weight of leaves, panicle, calm and root weight plant^{-1} (Table 8 and Appendix X). Results revealed that the highest dry weight of leaves, panicle, calm and root weight plant^{-1} at harvest was observed 8.75, 38.34, 17.62 and 7.42 g respectively in hybrid rice Tia which was closely followed by BRRI hybrid3. On the other hand, BRRI dhan45 gave the lowest dry weight of leaves, panicle, calm and root weight plant^{-1} at harvest (6.00, 24.45, 11.75 and 3.87 g respectively) followed by hybrid rice variety Moyna and BRRI hybrid 2. The results uphold with the findings of Islam *et al*. (2009), Amin *et al*. (2006), Son *et al*. (1998) and Patnaik *et al*. (1990) who reported that dry matter accumulation capacity depends mainly on varietal performance.

Table 8: Effect of the system of rice intensification (SRI) and traditional method on dry weight of single plant parts of different rice varieties

Treatment	Dry weight at harvest			
	Leaf dry weight plant^{-1} (g)	Panicle dry weight plant^{-1} (g)	Calm dry weight plant^{-1} (g)	Root dry weight plant^{-1} (g)
Effect of cultivation methods				
Traditional	6.96 b	28.88 b	14.18 b	5.24 b
SRI	8.00 a	35.25 a	16.47 a	6.69 a
$LSD_{0.05}$	1.044	2.389	1.007	0.529
CV (%)	8.326	9.159	7.514	6.338
Effect of variety				
BRRI hybrid2	6.59 d	28.34 cd	14.09 c	5.50 c
BRRI hybrid3	8.42 ab	39.67 a	17.42 a	7.17 ab
Heera1	8.17 b	34.34 b	16.22 b	6.84 b
Bolaka	8.34 b	34.92 b	17.17 a	6.92 ab
Tia	8.75 a	38.34 a	17.62 a	7.42 a
ACI Sampod	7.17 c	29.67 c	14.50 c	5.17 cd
Moyna	6.42 d	26.80 d	13.84 c	4.83 d
BRRI dhan45	6.00 e	24.45 e	11.75 d	3.87 e
$LSD_{0.05}$	0.3663	1.877	0.7172	0.5392
CV (%)	8.326	9.159	7.514	6.338

Values with common letter(s) within a column do not differ significantly at 5% level of probability analyzed by DMRT

Interaction effect of cultivation methods and variety had significant influence on dry weight plant^{-1} at harvest (Table 9 and Appendix X). Results indicated that the highest dry weight of leaves, panicle, calm and root weight plant^{-1} at harvest (9.67, 48.83, 19.17 and 8.33 g respectively) was obtained from the combination of *SRI* ×BRRI hybrid3 which was statistically similar with *SRI* × Tia combination for all dry matter parameters. Again, the lowest dry weight of leaves, panicle, calm and root weight plant^{-1} at harvest (6.50, 27.67, 13.17 and 4.00 g respectively) was obtained from the combination of *SRI* × BRRI dhan45 followed by *SRI* × BRRI hybrid2, *Traditional* × BRRI hybrid2, *Traditional* × ACI Sampod and *Traditional* × BRRI dhan45.

Table 9: Combined effect of the system of rice intensification (SRI) and traditional method on dry weight of single plant parts of different rice varieties

Treatment	Dry weight plant^{-1} at harvest			
	Dry leaf weight plant^{-1} (g)	Dry weight of panicle plant^{-1} (g)	Dry calm weight plant^{-1} (g)	Dry root weight plant^{-1} (g)
Traditional ×				
BRRI hybrid2	6.50 f	28.17 g	13.67 ef	5.33 f
BRRI hybrid3	7.17 e	30.50 f	15.67 bc	6.00 e
Heera1	8.17 c	32.67 e	15.83 bc	6.17 e
Bolaka	7.67 d	31.00 f	15.67 bc	6.00 e
Tia	8.17 c	35.00 d	16.40 b	6.67 d
ACI Sampod	6.50 f	27.67 g	13.33 fg	4.17 g
Moyna	6.00 g	24.77 h	12.50 g	3.83 g
BRRI dhan45	5.50 h	21.23 i	10.33 h	3.73 g
SRI ×				
BRRI hybrid2	6.67 f	28.50 g	14.50 de	5.67 ef
BRRI hybrid3	9.67 a	48.83 a	19.17 a	8.33 a
Heera1	8.17 c	36.00 d	16.60 b	7.50 c
Bolaka	9.00 b	38.83 c	18.67 a	7.83 bc
Tia	9.33 ab	41.67 b	18.83 a	8.17 ab
ACI Sampod	7.83 cd	31.67 ef	15.67 bc	6.17 e
Moyna	6.83 ef	28.83 g	15.17 cd	5.83 e
BRRI dhan45	6.50 f	27.67 g	13.17 fg	4.00 g
$LSD_{0.05}$	0.3981	1.352	0.9535	0.4474
CV (%)	8.326	9.159	7.514	6.338

Values with common letter(s) within a column do not differ significantly at 5% level of probability analyzed by DMRT

4.3 Yield parameters

4.3.1 Weight of 1000 grains

Cultivation method had not significant effect on 1000 grain weight rice (Table 10 and Appendix XI). But it was found that 1000 grain weight from Traditional method (26.49 g) was higher than SRI (26.25 g).

Significant influence of different varieties was observed on 1000 grain weight (Table 10 and Appendix XI). It is attained that the highest 1000 grain weight (28.67g) was in BRRI hybrid3 treatment followed by BRRI dhan45, Moyna and Tia. The lowest 1000 seed weight (21.91g) was observed in ACI Sampod. The results are in agreement with the findings of Chowdhury *et al*. (2005) and Rahman *et al*. (2002) who observed varied 1000 grains weight among different varieties of rice.

Combined effect of cultivation method and variety had significant influence on 1000 grain weight of rice (Table 11 and Appendix XII). Results indicated that the highest 1000 grain weight (28.77 g) was with *SRI* ×BRRI hybrid3 which was statistically identical with *SRI* × Moyna, *Traditional* ×BRRI hybrid3, *Traditional* × Tia and closely followed by *Traditional* × BRRI dhan45. On the other hand the lowest result 1000 grain weight (21.58 g) was recorded from *SRI* ×ACI Sampod followed by *Traditional* ×ACI Sampod. The results obtained from all other treatments combinations was significantly different compared to the highest and the lowest 1000 grain weight.

4.3.2 Fresh grain weight m^{-2}

Cultivation method had significant effect on Fresh grain weight m^{-2} of rice (10 and Appendix XI). It was found that fresh grain weight m^{-2} from SRI method (939.27 g) was higher than traditional (828.65 g).

Significant influence of different varieties was observed on Fresh grain weight m^{-2} (10 and Appendix XI). It is attained that the highest Fresh grain weight m^{-2} (1045.00 g) was in BRRI hybrid3 treatment where the lowest Fresh grain weight m^{-2} (694.17 g) was observed in BRRI dhan45.

Combined effect of cultivation method and variety had significant influence on fresh grain weight m^{-2} of rice (Table 11 and Appendix XII. Results indicated that the highest Fresh grain weight m^{-2} (1116.67 g) was with *SRI* ×BRRI hybrid3 followed by *SRI* × Tia. On the other hand the lowest result (688.33 g) was recorded from *Traditional* × BRRI dhan45 followed by *SRI* × BRRI dhan45. The results obtained from all other treatments combinations was significantly different compared to the highest and the lowest Fresh grain weight m^{-2}.

4.3.3 Fresh straw weight m^{-2}

Cultivation method had significant effect on Fresh grain weight m^{-2} of rice (10 and Appendix XI). It was found that the highest fresh straw weight m^{-2} was from SRI method (2205.31g) where the lowest was from traditional method (1201.15 g).

Significant influence of different varieties was observed on Fresh straw weight m^{-2} (Table 10 and Appendix XII). It is attained that the highest Fresh straw weight m^{-2} (2408.33 g) was in BRRI hybrid3 treatment where the lowest Fresh straw weight m^{-2} (873.34 g) was observed in BRRI dhan45.

Combined effect of cultivation method and variety had significant influence on fresh straw weight m^{-2} of rice (Table 11 and Appendix XII). Results indicated that the highest Fresh straw weight m^{-2} (2604.17 g) was with *SRI* ×BRRI hybrid3 followed by *SRI* × Tia. On the other hand the lowest result (849.17g) was recorded from *Traditional* × BRRI dhan45 followed by *SRI* × BRRI dhan45.

4.3.4 Grain yield

Cultivation methods had significant effect on grain yield of rice (Table 10 and Appendix XI). It was found that the highest grain yield was from SRI method (7.62 t ha^{-1}) where the lowest was from traditional method (6.59 t ha^{-1}). Bouman and Tuong (2010) suggested that there is a reduction in the grain yield in alternate wetting and drying when compared with rice grown with standing water. Grain yield, however decreased significantly when water was reduced to field capacity condition and this was in agreement with previous findings by Beyrouty *et al*. (1994); Grigg *et al*. (2000).

Different varieties significantly produced variable grain yield (10 and Appendix XI). The highest grain yield was recorded by BRRI hybrid3 (8.52 t ha^{-1}) followed by variety Heera1 and variety Tia where the lowest grain yield (5.19 t ha^{-1}) was obtained from BRRI dhan45 treatment, followed by variety BRRI hybrid 2. The results are in agreement with the findings of Islam *et al*. (2009), Bisne *et al*. (2006), Siddiquee *et al*. (2002) and Chowdhury *et al*. (2005) whose stated that grain yield differed significantly among the varieties.

Combined effect of cultivation method and variety had significant influence on grain yield (Table 11 and Appendix XII). The highest grain yield per hectare (9.77 t) was with *SRI* ×BRRI hybrid3 followed by *SRI* × Tia. The lowest result was recorded from *Traditional* × BRRI dhan45 (5.16 t) which was statistically identical with *SRI* × BRRI dhan45. The results obtained from the rest of the treatment combinations showed intermediate level of grain yield compared to the highest and the lowest grain yield.

4.3.5 Stover yield

Cultivation methods had significant effect on stover yield of rice (10 and Appendix XI). It was found that the highest stover yield was from SRI method (10.32 t ha^{-1}) where the lowest was from traditional method (9.36 t ha^{-1}).

Different varieties significantly produced variable grain yield (10 and Appendix XI). The highest stover yield was recorded by BRRI hybrid3 (11.16 t ha^{-1}) followed by variety Heera1 and variety Tia where the lowest stover yield (8.46 t ha^{-1}) was obtained from BRRI dhan45 treatment, followed by BRRI hybrid 2 and Moyna. The results uphold with the findings of Chowdhury *et al*. (2005), Akbar (2004), Patel (2000) and Om *et al*. (1999) where they concluded that stover yield differed significantly among the varieties.

Combined effect of cultivation method and variety had significant influence on stover yield (Table 11 and Appendix XII). The highest stover yield per hectare (11.91 t) was with *SRI* ×BRRI hybrid3 which was statistically identical with *SRI* × Tia. The lowest stover yield was recorded from *Traditional* × BRRI dhan45 (8.44 t ha^{-1}) which was statistically identical with *SRI* × BRRI dhan45. The results obtained from the rest of the treatment combinations showed intermediate level of grain yield compared to the highest and the lowest stover yield.

4.3.6 Harvest index

Cultivation method had significant effect on harvest index (Table 10 and Appendix XI). It was found that the highest harvest index was from SRI method (42.22%) where the lowest was from traditional method (41.19%).

Different varieties significantly produced variable harvest index (10 and Appendix XI). The highest harvest index was recorded by BRRI hybrid3 (43.26%) which was statistically identical variety Tia where the lowest harvest index (38.02%) was obtained from BRRI dhan45 treatment, followed by ACI Sampod and Moyna.

Combined effect of cultivation method and variety had significant influence on harvest index (Table 11 and Appendix XII). The highest harvest index (45.06) was with *SRI* ×BRRI hybrid3 followed by *SRI* × Tia. The lowest result was recorded from *Traditional* × BRRI dhan45 (37.94%) which was statistically identical with *SRI* × BRRI dhan45.

Table 10: Effect of the system of rice intensification (SRI) and traditional method on yield parameters of different rice varieties

Treatment	Yield parameters					
	1000 grain weight (g)	Fresh grain weight m^{-2} (g)	Fresh straw weight m^{-2} (g)	Grain yield (t ha^{-1})	Stover yield (t ha^{-1})	Harvest index (%)
Effect of cultivation methods						
Traditional	26.49	828.65 b	1201.15 b	6.59 b	9.36 b	41.19 b
SRI	26.25	939.27 a	2205.31 a	7.62 a	10.32 a	42.22 a
$LSD_{0.05}$	NS	6.866	13.681	0.112	0.233	0.411
CV (%)	6.684	13.599	14.517	6.671	7.333	8.274
Effect of variety						
BRRI hybrid 2	25.82 d	798.34 g	1425.83 g	6.44 e	9.13 e	41.34 c
BRRI hybrid3	28.67 a	1045.00 a	2408.33 a	8.52 a	11.16 a	43.26 a
Heera1	25.67 d	986.25 b	1882.50 c	8.03 b	10.69 b	42.89 ab
Bolaka	26.47 c	949.58 d	1783.34 d	7.60 c	10.28 c	42.47 b
Tia	27.16 b	960.84 c	2055.84 b	8.14 b	10.57 b	43.23 a
ACI Sampod	21.91 e	857.09 e	1656.25 e	6.67 d	9.43 d	41.37 c
Moyna	27.50 b	780.42 f	1540.42 f	6.30 f	9.03 e	41.07 c
BRRI dhan45	27.75 b	694.17 h	873.34 h	5.19 g	8.46 f	38.02 d
$LSD_{0.05}$	0.6075	9.549	12.338	0.129	0.148	0.4487
CV (%)	6.684	13.599	14.517	6.671	7.333	8.274

Values with common letter(s) within a column do not differ significantly at 5% level of probability analyzed by DMRT

Table 11: Combined effect of the system of rice intensification (SRI) and traditional method on yield parameters of different rice varieties

Treatment	Yield parameters					
	1000 grain weight (g)	Fresh grain weight m^{-2} (g)	Fresh straw weight m^{-2} (g)	Grain yield (t ha^{-1})	Stover yield (t ha^{-1})	Harvest index (%)
Traditional ×						
BRRI hybrid 2	25.60 ef	796.67 i	993.33 k	6.39 hi	9.10 e	41.25 ef
BRRI hybrid3	28.56 a	805.00 i	1007.50 j	6.51 g	9.19 e	41.46 ef
Heera1	26.57 cd	925.00 f	1338.33 h	7.60 de	10.22 d	42.65 cd
Bolaka	25.63 ef	863.33 g	1160.00 i	7.18 f	9.90 d	42.04 de
Tia	28.52 a	1019.17 e	1858.33 g	7.85 d	10.48 c	42.83 bcd
ACI Sampod	22.24 g	790.00 ij	962.50 l	6.13 j	8.92 ef	40.73 f
Moyna	26.70 cd	741.67 k	935.00 m	5.93 j	8.66 gh	40.64 f
BRRI dhan45	28.08 ab	688.33 m	849.17 o	5.16 k	8.44 h	37.94 g
SRI ×						
BRRI hybrid 2	26.04 de	800.00 i	2363.33 e	6.48 gh	9.16 e	41.43 ef
BRRI hybrid3	28.77 a	1116.67 a	2604.17 a	9.77 a	11.91 a	45.06 a
Heera1	24.76 f	1047.50 c	2426.67 c	8.46 c	11.16 b	43.12 bc
Bolaka	27.30 bc	1035.83 d	2406.67 d	8.01 d	10.66 c	42.90 bc
Tia	25.80 de	1070.83 b	2453.33 b	9.19 b	11.88 a	43.62 b
ACI Sampod	21.58 h	924.17 f	2350.00 e	7.20 f	9.94 d	42.01 de
Moyna	28.30 a	819.17 h	2145.83 f	6.66 g	9.39 e	41.50 ef
BRRI dhan45	27.41 bc	700.00 l	897.50 n	5.22 k	8.48 h	38.10 g
$LSD_{0.05}$	0.8371	10.142	13.883	0.271	0.347	0.7857
CV (%)	6.684	13.599	14.517	6.671	7.333	8.274

Values with common letter(s) within a column do not differ significantly at 5% level of probability analyzed by DMRT

Chapter 5

Summary and Conclusion

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted at the Sher-e-Bangla Agricultural University Farm, Dhaka, Bangladesh during the period from December 2015 to May 2016 to study the impact of the system of rice intensification (SRI) on morpho-physiological characteristics and productivity of hybrid rice varieties. The experimental treatments included two cultivation methods *viz*. Cultivation methods i) T_1 = Traditional method; Plant spacing, S_1 (15cm × 25cm) + Regular irrigation, I_1 and ii) T_2 = SRI method; Plant spacing, S_2 (20cm × 20cm) + Controlled irrigation, I_2 with eight varieties *viz*. (i) V_1 = BRRI hybrid dhan2, (ii) V_2 = BRRI hybriddhan3, (iii) V_3 = Heera1, (iv) V_4 = Bolaka, (v) V_5 = Tia, (vi) V_6 = ACI Sampod, (vii) V_7 = Moyna and (viii) V_8 = BRRI dhan45. The experiment was laid out in a randomized Complete Block Design (RCBD) with three replications.

Significant variation was found cultivation method and varieties. It was found that the tallest plant (101.75 cm) and lowest days required for panicle initiation (71.71, 82.33 and 91.96 days for first panicle initiation, 50% panicle initiation and 100% panicle initiation, respectively) was done by traditional cultivation methods. But the highest number of tillers plant^{-1} (13.29) at harvest, highest dry weight of leaves, panicle, calm and root weight plant^{-1} (8.00, 35.25, 16.47 and 5.24 g respectively), highest number of effective tillers hill^{-1} (13.29) and highest filled grains panicle^{-1} (160.67) was recorded by SRI system. Again, the shortest plant (97.51 cm at harvest), highest days required for panicle initiation (78.08, 88.83 and 98.33 days for first panicle initiation, 50% panicle initiation and 100% panicle initiation, respectively) was done by SRI where the lowest number of tillers plant^{-1} at harvest (9.44), lowest number of non-effective tiller hill^{-1} (5.56), lowest number of filled grains panicle^{-1}(144.90) and lowest dry weight of leaves, panicle, calm and root weight plant^{-1} (6.96, 28.88, 14.18 and 5.24 g respectively) were found by traditional method of rice cultivation.

In case of varietal performance, the highest plant height (104.1 cm at harvest), lowest days required for panicle initiation (65.67, 76.34 and 87.00 days for first panicle initiation, 50% panicle initiation and 100% panicle initiation, respectively) and highest dry weight of leaves, panicle, calm and root weight plant^{-1} at harvest (8.75, 38.34, 17.62 and 7.42 g respectively) in hybrid rice variety Tia where BRRI hybrid-3 showed the highest tillers plant^{-1} (14.67 at harvest), highest number of effective tillers hill^{-1} (14.67) but highest filled grains panicle^{-1} (179.30) was observed in variety of ACI Sampod.

The shortest plant (96.62 cm) and the highest days required for panicle initiation (83.33, 94.17 and 103.2 days for first panicle initiation, 50% panicle initiation and 100% panicle initiation, respectively) were obtained by hybrid rice variety ACI Sampad where the minimum tillers hill^{-1} at harvest (9.92), lowest filled grains panicle^{-1} (118.20) and lowest dry weight of leaves, panicle, calm and root weight plant^{-1} at harvest (6.00, 24.45, 11.75 and 3.87 g respectively) were observed in variety of BRRI dhan45 but the minimum effective tillers hill^{-1} (9.92) at harvest was found in hybrid rice variety Heera1.

Combined effect of traditional cultivation method and variety showed significant on growth and yield contributing parameters. It was found that the tallest plant (107.5 cm at harvest) and lowest days required for panicle initiation (61.00, 73.00 and 85.00 days for first panicle initiation, 50% panicle initiation and 100% panicle initiation, respectively) was by *Traditional* × Tia where *SRI* × BRRI hybrid3 treatment combination gave the highest number of tillers plant^{-1} (19.67 at harvest), highest dry weight of leaves, panicle, calm and root weight plant^{-1} at harvest (9.67, 48.83, 19.17 and 8.33 g respectively) and highest number of effective tillers hill^{-1} (19.67) but the highest filled grains panicle^{-1}(204.00) was observed in *SRI* × ACI

Sampod. The shortest plant (93.37 cm at harvest) and highest days required for panicle initiation (86.33, 96.33 and 105.3 days for first panicle initiation, 50% panicle initiation and 100% panicle initiation, respectively) were found from *SRI* × ACI Sampod but the lowest number of tillers plant^{-1} (8 7.50 at harvest) was found from *Traditional* ×BRRI hybrid3 treatment combination where *Traditional* × Heera1 showed the lowest number of effective tillers hill^{-1} (7.50) at harvest but Again, the lowest filled grains panicle^{-1} (112.00) was observed in *Traditional* × BRRI dhan45 where lowest dry weight of leaves, panicle, calm and root weight plant^{-1} at harvest (6.50, 27.67, 13.17 and 4.00 g respectively) was obtained from the combination of *SRI* × BRRI dhan45.

Considering yield parameters, cultivation methods showed significant variation. The highest grain yield (7.62 t ha^{-1}), highest stover yield (10.32 t ha^{-1}) and highest harvest index (42.22%) were found in SRI method where the lowest grain yield (6.59 t ha^{-1}), stover yield (9.36 t ha^{-1}) and harvest index (41.19%) were found from the lowest was from traditional cultivation method. Here, 1000 grain weight was not found to be significant by cultivation method.

Results revealed that in terms of varietal performance, highest 1000 grain weight (28.67g), highest grain yield (8.52 t ha^{-1}), highest stover yield (11.16 t ha^{-1}) and highest harvest index (43.26%) were recorded by BRRI hybrid3 where lowest grain yield (5.19 t ha^{-1}), lowest stover yield (8.46 t ha^{-1}) and lowest harvest index (38.02%) were obtained from BRRI dhan45 but the lowest 1000 grain weight (21.91g) was observed in ACI Sampod.

Combined effect of cultivation method and variety showed great influence on yield parameters. It was found that the highest 1000 grain weight (28.77 g), highest grain yield per hectare (9.77 t), highest stover yield per hectare (11.91 t) and highest harvest index (45.06%) were obtained from *SRI* ×BRRI hybrid3 where the lowest result grain yield 45 (5.16 t), lowest stover yield (8.44 t) and lowest harvest index (37.94%) were recorded from *Traditional* × BRRI dhan45 but the lowest result on1000 grain weight (21.58 g) was recorded from *SRI* ×ACI Sampod.

Finally, it can be concluded that SRI cultivation method is better than traditional cultivation method in respect of growth and yield of hybrid rice. Among studied rice varieties, BRRI hybrid dhan3 under SRI method produced the highest yield (9.77 t ha^{-1}) closely followed by Tia (9.19 t ha^{-1}) and Hera1 (8.46 t ha^{-1}).

Recommendation

1. For getting higher grain yield, hybrid rice varieties are to be cultivated following SRI method.
2. More research should be conducted with other SRI system including other hybrid and modern inbred rice varieties.
3. However, it needs more trials under farmer's field conditions at different agro-ecological zones of Bangladesh for the conformation of the findings.

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Appendices

APPENDICES

Appendix l: Experimental site showing in the map under the present study

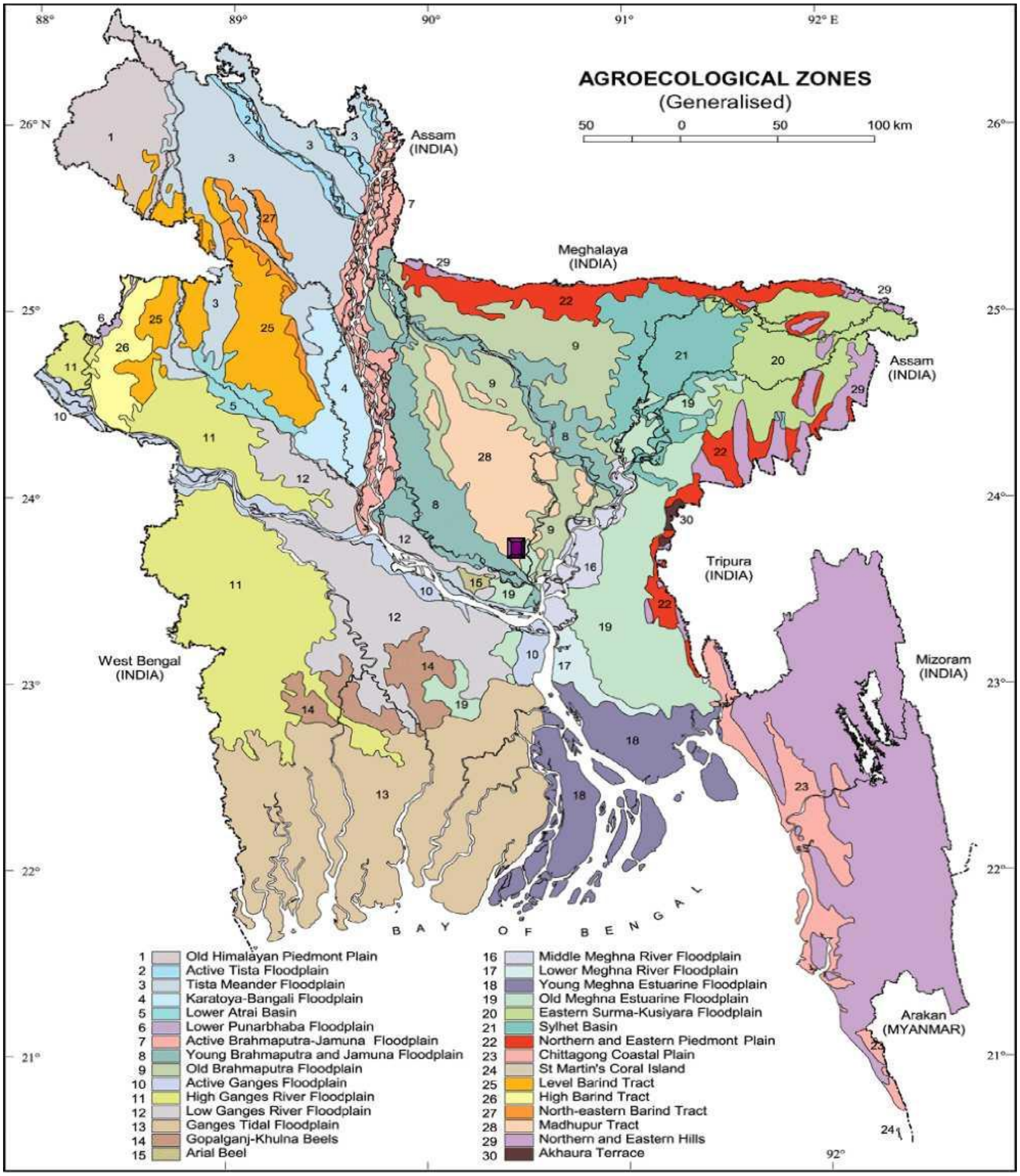


Fig. 1. Map of Bangladesh remarked with study area

Appendix II. Monthly records of air temperature, relative humidity, rainfall and sunshine during the period from November 2015 to February 2016

Year	Month	Air temperature (°C)			Relative humidity (%)	Rainfall (mm)	Sunshine (Hours)
		Max.	Min.	Avg.			
2015	December	28.2	13.5	20.9	79	8	3.8
2016	January	24.5	11.5	18.0	72	6	5.7
2016	February	33.1	12.9	23.0	55	10	8.1
2016	March	33.6	15.3	24.5	63	43	7.5
2016	April	36.0	21.20	28.6	65	86	9.5
2016	May	35.8	24.6	30.2	72	92	9.6

Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka-1212.

Appendix III. The mechanical and chemical characteristics of soil of the experimental site as observed prior to experimentation

Particle size constitution:

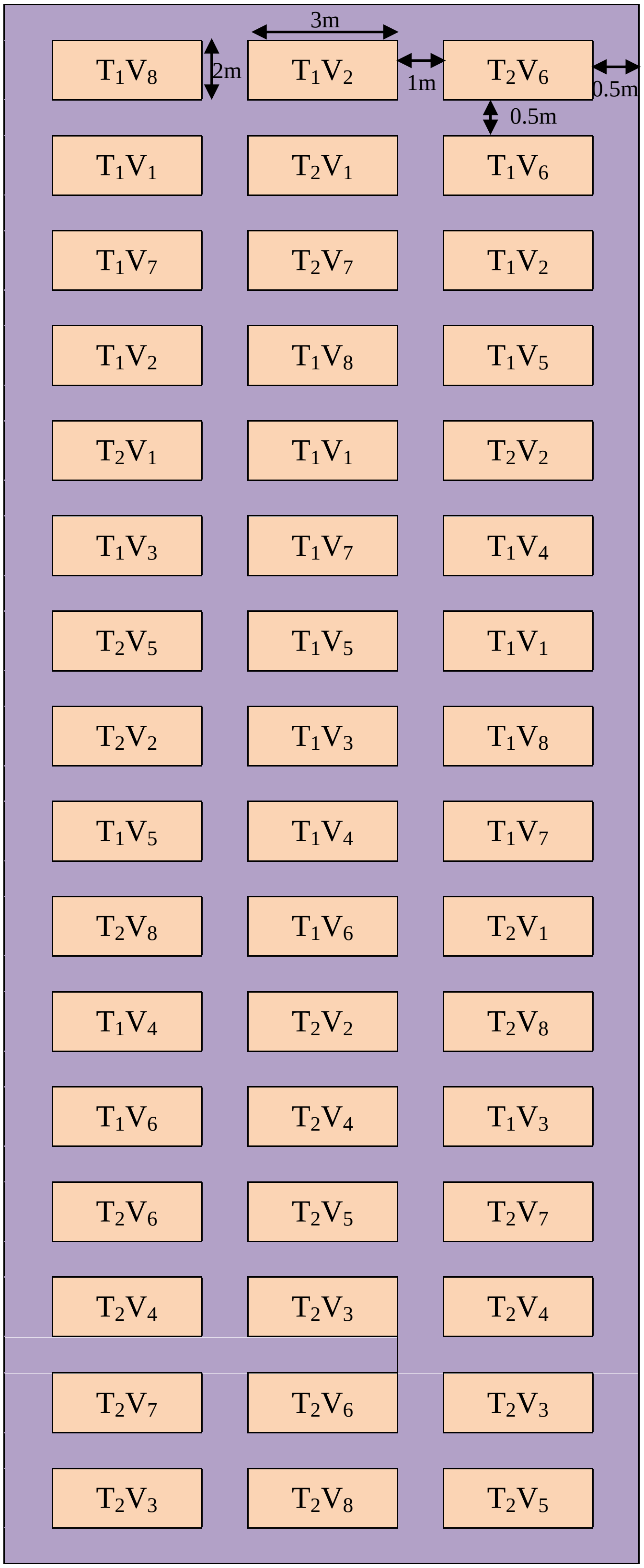
Sand	:	40 %
Silt	:	40 %
Clay	:	20 %
Texture	:	Loamy

Chemical composition:

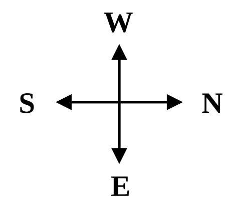
Constituents	:	0-15 cm depth
P^H	:	5.45-5.61
Total N (%)	:	0.07
Available P (µ gm/gm)	:	18.49
Exchangeable K (µ gm/gm)	:	0.07
Available S (µ gm/gm)	:	20.82
Available Fe (µ gm/gm)	:	229
Available Zn (µ gm/gm)	:	4.48
Available Mg (µ gm/gm)	:	0.825
Available Na (µ gm/gm)	:	0.32
Available B (µ gm/gm)	:	0.94
Organic matter (%)	:	0.83

Source: Soil Resources Development Institute (SRDI), Farmgate, Dhaka.

Appendix IV. Layout of the experiment field



LEGEND



Layout:

Plot size: 3m × 2 m

Plot spacing: 0.5 m

Between block: 1 m

Treatments:

Factor A: Plant spacing with irrigation

1. T_1 = Plant spacing, S_1 (15cm × 25cm) + Controlled irrigation, I_1
2. T_2 = Plant spacing, S_2 (25cm × 25cm) + Regular irrigation, I_2

Factor B: Variety – 8 varieties

1. V_1 = BRRI hybrid 2
2. V_2 = BRRI hybrid 3
3. V_3 = Heera1
4. V_4 = Bolaka
5. V_5 = Tia
6. V_6 = ACI Sampod
7. V_7 = Moyna

Fig. 9. Layout of the experimental plot

Appendix V. Effect on plant height of different rice varieties influenced by system of rice intensification (SRI)

Source of variation	Degrees of freedom	Mean square of plant height							
		20 DAS	30 DAS	40 DAS	50 DAS	60 DAS	70 DAS	80 DAS	At harvest
Replication	2	0.019	0.124	1.366	0.728	1.018	1.362	1.108	0.692
Factor A	1	18.777*	26.283*	32.624*	28.347*	26.386*	45.839**	38.297*	48.395*
Factor B	7	10.663**	12.884*	18.689*	16.389*	14.597*	22.514*	16.377**	24.861**
AB	7	14.596*	17.389*	15.633**	13.546*	18.614**	12.642*	10.389*	16.337**
Error	30	0.117	1.126	2.544	2.835	3.314	2.788	2.894	3.106

Appendix VI. Effect on number of tillers plant^{-1} of different rice varieties influenced by system of rice intensification (SRI)

Source of variation	Degrees of freedom	Mean square of number of tillers plant^{-1}							
		20 DAS	30 DAS	40 DAS	50 DAS	60 DAS	70 DAS	80 DAS	At harvest
Replication	2	0.120	0.591	1.051	1.022	0.464	1.402	1.003	1.021
Factor A	1	7.770*	9.40**	8.300*	10.684*	3.808**	9.098**	14.201*	15.261*
Factor B	7	11.162*	16.561*	15.039**	15.517*	7.165*	7.604*	19.265*	27.265*
AB	7	1.280**	3.033*	2.151*	4.613*	5.114*	7.898*	10.034**	8.031**
Error	30	0.117	0.241	2.267	3.372	1.167	2.781	2.921	3.804

Appendix VII. Effect on days to panicle initiation of different rice varieties influenced by system of rice intensification (SRI)

Source of variation	Degrees of freedom	Mean square of days to panicle initiation		
		First panicle initiation	50% panicle initiation	100% panicle initiation
Replication	2	2.926	3.811	3.988
Factor A	1	18.507**	12.633**	19.617**
Factor B	7	14.614*	17.119*	14.604*
AB	7	10.201*	8.622**	8.281*
Error	30	3.157	3.143	2.187

Appendix VIII. Effect on l tiller number of different rice varieties influenced by system of rice intensification (SRI)

Source of variation	Degrees of freedom	Mean square of tiller number		
		Number of effective tiller hill^{-1}	Number of non-effective tiller hill^{-1}	Number of total tiller hill^{-1}
Replication	2	0.513	0.094	0.495
Factor A	1	4.588*	NS	8.238*
Factor B	7	5.146**	2.762*	9.262*
AB	7	2.364*	0.641*	3.217*
Error	30	1.122	0.607	1.211

Appendix IX. Effect on number of grains panicle^{-1} of different rice varieties influenced by system of rice intensification (SRI)

Source of variation	Degrees of freedom	Mean square of number of grains panicle^{-1}		
		No. of filled grains panicle^{-1}	No. of unfilled grains panicle^{-1}	No. of total grains panicle^{-1}
Replication	2	2.099	0.122	1.087
Factor A	1	1.524*	0.887*	13.714 *
Factor B	7	7.119*	4.624**	7.577*
AB	7	8.211*	2.71*	14.281*
Error	30	2.774	7.694	2.436

Appendix X. Effect on dry weight of single plant of different rice varieties influenced by system of rice intensification (SRI)

Source of variation	Degrees of freedom	Mean square of dry weight			
		Dry leaf weight $plant^{-1}$ (g)	Dry weight of panicle $plant^{-1}$ (g)	Dry calm weight $plant^{-1}$ (g)	Dry root weight $plant^{-1}$ (g)
Replication	2	0.342	0.893	2.837	1.939
Factor A	1	13.575*	5.258*	22.033**	11.697**
Factor B	7	16.086**	9.762*	18.709*	16.644*
AB	7	6.641*	2.235*	4.618**	5.251*
Error	30	3.139	1.258	3.012	3.117

Appendix XI. Significant effect on yield parameters of different rice varieties influenced by system of rice intensification (SRI)

Source of variation	Degrees of freedom	Mean square of yield parameters					
		1000 seed weight (g)	Fresh grain weight m^{-2} (g)	Fresh straw weight m^{-2} (g)	Grain yield (t ha^{-1})	Stover yield (t ha^{-1})	Harvest index (%)
Replication	2	1.893	11.881	13.926	2.003	1.042	2.017
Factor A	1	NS	213.03**	311.69**	4.261*	9.684*	13.58*
Factor B	7	9.703*	315.706*	48.674*	7.295*	14.517*	9.02**
AB	7	6.252*	77.613**	113.271*	13.034**	4.663*	4.671*
Error	30	2.266	10.012	13.107	2.871	4.372	4.139


Department of Agricultural Botany
TITLE OF THE PROJECT
IMPACT OF THE SYSTEM OF RICE INTENSIFICATION (SRI) ON PHYSIOLOGICAL CHARACTERISTICS AND PRODUCTIVITY OF HYBRID RICE VARIETIES
Financing Authority: SAURES (2015-2016)
A) Varieties
i) BRRI hybrid dhan2
(ii) BRRI hybrid dhan3
(iii) Heera3
(iv) Panna1
(v) Tia
(vi) ACI6
(vii) Tej
(viii) BRRIdhan45
B) Methods of cultivation
(i) System of rice intensification (SRI)
(ii) Traditional rice cultivation (TRC)
Design: Split plot
Number of replications: 3
Project Investigator
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