SCREENING OF RICE VARIETIES RESPONSIVE TO SYSTEM OF RICE INTENSIFICATION (SRI) IN *BORO* SEASON

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CERTIFICATE

This is to certify that thesis entitled, **"SCREENING OF RICE VARIETIES RESPONSIVE TO SYSTEM OF RICE INTENSIFICATION (SRI) IN *BORO* SEASON"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE in AGRONOMY**, embodies the result of a piece of bonafide research work carried out by **TOUHIDUZZAMAN,** Registration No. **05-01676** 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.

Dated: June, 2011
Place: Dhaka, Bangladesh

Prof. Dr. Parimal Kanti Biswas
Supervisor

Dedicated

To My

Beloved Parents

&

Teachers

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The Author

SCREENING OF RICE VARIETIES RESPONSIVE TO SYSTEM OF RICE INTENSIFICATION (SRI) IN *BORO* SEASON

ABSTRACT

A field experiment was carried out at Agronomy research field, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh, during the period from December, 2010 to May 2011 for the screening of rice varieties responsive to SRI in *boro* season. The experiment consisted of sixteen treatments *viz.* BR3 (V_1), BR14 (V_2) BR16 (V_3), BRRI dhan28 (V_4), BRRI dhan29 (V_5), BRRI dhan36 (V_6), BRRI dhan45 (V_7), BRRI dhan50 (V_8), Binadhan-6 (V_9), Bina new line (V_{10}), BRRI hybrid dhan1 (V_{11}), BRRI hybrid dhan2 (V_{12}), BRRI hybrid dhan3 (V_{13}), Chamak (V_{14}), Hira1 (V_{15}) and Bhajan (V_{16}). The experiment was laid out in randomized complete block design with three replications. Experimental results showed that the sixteen varieties cultivated in *boro* season had significant difference among them in all agronomic parameters except plant dry weight at harvest, root dry weight at 90 DAT and at harvest, leaf area index at 90 DAT. The lowest seedling mortality rate was for Chamak (1.11%) at 7 DAT and Bhajan (0.74%) at 14 DAT. BRRI dhan28 had the highest seedling mortality rate at both 7 DAT and 14 DAT (12.95% and 9.61%). 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) and highest grain yield (6.86 t ha^{-1}), Binadhan-6 had the highest number of total grains panicle^{-1} (222.70) and number of filled grains panicle^{-1} (191.00), BR3 and BR14 both had the highest 1000-grain weight (30.63 g), BRRI hybrid dhan2 had the highest straw yield (7.70 t ha^{-1}) and biological yield (13.24 t ha^{-1}). BRRI dhan50 had the highest harvest index (49.30).

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LIST OF ACRONYMS

IRRI	International Rice Research Institute
BBS	Bangladesh Bureau of Statistics
BER	Bangladesh Economic Review
BRRI	Bangladesh Rice Research Institute
GDP	Gross Domestic Product
IR	International Rice
kg	Kilogram
FP	Farmers Practice
DAT	Days After Transplantation
DAS	Days After Sowing
FYM	Farm Yard Manure
RDF	Recommended Dose of Fertilizer
AWD	Alternate Wet and Dry
DSP	Direct Sowing Plant
TP	Transplanted Plant
SMP	Standard Management Practice
CF	Continuous Flooding
GL	Ground Level
RMP	Recommended Management Practice
PI	Panicle Initiations
LSD	Least Significant Difference
HI	Harvest Index
m^2	Meter square
No.	Number
NS	Non significant
%	Percentage
SRDI	Soil Research and Development Institute
t ha^{-1}	Ton per hectare
Anon.	Anonymous
AEZ	Agro-Ecological Zone
M. S.	Master of Science
CV%	Percent Coefficient of Variation
Cm	Centi-meter
et al.	And others
^0C	Degree Centigrade

Chapter I

Introduction

CHAPTER I

INTRODUCTION

Rice (*Oryza sativa*) is one of the major crops of the world. Rice is a semi aquatic annual grass plant and is the most important cereal crop in the developing world (Anon., 1997; Luh, 1991). Rice is the staple food of nearly half of the world's population, and is particularly important in Asia, where approximately 90% of world's rice is produced and consumed (Zeigler and Barclay, 2008; Khush, 2004). It is estimated that by the year 2025, the world's farmers should be producing about 60% more rice than at present to meet the food demands of the expected world population at that time (Fageria, 2007). Global rice production has trippled in the last five decades from 150 million tons in 1960 to 450 million tons in 2011, due to the rice Green Revolution in Asia. Since the introduction of high yielding semi-dwarf varieties in 1960s by the International Rice Research Institute (IRRI) more than 1000 modern rice varieties have been released to farmers in many Asian countries, resulting in a rapid increase in rice yields and global rice production. Global production dropped sharply at the beginning of the 21st Century, from 410 million tons in 2000 to 378 million tons in 2003 because of severe droughts in parts of Asia, but has recovered by growing 50 million tons between 2005 and 2011 (Rejesus *et al.*, 2012). A study showed that most asian countries won't be able to feed their projected population without irreversibly degrading their land resources, even with high levels of management inputs (Beinroth *et al.*, 2001).

Densely populated and threatened by floods and storms- Bangladesh in one of the poorer countries of the world. Agro-based developing country like Bangladesh is striving hard for rapid development of its economy. The economic development of the country is mainly based on agriculture. The contribution of agriculture sector in GDP is 20.87% (BER, 2008). Approximately, 12 % of GDP has been derived from crops while rice alone contributes 9.5 % to the agricultural GDP (BBS, 2008). In Bangladesh, all though 63% of the labor force is directly engaged in agriculture and 78% of total cropped area is devoted to rice production, the country is still suffering from a chronic shortage of food grain (BBS, 2008). Rice contributes more than 80 % to the total food supply. More than 95% of population consumes rice and it alone provides 76% of calorie and 66% of total protein requirement of daily food intake (Bhuiyan *et al.*, 2002).

The total production of rice in Bangladesh was 34.35 million metric tons from her 11.35 million hectares of land in the fiscal year 2010-2011 (BBS, 2011). A conservative statistics given by Bhuiyan *et al.* (2002) indicates that about 21% higher amount of rice 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.

System of Rice Intensification (SRI) is a technique or a set of practices and principles rather than as a "technology package" (Uphoff, 2004a). SRI is not a technology like the seed of high yielding varieties or like a chemical ferttilizer or insecticide. It is a system for managing plants, soil, water or nutrient together in mutually beneficial ways, creating synergies (Laulanie, 1993). With SRI management practices control or modify the microenvironment so that existing genetic potential 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). SRI is now a proven technology worldwide that can increase the productivity of irrigated rice cultivation by changing the management of plants, soil water and nutrients (Haden *et al.*, 2007; Kabir and Uphoff, 2007; Mishra *et al.*, 2006; Ceesay *et al.*, 2006; Latif *et al* .2005; Dobermann, 2004). SRI is a package of technologies that cuts the seed cost by 80-90% water savings of 25 to 50% . The system may require more labor but once the methods are mastered and complemented are being developed labor is saved. Furthermore SRI is environment friendly; accessible for farmers which have small land holdings and need to get highest yields possible from their available land, higher outrun with fewer broken grains, ripening about 7 days sooner than regular crops of the same variety, reducing the application of agrochemicals.

This details study was under taken with the following objectives:

- To compare the performances of the 16 rice varieties under SRI.
- Isolation of rice varieties responsive to SRI.

Chapter II

Review of Literature

CHAPTER II

REVIEW OF LITERATURE

Crop growth characters

Ahmed (2006) conducted and experiment at Agronomy Field Laboratory, Sher-e-Bangla Agricultural University, Dhaka during the period from December 2005 to May 2006 to study the influence of different cultivation methods on hybrid and inbred rice in boro season. The experiment consisted of two level of treatments viz. variety and cultivation method. The experiment was laid out in split-plot design with four replications. Experimental results showed that variety had significant effect on all the agronomic parameters except panicle length, total grains panicle^{-1}, straw yield and biological yield. The highest grain yield (8.26 t ha^{-1}) with lowest straw yield (7.25 t ha^{-1}) was obtained from Sonarbangla-1 and BRRI dhan 29 gave the lowest grain yield (7.53 t ha^{-1}) with highest straw yield (9.58 t ha^{-1}). Cultivation method also significantly influenced all the growth and yield attributes except unfilled grains panicle-1, 1000-grains weight and straw yield. The results revealed that nursery seedlings showed the best performance compared to other cultivation method. The highest grain yield (8.73 t ha^{-1}) and straw yield (9.21 t ha^{-1}) was obtained from the nursery seedlings and the lowest grain yield (7.23 t ha^{-1}) and straw yield (7.19 t ha^{-1}) was obtained from the SRI. Maximum harvest index 52.47 was calculated in the SRI and minimum harvest index 46.22 was found in the sprouted seeds broadcast. Tillers hill^{-1} of SRI was the highest among the treatments, however, it failed to perform well in terms of effective tillers m^{-2}, though sprouted seeds sown in line and broadcast showed opposite trends. The plants from sprouted seeds and SRI matured early compared to the nursery seedlings and clonal tillers. Sprouted seeds of the hybrid variety sown in line required 113 days, which is 33 days less than the required time for the traditional method of the inbred rice variety compared to the nursery seedlings and clonal tillers. Sprouted seeds of the hybrid variety sown in line required

113 days, which is 33 days less than the required time for the traditional method of the inbred rice variety.

Alam *et al.* (2009) carried out an experiment at the Agronomy field of the Sher-e-Bangla Agricultural University, Dhaka during the period from December, 2006 to June, 2007 study the relative performance of inbred and hybrid rice varieties at different levels of phosphorus. Three varieties of inbred and hybrid rice (BRRI dhan29, Aloron and Hira-2) and five levels of phosphorus (0, 24, 48, 72 and 96 Kg P_2O ha^{-1}) were the treatment variables. BRRI dhan29 and Aloron had statistically similar plant height at harvest and they were the tallest variety. BRRI dhan29 produced the lowest dry matter and aloron produced highest dry matter.

Al–mamun *et al.* (2011) found that weed competition is strong when the weed population increases and the weed growth is comparatively more exuberant and rapid than those of the desired crop plants. The weed species belonging to the family *poaceae* infested the experimental sight. All of them were grasses and they were *Paspalum disticum, echinochloa crugalli* and *Leersia hexandra.*

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.

Dilday *et al.* (1998); Kim *et al.* (1999); Azim *et al.* (2000) found that already a large number of rice varieties have found to suppress the several weed species when grown together under field and laboratory conditions.

Haque *et al.* (2006) conducted a field experiment to study the effect of nitrogen fertilizer on yielding ability of indigenous aromatic rice cultivars under stacking and non-stacking conditions. Rice cultivars were grown during *aman* season, 2002. There were four cultivars, namely, Shakkorkhora, Chinigura, Kalijira and Kataribhog, each with three levels of nitrogen fertilizer (0, 60 and 120 kg N ha^{-1}). They observed that leaf area index increased sharply after transplanting attaining a peak at heading stage and then decreased gradually towards maturity.

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 dhan-31 were used in both the seasons and BRRI hybrid dhanl was used in 2002. The main objective of the experiment was to compare the growth and yield behavior of hybrid and inbred rice varieties under controlled condition. They transplanted 30 day old seedlings in pots. They found that BRRI hybrid dhan1 produced 34.7 cm of roots at 75 DAT (105 DAS) and 36.26 g shoot dry matter in 50 DAT (80 DAS) and root: shoot length ration of 3.24 in 75 DAT (105 DAS).

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

Kavitha *et al.* (2010) carried out a field experiment during kharif seasons of 2006 and 2007, to study the effect of age of seedlings, weed management practices and humic acid application on SRI. Transplanting 14 days old seedlings with pre emergence application of Pretilachlor at the rate of 0.75 kg ha^{-1} and one mechanical weeding at 30 DAT and humic acid application as seedling dip (0.3%) and foliar spray twice significantly reduced weed growth and improved growth parameters, yield attributes and yield of rice.

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. SRI method produced significantly higher (3.99 t ha^{-1}) seed yield over traditional method. Although germination did not show significant variation among the methods of cultivation but vigor index recorded significantly higher values in SRI method. The 12 days seedlings produced more number of tillers per plant and productive tillers per plant. Wider spacing of 40 x 40 cm found to have significant influence on growth parameters. The younger seedlings (8 days-old) flowered about four to five days earlier as compared to 25 days-old seedlings. Significantly higher seed yield per ha (3.19 t) was produced by 12 days seedlings. The treatment combination of 12 days old seedling with wider spacing recorded maximum seed yield ha^{-1}. The seeds produced by transplanting of 12 days old seedlings with wider spacing recorded significantly higher germination and vigor index values.

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

Latif *et al.* (2005) Conducted an in experiments in eastern Bangladesh to investigate the system of rice intensification (SRI). In on-firm trials, they found that In SRI, 25 and 35% more labor was needed for weeding compared to BRRI and farmers' practices, respectively.

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

Mollah *et al.* (1992) observed that removal of greater numbers of tillers from the mother hill prolonged growth duration. This had, however, no influence on the grain yield and yield components as compared to the intact mother hill.

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.

Noguchi and Salam (2008) observed that the allelopathic potential of 102 Bangladesh rice (42 high yielding and 60 traditional cultivars) was determined against the seedling growth of cress, lettuce, *Echinochloa crusgalli* and *E. colonum.* High yielding rice cultivars, BRRI dhan37, BRRI dhan30 and BRRI dhan38 had the most significant inhibiting effect on the growth of cress, lettuce and *E. colonum,* and traditional rice cultivar, Kartikshail had the most significant inhibiting effect on barnyard grass. The high yielding rice cultivar, BR17 showed the greatest inhibitory activity with an average of 39.5% of the growth inhibition on roots and hypocotyls/shoots of cress, lettuce, barnyard grass and *E. colonum.*

San-oh *et al.* (2004) examined possible causes of the greater production of dry matter by plants broadcast in a submerged paddy field by comparing the characteristics of plants subjected to different methods of cultivation [the direct-sown plants (DSP) and transplanted plants (TP)] and with different planting patterns (51.3 hills m^{-2} and one plant per hill, namely, planting pattern I; and 17.5 hills m^{-2} and three plants per hill, namely, planting pattern III). The dry weight of aboveground parts at harvest and the grain yield were larger for DSP than for TP when we compared plants with the same planting pattern, and they were larger for plants in planting pattern I than for those in pattern III when we compared plants with the same cultivation method.

Satyanarayana *et al.* (2007) stated that when fields are not kept continuously flooded, weed growth becomes one of the problem, and farmers use excess water to reduce their labor requirements for weed control. Weeding can be quite labor demanding, but its timing is more flexible than in transplanting. So, weeding is a deterrent to SRI adoption.

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 (38.5% increase in root length over standard management practices) were observed in the morphology of SRI plants in terms of root growth. SRI produced 19.64% higher shoot length than standard management practices (SMP). 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 are index (34.18%).

Yield attributing components

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.

Anon. (2004b) embarked on trailing 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 increase 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 2004 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.

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 35cm×35cm spacing in Department of Agricultural Extension trials at Kishoregonj. But with the same spacing the number was 342 m^{-2} in locality 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 20cm×20 cm and 20cm×15cm spacing, respectively. At Kisoregonj the average number of filled grains per panicle with 35cm×35cm spacing was found more promising, which was 173 filled grains per panicle and 42 unfilled grain per panicle. At Rajshahi the average number of filled grains per panicle was 106 in case of SRI practice for local Parija variety and 70 in case of farmers practices. The grain weight was found 12% higher with SRI practice over farmers' practice (FP). The weight of 1000 grains was the lowest (18.75g) with 20cm×15cm spacing in case of farmers practice (FP) and the higher (28g) with 40cm×40cm spacing in case of SRI. 35cm×35cm spacing showed better performance both at locally Intensified Farming Enterprises and Department of Agricultural Extension trial 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 20cm×15cm spacing, respectively.

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

Bruno (2001) conducted on-farm experiments in the high plateau of Madagascar to evaluate the critical variables of SRI. Results showed that a minimum grain yield was about 8 t ha^{-1}. If the main factors were used under the optional conditions which had been identified through the experiment.

Chowhan (2003) reported that farmers were able to achieve on average, 30% higher production from SRI practice than traditional practice

Das (2003) reported that the System of Rice Intensification (SRI) gave more rice yield compared to the farmerns' practice (FP). The farmers from their SRI plots received 19% higher yield compared to their FP plots during *Boro* season in 2003. System of Rice Intensification (SRI) produced more straw (12%) compared to the hay produced in the farmers practice (FP) plot.

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 that 200% over the national average. So far these achievements result mainly from small plot sizes, but importantly aslo with traditional crop varieties and without chemical fertilizers.

Devaranjan (2005) reported that SRI method produced rice yields of 7 to 8 t ha^{-1} against normal 3 to 4 tons ha^{-1}.

Hirsch (2000) reproted that in rice sector in Madagascar SRI yields in the Antsirable and Amhoitra areas ranged between 6.7 and 10.2 t ha^{-1}, respectively.

Hossaen *et al.* (2011) conducted an experiment to evaluate the efficacy of different organic manure and inorganic fertilizer. The experiment consisted of 8 treatments on the yield and yield attributes of *Boro* Rice (*Oryza sativa* L.). BRRI dhan29 was the variety under experiment. The maximum number of effective tillers $hill^{-1}$ (13.52), the longest panicle (24.59 cm), maximum number of total grains $plant^{-1}$ (97.45), the highest weight of 1000 seeds (21.80 g), the maximum grain yield (7.30 t ha^{-1}) and straw yield (7.64 t ha^{-1}) was recorded from the treatment of 70% NPKS +2.4 t poultry manure ha^{-1}. Maximum harvest index 48.84% was observed in the treatment 70% NPKS + 2.4 t poultry manure ha^{-1}.

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 methods was mostly the outcome of higher total number of tillers $hill^{-1}$, highest panicle length and highest number of grain $panicle^{-1}$. Conventional method produced the lowest straw yield (4.29 t ha^{-1}).

Islam (1999) stated that in the SRI method plant spacing of 25cm×25cm or 20cm×20cm, yields were about the same (9.5 t ha^{-1} and 9.2 t ha^{-1}, respectively) but with spacing of 30cm×30cm, the yield increased up to 10.5 t ha^{-1}.

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

Latif *et al.* (2005) conducted a series of experiments in eastern Bangladesh to investigate the System of Rice Intensification (SRI). They observed that, BRRI dhan29 had the highest number of effective tillers m^{-2} (312.3). BRRI dhan29 had 250.3 effective tillers m^{-2}. BRRI dhan35 had 284.0 effective tillers m^{-2}, BRRI dhan36 had 282.7 effective tillers m^{-2}, BRRI Hybrid dhan1 had 286.78 effective tillers m^{-2}. SRI always resulted in higher panicle lengths than BRRI recommended practices and farmers practices. BRRI dhan 29 had 24.48 cm panicle length in SRI practice, 24.12 cm in BRRI recommended practice and 22.32 cm in farmers practice in Vagurapara, Chandina. In Matiara, sadar panicle lengths were 24.89 cm, 24.14 cm and 22.28 cm in respectively SRI, BRRI recommended and farmers practice. BRRI dhan28 had highest number of unfilled grains $panicle^{-1}$ (41.67). BRRI dhan29 had 28.0 unfilled grains $panicle^{-1}$, BRRI dhan35 had 41.33 unfilled grains $panicle^{-1}$, BRRI dhan36 had 27.67 unfilled grains $panicle^{-1}$, BRRI Hybrid dhan1 had 32.33 unfilled grains $panicle^{-1}$. BRRI dhan28 had 21.56 g thousand grain weight, BRRI dhan29 had 21.58 g thousand grain weight, BRRI dhan35 had 21.25 g thousand grain weight, BRRI dhan36 had 21.60 g thousand grain weight, BRRI Hybrid dhan1 had 21.53 g thousand grain weight. Thousand grain weight of BRRI dhan29 for 1 and 2 seedlings in SRI were 21.84 g and 22.12g respectively, for BRRI recommended practice with 2-3 seedlings, thousand grain weight was 22.17 and all of them were statistically similar. In comparison of short and long-duration varieties, the long-duration variety BRRI dhan29 yielded highest with SRI practices. In on farm trials, BRRI recommended management practices performed significantly well than SRI and resulted in higer grain yield.

Mazid *et al.* (2003) found that conventional practices of rice cultivation gave significantly higher grain yield compared to the SRI method of crop establishment. SRI method with 30 cm×30cm and 40 cm×40cm spacing and younger seedlings increased number of panicles/hill but total number of panicles per unit area was found to be low. They further included that, the SRI practice was not necessary for growing rice near the yield potential, and the conventional method of crop establishment was recommended for tice cultivation.

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

Miah *et al.* (2008) conducted an experiment in different northern districts viz. kurigram, Lalmonirhat and Gaibandha during 2006-07 cropping season under Agro-ecological zone-2 (Active Tista Floodplain) of Bangladesh. An attempted was made in *boro* season with view to know the effectiveness of System of Rice Intensification (SRI) planting method over the traditional planting method on growth and yield of *boro* rice (BRRI dhan28). Higher grain yield (7.50 t ha^{-1}) were obtained from SRI planting method in Kurigram. The highest 1000-grain weight (27 g) were obtained from SRI planting method in Gaibandha. On the other hand, the lowest 1000- grain weight (19.00g) were produced at Lalmonirhat.

Nissanka and Bandara (2004) evaluated the productivity of System of Rice Intensification (SRI) method with conventional rice farming systems in Sri Lanka. The tiller numbers at heading were significantly higher in SRI compared to other treatments. However when expressed in unit area basis, were not significantly different. Grain yield was 7.6 t ha^{-1} n the SR and it was 9%, 20% and 12% greater than the conventional transplanting and normal and high density broadcasting.

Oliver *et al.* (2008) conducted a field experiment at the Bangladesh Agricultural University (BAU) to find out possible effects of alternate wetting and drying irrigation (AWDI) on the yield, water use and water use efficiency (WUE) of *Boro* rice. The experimental layout was furnitured using split plot design (SPD) with two modern varieties (MV) of rice viz. BRRIdhan28 and BRRIdhan29, which received four irrigation treatments randomly and was replicated thrice. The treatments ranged from continuous submergence of the field to a number of delayed irrigations denoting application of 5 cm irrigation water when water level in the perforated PVC pipe fell 10, 20 and 30 cm below ground level (G.L.). They found that BRRI dhan28 produced highest 9.00 effective tillers hill^{-1} and BRRI dhan29 produced 11.00 effective tillers hill^{-1}. BRRI dhan28 produced 171.0 grains panicle^{-1} and BRRI dhan29 produced 217.67 grains panicle^{-1} in case of continuous submergence of soil with irrigation water. BRRI dhan28 produced highest number of unfilled grains per panicle (8.67) when water level fell 30 cm below ground level and in case of BRRI dhan29 highest number of unfilled grains per panicle (9.33) was produced when the water level fell 10 and 20 cm below ground level.

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}.

Reddy (2005) conducted a field experiment where SRI was compared with existing traditional cultivation methodology. In both systems (traditional and SRI), it was fonund that SRI could produce similar yield with less inputs.

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

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

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 an unrecognized, but significant, untapped growth potentials 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 the original reports of extraordinary high yields were likely to be the consequences of error.

Thakur *et al.* (2010) conducted an experiment in eastern India over three years, 2005-2007, to compare the performance of certain System of Rice Intensification (SRI) practices: transplanting single, young (10 days old) seedlings in a square pattern; no continuous flooding; and use of a mechanical weeder -with those currently endorsed by the Central Rice Research Institute of India, referred to here as recommended management practices (RMP). All plots received the same fertilization, a combination of organic and inorganic nutrients, and the SRI spacing used was 20% less than usually recommended. These selected SRI practices out-yielded RMP by 42%, with the higher yield. Significant measurable changes were observed in physiological processes and plant characteristics, such as longer panicles, more grains panicle^{-1} and higher percentage of grain-filling. The decreased plant density with SRI management was compensated for by increased per plant productivity. SRI hills with single plants were found to have deeper and better distributed root systems, higher xylem exudation rates, more open plant architecture with more erect and larger leaves, and more tillers than did RMP hills having multiple plants.

Thakur *et al.* (2011) conducted a field experiment in Bhubaneswar, 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 and physiology and what would be their impact on resulting crop performance, compared with currently recommended scientific management practices (SMP), including continuous flooding (CF) of paddies. The variety experimented was a medium duration variety named Surendra. The found that the average panicle length in SRI (22.5 cm) was higher than panicles in SMP (18.7cm). SRI produced higher number of total grains panicle^{-1} higher 1000-grain weight (g) than SMP. With SRI practices, grain yield was increased significantly and straw yield was lower over the standard management practices (SMP). SRI produced 13.79 t ha^{-1} biological yield compared to 13.57 t ha^{-1} of biological yield produced in standard management practices. Although grain yield was much higher in SRI compared to SMP and incase of straw yield it was vise versa. The harvest index in SRI was 47.21% over the harvest index of 32.42%. in SMP.

Uddin *et al.* (2012) carried out a field study with BRRI dhan29 at the Soil Science field laboratory, BAU, Mymensingh during the period from February to June 2007 to evaluate the effects of split application on the yield, nutrient content, and nutrient uptake of BRRI dhan29. They found highest biologial yield to be 11.82 t ha^{-1}.

Uphoff (2004b) reported that SRI offer unprecedented opportunities for improving rice production in a variety of situations around the world, not just by increments but even by multiples. SRI sounds 'too good to be true, but increasing evidence from research and its spreading adoption by farmers were showing that SRI was as productive and as beneficial as reported by its proponents, initially Association Tefy Saina, an indigenous NGO in Madagascar. Less than five years ago, SRI was known and practiced only in Madagascar. Today there were confirming results from 18 additional countries ranging from China to Peru, with average yields from SRI in the 7-8 t ha^{-1} range, and with yields over 15 t ha^{-1} reported from at least four countries beyond Madagascar.

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.

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 System of Rice Intensification (SRI) cultivation. The production increased could be notable. With these modifications, grain yield exceeded 12t ha^{-1}, 46% greater than in control using field comparison.

Chapter III

Materials and Methods

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted in the Agronomy field Laboratory, Sher-e-Bangla Agricultural University, Dhaka-1207 during the period from December, 2011 to May, 2012.

3.1 Site description

3.1.1 Geographical location

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

3.1.2 Agro-ecological Region

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

3.1.3 Climate

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

3.1.4 Soil

The soil of the experimental site belongs to the general soil type, Shallow Red Brown Terrace Soils under Tejgaon Series. Top soils were silt loam in nature. After harvest of crops the pH ranged from 5.5 (highly acidic)-6.4 (slightly acidic). The percentage of organic matter percentage ranged from 0.74 (very low)-1.95 (medium), total Nitrogen percentage ranged from 0.037 (vary low)-0.097 (low). Available Potassium (mg 100 g^{-1} soil) ranged from 0.17 (medium)- 0.33 (high). Available Phosphorus ranged from (μg g^{-1} soil) 33.2-39.2 (Appendix IV).

3.2 Details of the experiment

3.2.1 Treatments

1.BR3 (V_1)
2.BR14 (V_2)
3.BR16 (V_3)
4. BRRI dhan28 (V_4)
5. BRRI dhan29 (V_5)
6. BRRI dhan36 (V_6)
7. BRRI dhan45 (V_7)
8. BRRI dhan50 (V_8)
9. Binadhan-6 (V_9)
10. Bina new line (V_{10})
11. BRRI hybrid dhan1 (V_{11})
12. BRRI hybrid dhan2 (V_{12})
13. BRRI hybrid dhan3 (V_{13})
14. Chamak (V_{14})
15. Hiral (V_{15})
16. Bhajan (V_{16})

3.2.2 Experimental design

The experiment was laid out in a Randomized Complete block design with three replications. Total numbers of unit plots were 48. The size of unit plot was 3m×2.7m (8.1m^2) . The distances between plot to plot and replication to replication were 0 .75m and 1m respectively. The layout of the experiment has been shown in the Appendix II.

3.3 Planting material

Sixteen rice varieties were used as plant material.

3.3.1 Description of variety: BR3

BR3, a high yielding variety of *aus*, *aman* and *boro* season was developed by the Bangladesh Rice Research Institute (BRRI), Joydebpur, Gazipur, Bangladesh. It was released in 1970. It was obtained by the cross of IR 506-1-133 and local variety Lotishile. Its genetic line number is 27-10-1. It takes 130 days to mature in *aus* season, 145 days in *aman* season and 170 days in *boro*. It attains a plant height of 95-100 cm. The grains are medium bold. The cultiver gives an average grain yield of 4.0 t ha^{-1} for *aus* and *aman* and 6.5 t ha^{-1} in *boro*.

3.3.2 Description of variety: BR14

BR14, a high yielding variety of *aus*, and *boro* season was developed by the Bangladesh Rice Research Institute (BRRI), Joydebpur, Gazipur, Bangladesh. It was released in 1983. It was obtained by crossing IR 5 and BR3. The flag leaf of this variety tends to droop of after panicle initiation. Grains on the upper portion of the panicle have awn. It is a strong and tall variety so it does not go under water even with waste high flood in the field. It takes 160 days to mature in *boro* season. It attains a plant height of 120 cm. The grains are medium bold white. The variety gives an average grain yield of 5.0 t ha^{-1} for *aus* and 6.0 t ha^{-1} for *boro* season.

3.3.3 Description of variety: BR16

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

3.3.4 Description of variety: BRRI dhan28

BRRI dhan28, a high yielding variety of *boro* season was developed by the Bangladesh Rice Research Institute (BRRI), Joydebpur, Gazipur, Bangladesh. BRRI dhan28 is obtained from the cross between BR6 and purbachi and it was released in 1994. It is a very popular variety for *boro* season and it attains a plant height of 90 cm. It gives an average yield of 6.0 t ha^{-1} in 140 days of growth duration. The flag leaf tends to droop when the panicle comes out and the grain is medium slender and white.

3.3.5 Description of variety: BRRI dhan29

BRRI dhan29, a high yielding variety of *boro* season was developed by the Bangladesh Rice Research Institute (BRRI), Joydebpur, Gazipur, Bangladesh. It was released in 1994. It takes 155 days to mature. It attains a plant height of 95-100 cm and at maturity the flag leaf remains green and erect. The grains are medium slender with light golden husks and kernels are white in color. The variety gives an average grain yield of 7.5 t ha^{-1}.

3.3.6 Description of variety: BRRI dhan36

BRRI dhan36, a high yielding variety of *boro* season was developed by the Bangladesh Rice Research Institute (BRRI), Joydebpur, Gazipur, Bangladesh BRRI dhan 36 is a *boro* variety which gives an average yield of 5.0 t ha^{-1} in 140 days of growth duration. It has long and slender grain shape and size. This variety was released in the year of 1998. It is a cold tollerant variety and it is an early variety.

3.3.7 Description of variety: BRRI dhan45

BRRI dhan45, a high yielding variety of *boro* season was developed by the Bangladesh Rice Research Institute (BRRI), Joydebpur, Gazipur. It is a *boro* variety for cultivation in *boro* season and it was released in the year of 2005. This variety attains an average plant height of 100 cm. It gives an average yield of 6.5 t ha^{-1} in 145 days of growth duration.

3.3.8 Description of variety: BRRI dhan50

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

3.3.9 Description of variety: Binadhan-6

This variety also released in 1998 by Bangladesh Institute of Nuclear Agriculture. Its plant height is similar to Binadhan-5, but it bears more tillers and gives a maximum grain yield of 9.0 tons ha^{-1} with an average yield of 7.5 t h^{-1}, which is higher than hybrid rice. Maturity period is about 160-165 days. Grains are medium bold and bright in colour.

3.3.10 Description of variety: Bina new line

This is experimental line under study by Bangladesh Institute of Nuclear Agriculture. It is expected to mature in 150 days.

3.3.11 Description of variety: BRRI hybrid dhan1

It is a hybrid variety for *boro* season developed and released by Bangladesh Rice Research Institute (BRRI), Joyedebpur, Gazipur in the year of 2001. This is the first hybrid variety released by BRRI. The stem and leaves of this variety is deep green and erect so it receives sunlight equally and carbohydrate synthesis is higher. Rice grain is medium coarse. Transparent and white. Rice grains of this variety contains 8.9% protein and 27.0% amylase. This variety plants attains 110 cm of height at 155 days of growth duration and gives an average yield of 8.5 t ha^{-1}.

3.3.12 Description of variety: BRRI hybrid dhan2

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

3.3.13 Description of variety: BRRI hybrid dhan3

BRRI hybrid dhan3 was released in 2009 by BRRI. It is the genetic line BR 1251H obtained by hybridization of BR11A and BR 063-4-4-3-1R. It gives an amazing yield of 9.0 t ha^{-1} in 145 days of growth duration. Plants attains a height of 110 cm. Rice grians are medium coarse and this is an early hybrid variety which can also be cultivated as an alternative to BRRI dhan28.

3.3.14Description of variety: Chamak

Chamak is a hybrid rice variety imported from China.

3.3.15 Description of variety: Hira1

Hira1 is a hybrid rice which is released by the Supreme Seed Co. Ltd. This rice variety was imported from China. The life cycle is around 150 days. The yield is aroung 8.0 t ha^{-1}.

3.3.16 Description of variety: Bhajan

Bhajan is a local rice variety cultivated in *boro* season. This variety is cultivated in Jessore region and probably locally introduced from India.

3.4 Crop management

3.4.1 Seedling raising

3.4.1.1 Seed collection

Seeds of BR3, BR14, B16, BRRI dhan28 , BRRI dhan29, BRRI dhan36, BRRI dhan45, BRRI dhan50, BRRI hybrid dha1, BRRI hybrid dhan2, BRRI hybrid dhan3 were collected from Genetic Resources and Seed Division, BRRI, Joydebpur, Gazipur, Bangladesh. Binadhan-6 and Bina new line were collected from BINA, BAU campus, Maymensingh-2202. The variety Hira1 was collected from Supreme Seed Co. Ltd., Amin Court (8th Floor) 62-63, Motijheel. Chamk was also collected from a private seed company. Both Hira1 and Chamak 1 hybrid varieties originated from Chaina. Bhajan is a local variety which is cultivated in Jessore region and seed was collected from the farmers of that locality.

3.4.1.2 Seed sprouting

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

3.4.1.3 Preparation of seedling nursery

Sprouted seeds were sown as broadcast in 16 portable trays containing soil and cow dung each for the 16 varieties. Thin plastic sheets were placed at the base of the trays to protect water loss. The moisture of the trays was controlled accurately by applying water every day, which were kept inside a room at night to protect the seedlings from freezing temperature of the season and kept in sunlight at daytime for proper development of seedlings.

3.4.1.4 Seed Sowing

Seeds were sown in the portable trays on December 27, 2011. Sprouted seeds were sown uniformly as possible.

3.4.2 Collection and preparation of soil sample

Soil samples were collected in three steps. as before applying compost and fertilizers in the field, after applying compost and fertilizers in the field and 16 samples were collected from the 16 plots of the first replication after the harvest of crop. The first two samples were composite samples made by collecting soil from different locations of the experimental field and thoroughly mixing it together. Then the samples were air dried and sieved through a 10-mesh sieve and stored in a clean plastic container for physical and chemical analysis.

3.4.3. Preparation of experimental field

The experimental field was first ploughed on December 20, 2010 with the help of a tractor drawn plough, later on January 4, 2011 the land was irrigated and prepared by three successive ploughing and cross ploughing with a tractor drawn plough and subsequently leveled by laddering. Immediately after final land preparation, the field layout was made on January 6, 2012. Individual plots were cleaned and finally leveled with the help of wooden plank so that no water pocket could remain in the puddled field.

3.4.4 Fertilizer application

The experimental area was fertilized with 110, 90, 76, 60, 7 kg ha^{-1} Urea, TSP, MP, Gypsum and zinc sulphate, respectively. The entire amounts of triple super phosphate, muriate of potash, gypsum and zinc sulphate were applied as basal dose at final land preparation. Urea was top-dressed in three equal installments, after seedling recovery, during the vagetation stage and at 7 days before panicle initiation.

3.4.5 Uprooting and transplanting of seedlings

In case of SRI treatments 12 days old seedlings were uprooted from the trays and transplanted on January 7, 2011. The trays were brought to the main field and seedlings were planted in the prepared plot just after uprooting and this process was completed within one minute.

3.4.6 Intercultural operations

3.4.6.1 Thinning and gap filling

After transplanting the seedlings gap filling was done whenever it was necessary using the remaining seedlings from the previous sources.

3.4.6.2 Weeding

The crop was infested with some weeds during the early stages of crop establishment. Two hand weeding were done, first weeding was done at 15 days after transplanting followed by second weeding at 30 days after first weeding.

3.4.6.3 Application fo irrigation water

Water management is the most important and complicated aspect of SRI method. Alternate wetting and drying of crop field is desired in SRI method. Water level should be dried in such a level that hairline cracks should develop in the field. The irrigation must be applied to such amount that the field remains moist. But not fully submerged. The field was allowed to dry for 4 to 5 days after each irrigation for better root growth and maximum tillering throughout the vegetative phase. From panicle initiation (PI) to hard dough stage, a thin layer of water (2-3 cm) was kept on the plots. Again water was drained out from the plots during the end of ripening stage.

3.4.6.4 Plant protection meausres

Plants were infested with rice stem borer (*Scirpophaga incertolus*) to some extent which was successfully controlled by applying Diazinon @ 10 ml 10 litre^{-1} water for 5 decimal lands when infestation was observed. Crop was protected from birds during grain filling period. Watching was done propely, especially during morning and afternoon.

3.4.6.5 Harvesting and post harvest operation

Maturity of crop was determined when 90% of the grains become golden yellow in color. The harvesting was done by cutting the hills above the soil from 6 m^2 harvest area of each plot. The harvesting plants were bundled and tagged properly, carried to the threshing floor, threshed, separately and weighed after proper sun drying at 14% graind moisture level.

3.4.7 Recording of data

Experimental data were determined from 30 days of growth duration and continued until harvest. Dry weights of plant were collected by harvesting respective number of hills at different dates from the inner rows leaving border rows and harvest area for grains. The following data were determined during the experimentation.

A. Crop growth characters

i. Seedling mortality plot^{-1} (%)
ii. Plant height (cm) at 30, 60, 90 DAT and at harvest
iii. Plant root length (cm) at 30, 60, 90 DAT and at harvest

iv. Plant shoot length (cm) at 30, 60, 90 DAT and at harvest
v. Plant root length: shoot length at 30, 60, 90 DAT and at harvest
vi. Plant dry weight (g) at 30, 60, 90 DAT and at harvest
vii. Leaf area index (LAI) at 30, 60, 90 DAT and at harvest
viii. Time of initial and fifty percent flowering
ix. Weed population m^{-2} and weed dry matter m^{-2} at 30 and 60 DAT
x. Number of tillers $hill^{-1}$ at 30, 60, 90 DAT and at harvest
xi. Time of harvest

B. Yield attributing components

i. Effective tillers $hill^{-1}$ at harvest (no.)
ii. Ineffective tiller $hill^{-1}$ at harvest (no.)
iii. Panicle length (cm)
iv. Grains $panicle^{-1}$ (no.)
v. Filled grains $panicle^{-1}$ (no.)
vi. Unfilled grains $panicle^{-1}$ (no.)
vii. Weight of 1000-grains (g)
viii. Grain yield (t ha^{-1})
ix. Straw yield (t ha^{-1})
x. Biological yield (t ha^{-1})
xi. Harvest index (%)

3.4.8 Detailed procedure of recording of data

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

A. Crop growth characters

i. Seedling mortality $plot^{-1}$ (no.)

The number of dead seedlings in each plot was counted visually at 7 and 14 days after transplantation from which seedling mortality rate (%) was calculated.

ii. Plant height (cm)

Plant height was measured at 30, 60, 90 DAT and at harvest. The height of the plant was determined by measuring the distance from the soil surface to the tip of the leaf height before heading and to the tip of panicle after heading. Plant height was measured in cm.

iii. Plant root length (cm)

Plant root length was measured at 30, 60, 90 DAT and at harvest. Two hills from each plot were uprooted at respective dates from which root length were measured by beginning from the base of the plant to the tip of the root. Plant root lengths were measured were in cm.

iv. Plant shoot length (cm)

Plant shoot length was measured at 30, 60, 90 DAT and at harvest. Two hills from each plot were uprooted randomly at respective dates from each plot and root length were measured by beginning from the base of the plant to the tip of the leaf when in vegetative condition and to the tip of the panicle after heading. Plant shoot lengths were measured in cm.

v. Plant root length: shoot length ratio

Shoot lengths measured at 30, 60, 90 DAT and at harvest were divided by the root lengths measured at 30, 60, 90 DAT and at harvest and the ration was recorded.

vi. Dry weight of plant (g)

The sub-samples of 2 hills plot^{-1} was uprooted from predetermined line which were oven dried until constant level. From which the weight of above ground dry matter were recorded at 30 days intervals and at harvest. Dry weight was measured in g.

vii. Leaf area index (LAI)

The leaf area of plant is one of the major determinants of its growth. It is the ration of leaf area to its ground area (Radford, 1967) and it is the functional size of the standing crop on unit land area (Hunt, 1978). It depends on the growth, number of leaves plant^{-1}, population density and leaf senescence (Khan, 1981). The higher productivity of a crop depends on the persistence of high LAI over a greater part of its vegetative phase. The rate of crop photosynthesis depends on the LAI. After germination LAI increases and reaches the peak levels after that in declines due to increased senescence (Katiya, 1980). Leaf area index were estimated measuring the length and average width of lead and multiplying by a factor of 0.75 followed by Yoshida (1981).

viii. Time of initial and fifty percent flowering

Time of flowering (days) was recorded when first flowers emerged in a plot and when 50% flowers emerged in a plot.

ix. Weed population and weed dry matter

Weed population and weed dry weight was calculated by taking quadrate in each plot and collecting all the weed available within that quadrate and counting their number and taking weight as oven dry basis. Weeding was completer after taking weed samples from each plot.

x. Time of harvest

Time of harvest (days) was recorded when the crop was harvested.

B. Yield and yield attributing characters

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

The panicle which had at least one filled grain was considered as effective tiller. The number of effective tiller of 5 hills were recorded and the mean was expressed as number of non-effective tillers hill^{-1}.

ii. Non-effective tillers hill^{-1} (no.)

The panicle which had no grain was considered as ineffective tillers. The numbers of non-effective tillers of 5 hills were recorded and the mean was expressed as effective tiller number hill^{-1}.

iii. Total tillers hill^{-1} (no.)

Number of tillers hill^{-1} were counted at 30, 60, 90 DAT and at harvest from five randomly pre-selected hills and averaged and was expressed as number hill^{-1}. Only those tillers having three or more leaves were used for counting.

iv. Length of panicle (cm)

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

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

Grains were considered to be filled if 50% kernel was present there in. The number of total filled grains present on ten panicles were recorded and finally averaged.

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

Unfilled grains means absence of less than 50% kernel inside and such grains present each of ten panicles were counted and finally averaged.

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

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

viii. Weight of 1000 grains (g)

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

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

Grain yield was determined from the central area of 6 m^2 from each plot and expressed as t ha^{-1} and adjusted with 14% moisture basis. Grain moisture content was me*asu*red by using a digital moisture tester.

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

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

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

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

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

xii. Harvest index (%)

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

Harvest index (%) = grain yield/biological yield×100.

3.4.9 Chemical analysis of soil samples

Soil sample were analyzed for both for physical and chemical preparation in the laboratory of the SRDI, Farmgate, Bangladesh. The properties studied included pH, organic matter, total N, available Phosphorus, and exchangeable K. The soil was analyzed following standard methods.

3.4.10 Statistical analysis

All the collected data were analyzed following the analysis of variance (ANOVA) technique using MSTAT package and the mean difference were adjusted by LSD technique. (Gomez and Gomez, 1984).

Chapter IV

Results and Discussion

CHAPTER IV

RESULTS AND DISCUSSION

This study was conducted to screen rice varieties responsive to SRI (System of Rice Intensification) in *boro* season. Analysis of variance of data on different growth, development and yield attributing characters as well as yield as influenced by System of Rice Intensification are presented and interpreted here. The results are also presented and discussed under this section.

4.1 Crop growth character

4.1.1 Seedling mortality rate

Significant difference was found in case of seedling mortality rate (%) within the sixteen rice varieties (Appendix V). Each plot had 8.1 m^2 and 90 plants of population. BRRI dhan-28 had the highest seedling mortality in both 7 DAT and 14 DAT (12.95% and 9.61% respectively). The variety Chamak had lowest tiller mortality (1.11%) in 7 DAT and Bhajan had the lowest seedling mortality (0.74%) in 14 DAT (Fig 1). BRRI dhan28 had 11.86% higher tiller mortality compared to the variety Chamak in 7 DAT and 8.89% higher tiller mortality rate compared to the variety Bhajan in 14 DAT (Fig 1). The descending order of the varities for seedling mortality at 7 DAT was BRRI dhan28 > BRRI hybrid dhan3 > BRRI dhan45 > BRRI dhan29 > Bina new line > Hira1 > BR14 > BRRI dhan36 > BRRI hybrid dhan1 > BRRI dhan50 > Binadhn6 > Bhajan > BR16 > Chamak > BR3 > BRRI hybrid dhan2. The descending order of the varieties for seedling mortality at 14 DAT was BRRI dhan28 > BRRI dhan29 > BRRI hybrid dhan1 > BRRI dhan45 > Chamak > BR3 > BR14 > BRRI dhan50 > BRRI hybrid dhan3 > BRRI dhan36 > BR16 > Bina new line > Binadhan-6 > BRRI hybrid dhan2 > Hira1 > Bhajan.

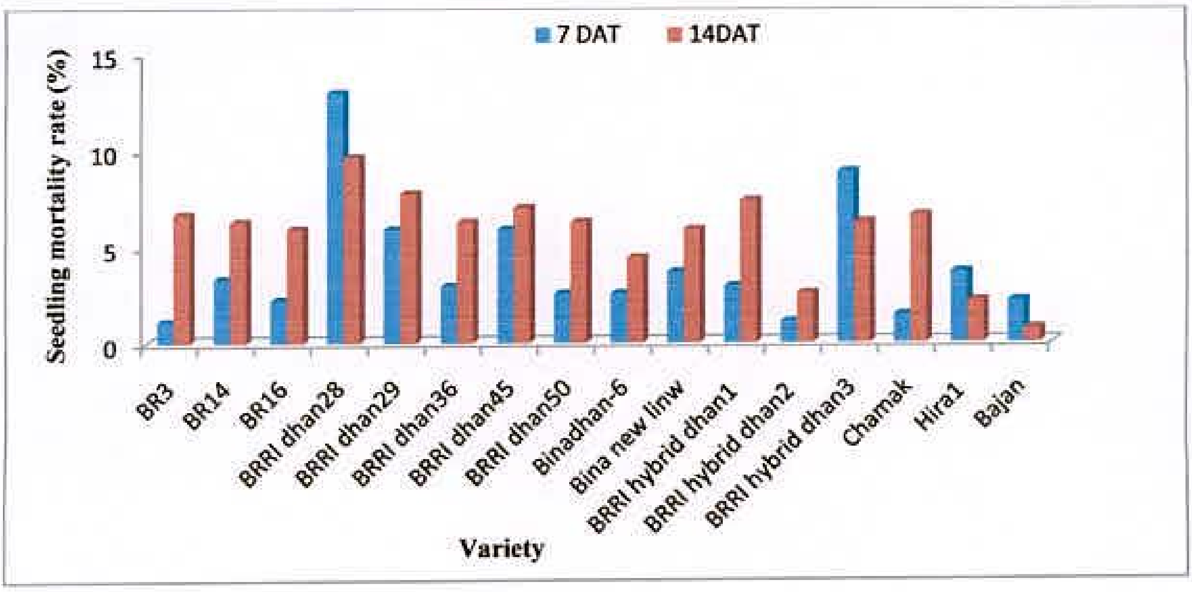

Figure 1. Seedling mortality at 7 DAT and 14 DAT of sixteen *boro* rice varieties cultiveated in System of Rice Intensification [$LSD_{(0.05)}$ at 7 DAT= 6.81, 14 DAT=6.19]

4.1.2 Plant height

Significant difference was found in plant height of the sixteen rice varieties in 30, 60, 90 DAT and at harvest (Appendix VI). At 30 DAT, BRRI hybrid dhan2 (20.90) had highest and BR3 (15.00cm) had lowest plant height. BRRI hybrid dhan2 was 22.23% higher in plant height than BR3 (Table 1). The descending order of the plant height of the sixteen rice varieties at 30 DAT was BRRI hybrid dhan2 > BRRI hybrid dhan1 > Hira1 > Bhajan > BRRI dhan50 > Bina new line > BRRI dhan36 > BRRI dhan45 > BR16 > Chamak > Binadhan-6 > BRRI hybrid dhan3 > BR14 > BRRI dhan28 > BRRI dhan29 > BR (table 1). At 60 DAT, Bina new line (48.62 cm) had the highest shoot length and BR3 (35.43 cm) had the lowest shoot length and Bina new line was 27.13% taller than BR3 (Table 1). The descending order of the sixteen rice varieties for plant height at 60 DAT was Bina new line > BRRI dhan36 > Chamak > Hira1 > BRRI hybrid dhan1 > BR14 > BRRI hybrid dhan2 > Binadhan-6 > Bhajan > BRRI hybrid dhan3 > BRRI dhan50 > BR16 > BRRI dhan45 > BRRI dhan28 > BRRI dhan29 > BR3. In 90 DAT, statisticallly significant difference was found and BRRI dhan45 (88.73 cm) showed the highest shoot length. BR3 (56.30 cm) had the shortest shoot length in 90 DAT like at 60 DAT. No other plant had shoot length statistically similar to BR3 in 90 DAT. BRRI dhan45 was 36.55%

taller than BR3 in 90 DAT (table 1). The descending order of the sixteen rice varieties for their plant height at 90 DAT was BRRI dhan45 > Bina new line > BR14 > BRRI dhan28 > Hira1 > BRRI dhan36 > BRRI hybrid dhan2 > Chamak > BRRI hybrid dhan1 > Binadhan-6 > Bhajan > BRRI hybrid dhan3 > BRRI dhan50 > BRRI dhan29 > BR16 > BR3. At harvest, Binadhan-6 (107.7 cm) had the highest plant height. No other rice variety but BRRI hybrid dhan1 (104.4cm) had statistically significant plant height to Binadhan-6. BRRI dhan50 had the lowest plant height (78.17cm). BR3 and BRRI dhan36 had statistically similar plant height. BR14, Bina new line, Hira1 showed higher plant height until 90 DAT. BR3 was the shortest variety until the harvest. Alam *et al.* (2009) found that hybrid varieties Aloron and Hira-2 had statistically similar plant height till 100 DAT. Plant height of Hira-2 became shorter than Aloron at harvest. Plant height of Hira-2 was 98.24 cm at harvest which is almost equal to the shoot length Hira1 found in this experiment (98.13 cm). Plant height of BRRI dhan29 was found to be 100.26 cm by alam *et al.* (2009) which is 10.70% taller than the plant height observed in this experiment. Ahmed (2006) stated that among five cultivation methods (sowing sprouted seeds in line, sowing sprouted seeds in broadcast, transplanting nursery seedlings and clonal tiller cultivation), at 30 DAS/T, the tallest plant (74.08 cm) was obtained from the clonal tillers followed by the SRI (44.41 cm) which was statistically similar with the nursery seedlings (43.53 cm) and the shortest plant height (25.89 cm) was obtained from the sprouted seeds in line that was statistically similar with the sprouted seeds broadcast (27.61 cm). The tallest plant height (95.47 cm) was recorded at 50 DAS/T from the clonal tillers followed by the nursery seedlings (80.74 cm). Similar trend was also observed at 70 DAS/T. At harvest, the tallest plant (107.73 cm) was obtained from the SRI, which was statistically similar with the nursery seedlings (106.12 cm) and sprouted seeds in line (103.71 cm) and the shortest plant height was obtained from the clonal tillers (102.15 cm) that was similar with the sprouted seeds broadcast (101.98 cm).

Table 1. Plant height of sixteen *boro* rice varieties at different growth stages grown in the system of rice intensification

Treatments	Plant height (cm) at			
	30 DAT	60 DAT	90 DAT	harvest
BR3 (V_1)	15.00 d	35.43 e	56.30 g	83.47 e-g
BR14 (V_2)	17.00 a-d	45.09 a-d	80.67 a-c	97.20 bc
BR16 (V_3)	19.08 a-d	41.90 b-e	62.47 fg	87.80 d-f
BRRI dhan28 (V_4)	16.00 b-d	39.76 c-e	80.63 a-c	92.53 cd
BRRI dhan29 (V_5)	15.46 cd	39.55 de	64.76 e-g	89.53 de
BRRI dhan36 (V_6)	19.47 a-d	47.19 ab	77.71 b-d	81.67 fg
BRRI dhan45 (V_7)	19.13 a-d	43.10 b-e	88.73 a	89.60 de
BRRI dhan50 (V_8)	19.69 a-d	41.88 a-d	67.75 d-f	78.17 g
Binadhan-6 (V_9)	18.01 a-d	43.87 a-d	74.44 c-e	107.70 a
Bina new line (V_{10})	19.57 a-d	48.62 a	87.34 ab	98.90 bc
BRRI hybrid dhan1 (V_{11})	20.70 ab	45.55 a-d	75.20 c-e	104.40 ab
BRRI hybrid dhan2 (V_{12})	20.90 a	45.02 a-d	77.48b cd	93.73 cd
BRRI hybrid dhan3 (V_{13})	17.00 a-d	43.55 a-d	72.49 c-f	94.67 cd
Chamak (V_{14})	18.99 a-d	46.23 a-c	75.79 cd	97.47 bc
Hiral (V_{15})	20.39 ab	45.87 a-d	79.43 a-c	98.13 bc
Bhajan (V_{16})	20.18 a-c	43.82 a-d	73.35 c-e	94.20 cd
LSD (0.05)	4.76	6.64	10.58	7.35
CV (%)	15.41	9.15	8.50	4.74

4.1.3 Plant root length

Statistically significant difference was found among the plant root length of the sixteen rice varieties at 30, 60, 90 DAT and at harvest (Appendix VII). At 30 DAT, highest plant height was for the variety Hira1 (12.80 cm) and BRRI dhan45 (7.08 cm) had lowest plant root length at 30 DAT. Hira1 was had 44.69% higher root length than BRRI dhan45. All the verities but Hira1 had statistically similar root length. The descending order of the numerical values for plant root length of varieties at 30 DAT was Hira1 > BRRI hybrid dhan1 > Bina new line > BRRI hybrid dhan3 > BR3 > BRRI dhan50 > BRRI dhan36 >Bhajan > Chamak > Binadhan-6 > BRRI hybrid dhan2 > BR14 > BR16 > BRRI dhan28 > BRRI dhan29 > BRRI dhan45 (Table 2). At 60 DAT, BR16 (34.35 cm) had the highest root length and BRRI dhan36, BRRI dhan50, Binadhan-6, BRRI hybrid dhan1, BRRI hybrid dhan2, Chamak, Bhajan, Hira1 had statistically similar toot length to it. BRRI dhan28 (19.87 cm) had lowest root length and BR3, BR14, BRRI dhan36, BRRI dhan45, BRRI dhan50, Bina new line, BRRI hybrid dhan1, BRRI hybrid dhan3, Hira1, Bhajan had statistically similar root length to it. BR16 had 42.15% higher root length than BRRI dhan28. The descending order of the verities for the numerical value of their shoot length at 60 DAT was BR16 > Binadhan-6 > BRRI dhan36 > BRRI hybrid dhan2 > Chamak > Hira1 > BRRI hybrid dhan1 > BRRI dhan50 > Bhajan > BRRI hybrid dhan3 > BRRI dhan29 > BRRI dhan45 > BR3 > Bina new line > BR14 > BRRI dhan28 (table 2). At 90 DAT, BRRI hybrid dhan1 (34.62 cm) had the highest root length and BRRI dhan28, BRRI dhan45, BRRI dhan50, BRRI hybrid dhan2, BRRI hybrid dhan3, Hira1 and Bhajan had statistically similar root length to it .BR14 (16.67 cm) had the lowest root length and BR3, BR16, BRRI dhan28, BRRI dhan29, BRRI dhan36, BRRI dhan45, BRRI dhan50, Binadhan-6, Bina new line, BRRI hybrid dhan2, BRRI hybrid dhan3, Hira1, Chamak had statistically similar root length to it. BRRI hybrid dhan1 had 52.85% higher root length than BR14. The descending order of the varieties for numerical value for shoot lengths was BRRI hybrid dhan1 > BRRI hybrid dhan2 > BRRI dhan50 > Binadhan-6 > Hira1 > Bhajan > BRRI hybrid dhan3 > BRRI dhan29 > BR16 > BRRI dhan36 > BR3 > BRRI dhan45 > BRRI dhan28 > Bina new line > Chamak > BR14 (table 2). At harvest, BRRI hybrid dhan1 (25.47 cm) had the highest root length which was 35.88% higher than the variety BRRI dhan36 (16.33 cm) which had shortest root length. BR3, Binadhan-6, Hira1 had statistically similar root lengths to BRRI hybrid dhan1 and BR14, BRRI dhan28, BRRI dhan45, BRRI dhan50, Bina new line, BRRI hybrid dhan2, BRRI hybrid dhan3, and Bhajan had statistically similar root length to BRRI dhan36 (table 3). BRRI hybrid dhan1, Hira1 had the highest root length until harvest .Root lengths were the shortest for the varieties at 30 DAT. Then they gradually increased in 60 DAT and 90 DAT for most of the varieties. But root lengths decreased at maturity for all the varieties except BR14.This is may be due to the reason that the verities reached their maturity at harvest and the roots stopped growth and began to degrade and as a result the root length decreased. Islam *et al.* (2009) found that BRRI hybrd dhan1 reuslted in 34.7 cm root length at 75 DAT (105 DAS) which is higher than the root length of 26.63 cm produced by BRRI hybrid dhan1at 60 DAT (72 DAS) and equal to the root length of 34.62 cm produced by BRRI hybrid dhan1at 90 DAT (102 DAS) in this experiment under discussion. Islam *et al.* (2009) found that BRRI hybrid dhan1 produced 34.7 cm long roots at 75 DAT (105 DAS) compared to 34.62cm of root length produced by BRRI hybrid dhan1 at 90 DAT (102 DAS) in the experiment under discussion which is only 0.23% shorter taking in consideration that it had 3 day less growth time .Thakur *et al.* (2011) found that SRI had 38.5% increase in root length over standard management practices in early-ripening stage of development. Tao Longxing *et al.* (2002) reported that root growth was markedly greater in the plants raised under SRI than in traditional system. Root dry matter and root depth were also more in SRI compared to traditional rice. Mishra *et al.* (2006) explained that the simplest way to increase rooting depth and the root distribution of crops is to increase the duration of the vegetative period. This may be achieved by sowing earlier or by delaying flowering. SRI practice recommends transplanting younger seedlings (15 day-old) with wider spacing. This seedling age helps the plant to enjoy a prolonged vegetative period along with better canopy growth, while an optimization of spacing enhances canopy photosynthesis by avoiding shading effects.

Table 2. Plant root length of sixteen *boro* rice varieties at different growth stages grown in the system of rice intensification

Treatments	Mean root length (cm) at			
	30 DAT	60 DAT	90 DAT	harvest
BR3 (V_1)	9.16 b	24.00 b-d	25.25 bc	22.25 ab
BR14 (V_2)	7.68 b	21.30 cd	16.67 b	18.50 bc
BR16 (V_3)	7.38 b	34.35 a	25.75 bc	18.33 bc
BRRI dhan28 (V_4)	7.21 b	19.87 d	23.92 ab	17.58 c
BRRI dhan29 (V_5)	7.16 b	25.00 b-d	26.58 b	18.67 bc
BRRI dhan36 (V_6)	8.83 b	29.97 a-c	25.33 bc	16.33 c
BRRI dhan45 (V_7)	7.08 b	24.47 b-d	24.00 ab	16.50 c
BRRI dhan50 (V_8)	9.00 b	26.58 a-d	29.08 ab	19.50 bc
Binadhan-6 (V_9)	8.23 b	30.28 ab	28.17 bc	24.50 a
Bina new line (V_{10})	9.55 ab	21.58 b-d	23.50 bc	19.00 bc
BRRI hybrid dhan1 (V_{11})	9.67 ab	26.63 a-d	34.62 a	25.47 a
BRRI hybrid dhan2 (V_{12})	7.97 b	29.83 a-c	29.75 ab	19.22 bc
BRRI hybrid dhan3 (V_{13})	9.28 b	25.30 b-d	27.17 ab	19.00 bc
Chamak (V_{14})	8.52 b	29.00 a-c	22.42 bc	18.17 bc
Hiral (V_{15})	12.80 a	28.72 a-d	27.67 ab	22.00 ab
Bhajan (V_{16})	8.82 b	26.38 a-d	27.58 ab	18.50 bc
LSD (0.05)	3.371	8.980	8.350	4.405
CV (%)	23.38	20.36	19.43	13.48

4.1.4 Plant shoot length

Statistically significant difference was found in the plant shoot length of the sixteen varieties at 30, 60, 90 DAT and at harvest (Appendix VIII). At 30 DAT, Hira1 (23.78 cm) had the highest shoot length and BR3 (14.20 cm) had the lowest shoot length. Hira1 had 40.28% higher shoot length than BR3. BR14, BRRI dhan50, BRRI hybrid dhan1, BRRI hybrid dhan2, Chamak, Bhajan had statistically similar shoot lengths to Hira1. BRRI dhan28, Binadhan-6, Bina new line had statistically similar shoot length to BR3. BR16, BRRI dhan29, BRRI dhan36, BRRI dhan45, BRRI hybrid dhan3 had statistically similar shoot lengths to both BR3 and Hira1.The descending order of the rice varieties for their shoot lengths was Chamak > BRRI hybrid dhan1 > BRRI hybrid dhan2 > BRRI dhan50 > Bhajan > Chamak > BRRI dhan45 >BRRI hybrid dhan3 > BRRI dhan36 > BRRI dhan29 > BR16 > Binadhan-6 > Bina new line > BRRI dhan28 > BR14 > BR3 (Table 3). At 60 DAT, BR14 (59.07 cm) had the maximum shoot length and BR3 (46.03 cm) had the minimum shoot length. BR14 had 22.08% higher shoot length than BR3. BRRI dhan36 and BRRI dhan 50 has statistically similar shoot length to BR14 and Bina new line had statistically similar shoot length to BR3. BR 16, BRRI dhan28, BRRI dhan29, BRRI dhan45, Binadhan-6, BRRI hybrid dhan1, BRRI hybrid dhan2, BRRI hybrid dhan3, Chamak, Hira1, Bhajan had statistically similar shoot length to the varieties with highest and lowest shoot length. The descending order of shot length of plants of sixteen varieties was BR14 > BRRI dhan36 > BRRI dhan50 > BRRI hybrid dhan2 > Hira1 > BRRI hybrid dhan3 > BRRI hybrid dhan1 > BRRI dhan28 > BRRI dhan29 > Binadhan-6 > Bhajan > BR16 > BRRI dhan45 > Bina new line > BR3 (Table 3). At 90 DAT, Bina new line (93.08 cm) had highest shoot length and BR14, BRRI dhan28, BRRI dhan36, BRRI dhan45, BRRI dhan50, Binadhan-6, BRRI hybrid dhan1, BRRI hybrid dhan2, Chamak, Hira1 had statistically similar shoot length. BR3 (61.67 cm) resulted in shortest plant shoot length and BRRI dhan29, Bhajan had statistically similar shoot length. BR16 had statistically similar shoot length to the varieties with highest and lowest shoot length. Bina new line had 33.75% higher shoot length than BR3. The descending order of the varieties for their shoot length at 90 DAT was Bina new line > BRRI dhan28 > Hira1 > BRRI hybrid dhan2 > BRRI dhan45 > Chamak > BR14 > BRRI hybrid dhan3 > BRRI dhan36 > BRRI hybrid dhan1 > BRRI dhan50 > Binadhan-6 > BR16 > BRRI dhan29 > Bhajan > BR3 (table 3). At harvest, BRRI hybrid dhan1 (111.3 cm) showed the highest shoot length and Binadhan-6 had statistically similar shoot length also. BRRI dhan36 (81.00 cm) had the lowest shoot length and BRRI dhan50 had similar shoot length. BRRI hybrid dhan1 had 27.22% higher shoot length than BRRI dhan36. The descending order of the varieties for their shoot length at harvest was BRRI hybrid dhan1 > Binadhan-6 > Chamak > BRRI dhan29 > Hira1 > BR14 > Bina new line > Bhajan > BRRI hybrid dhan3 > BR16 > BRRI dhan28 > BR3 > BRRI dhan45 > BRRI hybrid dhan2 > BRRI dhan50 > BRRI dhan36 (table 3). Among the sixteen *boro* rice varieties, Binadhan-6 and BRRI hybrid dhan1 consistently resulted in higher shoot length until harvest. BR3 and BR16 were the two varieties resulting in constantly smaller shoot length. Variations among the shoot lengths of the varieties increased as the growth progressed and the variation was most frequent at harvest. Thakur *et al.* (2011) found that SRI resulted in 84.0 cm shoot length or Culm height compared to 67.5 cm shoot length resulted in SMP (standard management practices) in ripening stage. SRI produced 19.64% higher shoot length than SMP.

Table 3. Plant shoot length of sixteen *boro* rice varieties at different growth stages grown in system or rice intensification

Treatments	Shoot length(cm) at			
	30 DAT	60 DAT	90 DAT	harvest
BR3 (V_1)	14.20 d	46.03 c	61.67 d	91.83 b-d
BR14 (V_2)	16.03 ca	59.07 a	88.33 ab	97.00 b-d
BR16 (V_3)	18.17 a-d	49.93 a-c	77.17 a-d	92.50 b-d
BRRI dhan28 (V_4)	16.18 cd	52.93 a-c	93.00 a	92.33 b-d
BRRI dhan29 (V_5)	18.17 a-d	51.70 a-c	74.08 b-d	99.67 b
BRRI dhan36 (V_6)	18.65 a-d	58.53 a	83.67 ab	81.00 f
BRRI dhan45 (V_7)	19.20 a-d	48.42 a-c	91.00 ab	90.00 c-e
BRRI dhan50 (V_8)	22.60 ab	57.27 ab	81.83 ab	82.33 ef
Binadhan-6 (V_9)	17.72 b-d	50.90 a-c	80.50 a-c	110.30 a
Bina new line (V_{10})	16.23 cd	47.52 bc	93.08 a	97.00 b-d
BRRI hybrid dhan1 (V_{11})	23.30 ab	53.32 a-c	82.00 ab	111.30 a
BRRI hybrid dhan2 (V_{12})	22.63 ab	56.03 a-c	91.50 a	88.33 d-f
BRRI hybrid dhan3 (V_{13})	18.78 a-d	54.05 a-c	84.37 ab	94.33 b-d
Chamak (V_{14})	21.12 a-c	52.10 a-c	89.17 ab	100.30 b
Hira1 (V_{15})	23.78 a	55.90 a-c	92.67 a	97.83 bc
Bhajan (V_{16})	22.27 ab	50.25 a-c	64.67 cd	95.00 b-d
LSD (0.05)	5.935	10.90	17.02	8.874
CV (%)	18.43	12.39	12.29	5.60

4.1.5 Plant root length: shoot length ratio

Plant root length: shoot length ratio of the sixteen *boro* rice varieties had statistically significant differences among their root length: shoot length ratio at 30, 60, 90 DAT and at harvest (Appendix IX). Root: shoot length ratio was determined by dividing the shoot length of a variety measured at a definite time and by the root length measured at that time. BRRI dhan45 (2.88) had the highest ratio at 30 DAT and BR16, BRRI dhan29, BRRI dhan50, BRRI hybrid dhan1, BRRI hybrid dhan2, Chamak, Bhajan had statistically similar root: shoot length ratio. BR3 (1.54) had the lowest ratio at 30 DAT and BR14, BRRI dhan36, Binadhan-6, Bina new line, BRRI hybrid dhan3, Hira1 had statistically similar root: shoot length ratio. BRRI dhan28 had statistically similar ratio to both BR3 and BRRI dhan45 .BRRI dhan45 had 46.58% higher ratio than BR3. The descending order of the varieties for their root: shoot length ratio was BRRI dhan45 > BRRI hybrid dhan2 > Bhajan > BRRI dhan29 > BRRI dhan50 > BRRI hybrid dhan1 > Chamak > BR16 > BRRI dhan28 > Binadhan-6 > BRRI dhan36 > BR14 > BRRI hybrid dhan3 > Hira1 > Bina new line > BR3 (table 4).

At 60 DAT, BR14 (2.77) had the highest root-shoot length ratio and BR16 (1.593) had the lowest root length shoot length ratio. Only BRRI dhan28 had statistically similar values to BR14 and BR3, BRRI dhan36, Binadhan-6, BRRI hybrid dhan1, BRRI hybrid dhan2, Chamak, Hira1, Bhajan had statistically similar ratio to BR16. BR14 had 42.55% higher root: shoot length ratio than BR16. The descending order of the varieties for their root-shoot length ratio at 60 DAT was BR14 > BRRI dhan28 > Bina new line > BRRI hybrid dhan3 > BRRI dhan50 > BRRI dhan29 > BRRI dhan45 > BRRI hybrid dhan1 > BRRI dhan36 > Hira1 > BR3 > Bhajan > BRRI hybrid dhan2 > Chamak > Binadhan-6 > BR16 (Table 4).

At 90 DAT, BR14 (5.86) showed the highest ratio and no other variety had statistically similar ratio to it. BR3 (2.45) showed the lowest ratio. BR14 had 58.12% higher ration than the lowest ration at 90 DAT. The descending order of the varieties for root-shoot length at 90 DAT was BR14 > Chamak > BR16 > BRRI dhan28 > Bina new line > BRRI dhan45 > BRRI dhan36 > Hira1 > BRRI hybrid dhan2 > BRRI hybrid dhan3 > Bhajan > Binadhan-6 > BRRI dhan29 > BRRI dhan50 > BRRI hybrid dhan1 > BR3 (table 4).

At harvest, Chamak (5.53) showed the highest root: shoot length ratio and BR14, BRRI dhan28, BRRI dhan29, BRRI dhan45, Bhajan had statistically similar root: shoot length ratio to Chamak. BR3 (4.15) showed the lowest ratio and Hira1, BRRI hybrid dhan1, BRRI dhan50, had statistically similar ratio to BR3. Root: shoot length ratio of BR16, BRRI dhan36, Binadhan-6, Bina new line, BRRI hybrid dhan2, BRRI hybrid dhan3 had statistically similar values to both BR3 and Chamak. Chamak had 24.9% higher ratio than BR3. The descending order of the varieties for root-shoot length ratio at harvest was Chamak > BRRI dhan45 > BRRI dhan28 > BRRI dhan29 > BR14 > Bhajan > Bina new line > BR16 > BRRI hybrid dhan3 > BRRI dhan36 > BRRI hybrid dhan2 > Binadhan-6 > Hira1 > BRRI hybrid dhan1 > BRRI dhan50 > BR3 (table 4). Islam *et al.* (2009) found that BRRI hybrid dhan1 resulted root-shoot length ration of 3.24 in 75 DAT (105 DAS) compared to the root-shoot length ration of 2.483 at 90 DAT (102 DAS) in the experiment under discussion.

Table 4. Plant root length: shoot length ratio of sixteen *boro* rice varieties at different growth stages

Treatments	Root length : shoot length at			
	30 DAT	60 DAT	90 DAT	harvest
BR3 (V_1)	1.54 d	1.92 c-e	2.45 d	4.15 e
BR14 (V_2)	2.08 cd	2.77 a	5.86 a	5.33 a-d
BR16 (V_3)	2.46 a-c	1.59 e	4.16 b	5.07 a-e
BRRI dhan28 (V_4)	2.22 a-d	2.66 ab	3.98 bc	5.41 ab
BRRI dhan29 (V_5)	2.55 a-c	2.08 cd	2.84 b-d	5.40 a-c
BRRI dhan36 (V_6)	2.11 cd	1.99 c-e	3.39 b-d	4.93 a-e
BRRI dhan45 (V_7)	2.88 a	2.06 cd	3.79 b-d	5.46 ab
BRRI dhan50 (V_8)	2.51 a-c	2.14 cd	2.83 b-d	4.40 de
Binadhan-6 (V_9)	2.15 b-d	1.713 de	2.89 b-d	4.55 a-e
Bina new line (V_{10})	1.70 d	2.26 bc	3.97 bc	5.11 a-e
BRRI hybrid dhan1 (V_{11})	2.49 a-c	2.01 c-e	2.48 cd	4.42 c-e
BRRI hybrid dhan2 (V_{12})	2.81 ab	1.89 c-e	3.21 b-d	4.60 a-e
BRRI hybrid dhan3 (V_{13})	2.02 cd	2.16 cd	3.16 b-d	4.97 a-e
Chamak (V_{14})	2.48 a-c	1.79 c-e	4.33 b	5.53 a
Hiral (V_{15})	1.95 cd	1.97 c-e	3.34 b-d	4.50 b-e
Bhajan (V_{16})	2.59 a-c	1.90 c-e	2.93 b-d	5.24 a-d
LSD (0.05)	0.6875	0.4716	1.514	0.9857
CV (%)	18.04	13.77	26.09	11.93

4.1.6 Plant dry weight

Total plant dry weight (g plant^{-1}) of sixteen *boro* rice varieties at 30, 60 and 90 DAT had statistically significant differences. But at harvest, there was no statistically significant difference (appendix X). At 30 DAT, BRRI dhan28 (0.42 g) had the highest and BR14 (0.11 g) had the lowest dry weight per plant. BRRI dhan28 had 73.70% higher dry weight plant^{-1} than BR14. The descending order of the numerical values of plant dry weight of the sixteen varieties at 30 DAT was BRRI dhan28 > BRRI hybrid dhan2 > Hira1 > Bhajan > BRRI hybrid dhan1 > BRRI dhan50 > Chamak > BRRI dhan36 > Bina new line > BR16 > BRRI hybrid dhan3 > BRRI dhan45 > BR3 > BRRI dhan29 > Binadhan-6 > BR14 (table 5). At 60 DAT, BRRI hybrid dhan1 (27.52 g) had the highest plant dry weight and BRRI dhan36 had statistically similar plant dry weight. Bina new line (6.49 g) had the lowest plant dry weight and all the varieties except BRRI dhan36, BRRI dhan50, BRRI hybrid dhan1, BRRI hybrid dhan2 had statistically similar plant dry weight. BRRI hybrid dhan1 had 76.42% higher plant dry weight than Bina new line (table 5). The descending order of the plant dry weight of the varieties was BRRI hybrid dhan1 > BRRI dhan36 > BRRI hybrid dhan2 > BRRI dhan50 > Hira1 > Bhajan > BRRI dhan29 > BR16 > Chamak > Binadhan-6 > BRRI hybrid dhan3 > BRRI dhan45 > BR3 > BR14 > BRRI dhan28 > Bina new line. At 90 DAT, BRRI hybrid dhan1 (59.58 g) had the highest plant dry weight and all the varieties had statistically similar plant dry matter to it. Bina new line (28.78 g) had the lowest dry weight and all other varieties but BRRI hybrid dhan1 had statistically similar plant dry weight to it. BRRI hybrid dhan1 had 51.7% higher plant dry matter than Bina new line. The descending order of the varieties was BRRI hybrid dhan1 > BRRI dhan29 > Chamak > BRRI dhan36 > BR16 >

BR14 > BRRI hybrid dhan2 > Hira1 > BR3 > Bhajan > BRRI dhan28 > Binadhan-6 > BRRI dhan50 > BRRI hybrid dhan3 > BRRI dhan45 > Bina new line (table 5). At harvest, BRRI dhan29 (102.70 g) had the highest numerical value for plant dry weight and BRRI dhan45 (59.24 g) had the lowest numerical value. BRRI dhan29 had 42.32% higher dray matter than BRRI dhan45. The descending order of the varieties at harvest was BRRI dhan29 > BRRI hybrid dhan1 > BR16 > BRRI dhan36 > BRRI hybrid dhan2 > BR14 > Chamak > BR3 > Binadhan-6 > Hira1 > Bhajan > BRRI dhan28 > BRRI hybrid dhan3 > Bina new line > BRRI dhan45 (tale 5). BRRI dhan28, BRRI dhan29 and BRRI hybrid dhan1 had higher plant dry matter throughout the period upto harvest and Bina new line, BR14, BRRI hybrid dhan3 had poor total plant dry matter throughout the period up to harvest.

Alam *et al.* (2009) found that at 100 DAT in normal farming practice BRRI dhan29 produced 34.70 g total dry weight which is much lower than total dry matter production by BRRI dhan29 (102.70 g) in this experiment. Islam *et al.* (2009) transplanted 30 day old seedlings and found that BRRI hybrid dhan1 produced 40.88 g dry matter per plant at 50 DAT and 59.03 g dry matter per plant at 75 DAT which is lower than 59.58 g dry matter produced at 90 DAT by BRRI hybrid dhan1 in this experiment. Nissanka and Bandara (2004) stated that total dry matter production in rice farming were higher in System of Rice Intensification (SRI) compared to farmers practice (FP).

Table 5. Total plant dry matter of sixteen *boro* rice varieties at different growth stages grown in system of rice intensification

Treatments	Plant dry weight (g) at			
	30 DAT	60 DAT	90 DAT	harvest
BR3 (V_1)	0.20 ab	9.13 cd	46.81 ab	86.61
BR14 (V_2)	0.11 b	7.97 cd	52.70 ab	92.12
BR16 (V_3)	0.25 ab	13.73 b-d	53.41 ab	95.93
BRRI dhan28 (V_4)	0.42 a	7.25 cd	43.91 ab	80.62
BRRI dhan29 (V_5)	0.18 ab	14.02 b-d	56.66 ab	102.7
BRRI dhan36 (V_6)	0.27 ab	21.69 ab	53.44 ab	95.79
BRRI dhan45 (V_7)	0.20 ab	10.20 cd	32.22 ab	59.24
BRRI dhan50 (V_8)	0.32 ab	17.10 bc	42.87 ab	72.31
Binadhan-6 (V_9)	0.15 b	11.29 cd	43.04 ab	81.63
Bina new line (V_{10})	0.26 ab	6.49 d	28.78 ab	59.38
BRRI hybrid dhan1 (V_{11})	0.32 ab	27.52 a	59.58 a	97.32
BRRI hybrid dhan2 (V_{12})	0.41 a	17.51 a-c	51.52 ab	94.30
BRRI hybrid dhan3 (V_{13})	0.23 ab	10.58 cd	38.67 ab	70.40
Chamak (V_{14})	0.29 ab	13.13 b-d	56.16 ab	91.57
Hiral (V_{15})	0.36 ab	16.16 b-d	50.51 ab	80.96
Bhajan (V_{16})	0.33 ab	15.79 b-d	44.17 ab	80.86
LSD (0.05)	0.2529	10.31	28.49	NS
CV (%)	56.32	45.05	36.23	34.91

The root dry weight of the sixteen *boro* rice varieties had statistically significant differences among them at 60 DAT (Appendix XI). BRRI hybrid dhan1 (16.90 g) had the highest root dry matter and BRRI dhan36 (11.34 g) had statistically similar root dry matter. Bina new line (2.56 g) had lowest root dry weight. BRRI hybrid dhan1 had 84.85% higher root dry weight over Bina new line at 60 DAT. The sixteen varieties had statistically significant difference among their shoot dry weight at 60 DAT (Appendix XI). BRRI hybrid dhan1 (18.14 g) had the highest shoot dry weight and Bina new line (3.95 g) had lowest shoot dry weight. BRRI hybrid dhan1 had 78.22% higher shoot dry weight over Bina new line (table 6).

At 90 DAT, sixteen *boro* rice varieties had statistically significant difference among their root dry weight (Appendix XI). BRRI dhan29 (23.35 g) had highest and BRRI dhan45 (8.08 g) had lowest root dry weight and BRRI dhan29 had 65.40% higher plant root dry matter (table 6). At 90 DAT, the sixteen varieties had no statistically significant difference among their shoot dry weight (Appendix XI). Chamak (40.60 g) had the highest numerical value for shoot dry weight and Bina new line (20.56 g) had lowest numerical value for shoot dry. Chamak had 49.36% higher numerical value for shoot dry weight (table 6). At harvest, the sixteen rice varieties cultivated in *boro* season had statistically significant difference among their root dry weight (Appendix XI). BRRI dhan28 (39.38 g) had highest root dry matter and BRRI dhan45 (10.43 g) had the lowest root dry matter. BRRI dhan28 had 73.51% higher root dry matter over BRRI dhan45 (table 6).

At harvest, there was no statistical difference among the verities incase of shoot dry weight (Appendix XI). BRRI hybrid dhan2 (75.81 g) had highest numerical value for shoot dry weight. Bina new line (44.66 g) had lowest numerical value for shoot dry weight. BRRI hybrid dhan2 had 41.09% higher shoot dry weight over Bina new line.

Islam *et al.* (2009) found that BRRI hybrid dhan1 produced 36.26 g shoot dry weight at 50 DAT (80 DAS) which is much higher than the root dry matter production of 18.14g at 60 DAT (72 DAS) in this experiment. Root dry matter production was 2.50 g plant^{-1} which is a lot less compared to the root dry matter production of 18.14 g by BRRI hybrid dhan1 in this experiment. The partitioning of the dry weight in SRI is significant. Partitioning of dry weight is much more in root than in shoot. It is may be because the alternate wetting and drying condition of the field that is an important character of System of Rice Intensification which makes the plant to generate more roots than shoot in vegetative period which is caused by partitioning of dry weight to the root zone. Roots in aerobic soil senesce much less, more slow than anaerobic soil. SRI facilitates more aerobic soil condition. This also aids in higher root dry matter found in SRI practice. This finding is supported by Thakur *et al.* (2011). SRI encourages transplanting of a single seedling hill^{-1}. This enhances root development and growth as there is more space and resources for the root system to develop. San-oh *et al.* (2004) concurred with this conclusion.

Table 6. Root and shoot dry weight of sixteen *boro* rice varieties at different growth stages grown in system of rice intensification

Treatments	Dry matter (g)					
	At 60 DAT		At 90 DAT		At harvest	
	Root	Shoot	Root	Shoot	Root	Shoot
BR3 (V_1)	3.76 cd	5.37 bc	16.02 a-e	30.97	29.65 a-c	56.97
BR14 (V_2)	2.81 d	5.15 bc	14.14 a-e	38.56	20.09 b-d	72.03
BR16 (V_3)	5.73 b-d	8.00 bc	22.88 ab	30.53	33.60 ab	62.33
BRRI dhan28 (V_4)	2.33 d	4.92 bc	14.78 a-e	29.14	24.50 a-d	56.12
BRRI dhan29 (V_5)	5.88 b-d	8.14 bc	23.35 a	33.31	39.38 a	63.31
BRRI dhan36 (V_6)	11.34 ab	11.71 ab	18.50 a-d	38.35	24.79 a-d	71.01
BRRI dhan45 (V_7)	4.15 cd	6.06 bc	8.08 e	24.14	10.43 d	48.81
BRRI dhan50 (V_8)	6.12 b-d	10.98 a-c	13.74 b-e	29.13	21.28 b-d	50.88
Binadhan-6 (V_9)	4.70 cd	6.58 bc	15.10 a-e	27.94	25.88 a-d	55.75
Bina new line (V_{10})	2.560 d	3.95 c	8.13 e	20.65	14.71 cd	44.66
BRRI hybrid dhan1 (V_{11})	16.90 a	18.14 a	21.51 a-c	38.07	26.72 a-d	70.61
BRRI hybrid dhan2 (V_{12})	8.19 bc	8.61 bc	12.99 c-e	38.53	18.49 b-d	75.81
BRRI hybrid dhan3 (V_{13})	4.13 cd	6.46 bc	13.57 b-e	25.10	23.19 a-d	47.21
Chamak (V_{14})	5.64 b-d	7.49 bc	15.55 a-e	40.60	24.83 a-d	66.74
Hiral (V_{15})	6.64 b-d	9.52 bc	14.07 a-e	36.44	16.96 cd	64.00
Bhajan (V_{16})	7.55 b-d	8.24 bc	11.67 de	32.53	24.36 a-d	56.20
LSD (0.05)	6.09	7.26	9.60	NS	16.53	NS
CV (%)	58.99	53.87	37.75	38.20	41.88	38.80

4.1.7 Leaf area index (LAI)

The sixteen *boro* rice varieties had statistically significant differences among their leaf area index at 30 DAT (Appendix XII). BRRI hybrid dhan2 (0.099) had the highest leaf are index and BRRI dhan28 (0.020) had the lowest leaf area index. BRRI hybrid dhan2 had 79.79% higher leaf area index than BRRI dhan28. BR16, BRRI dhan36, BRRI dhan45, BRRI dhan50, Bina new line, Bhajan had statistically similar leaf area index to BRRI hybrid dhan2. All the varieties except BRRI hybrid dhan2 had statistically similar leaf area index to BRRI dhan28. The descending order of the varieties for their leaf area index at 30 DAT was BRRI hybrid dhan2 > Bina new line > BR16 > Bhajan > BRRI dhan45 > BRRI dhan36 > BRRI dhan50 > Hira1 > BRRI hybrid dhan1 > BR14 > Binadhan-6 > Chamak > BRRI dhan29 > BRRI hybrid dhan29 > BR3 > BRRI dhan28 (Table 7). At 60 DAT, the leaf area index values of the sixteen varieties had statistically significant difference among them (Appendix XI). Hira1 (1.50) had the highest leaf area index and BRRI dhan28 (0.87) again had the lowest leaf area index like it had the lowest leaf area index at 30 DAT. Hira1 had 42% higher leaf area index than BRRI dhan28. The descending order of the varieties for their leaf area index at 60 DAT was Hira1 > BR16 > BINA new line > BRRI hybrid dhan1 > BRRI dhan36 > BRRI dhan29 > BRRI hybrid dhan2 > BRRI dhan50 > Chamak > BRRI dhan45 > Bhajan > Bina new line > BR14 > BR3 > BRRI hybrid dhan3 > BRRI dhan28 (Table 7). At 90 DAT, there was no statistically significant difference among the leaf area index of the sixteen *boro* rice varieties (appendix XII). BR3 (5.737) became the variety with highest numerical value for leaf area index and BR14 (4.056) had the lowest numerical value for leaf area index. BR3 had 29.30% higher leaf area index than BR14. The descending order of the varieties for their leaf area index at 90 DAT was BR3 > Bhajan > BRRI dhan29 > BRRI dhan36 > Chanmak >

Hiral > BRRI hybrid dhan2 > BR16 > Binadhan-6 > Bina new line > BRRI dhan50 > BRRI hybrid dhan1 > BRRI dhan45 > BRRI hybrid dhan3 > BRRI hybrid dhan28 > BR14 (Table 7). At harvest, vairties had statistically significant difference for leaf area index (Appendix XII). Bhajan (4.45) had the highest leaf area index and again BRRI dhan28 (2.46) had the lowest leaf area index like it had the lowest leaf area index at 30 and 60 DAT. Bhajan had 44.75% higher leaf area index over BRRI dhan28. BR3, BRRI dhan29, Binadhan-6, BRRI hybrid dhan1, Hira1 had statistically similar leaf area index to Bhajan. BR14, BRRI dhan45, BRRI dhan50, Bina new line, BRRI hybrid dhan2, BRRI hybrid dhan3 had statistically similar leaf area index to BRRI dhan28. BR16, BRRI dhan36, Chamak had statistically similar leaf area index to the varieties with the highest and lowest leaf area index. The descending order of the leaf area index of the sixteen varieties are as was Bhajan > Bina new line > BR3 > BRRI dhan29 > BRRI hybrid dhan1 > Hira1 > Chamak > BRRI dhan36 > BR16 > BRRI hybrid dhan3 > BRRI dhan50 > BRRI hybrid dhan2 > Bina new line > BRRI dhan45 > BR14 > BRRI dhan28 (table 7). The leaf area index for all sixteen *boro* rice varieties gradually increased from 30 DAT, 60 DAT up to 90 DAT. The leaf area index reduced at harvest. This is because at harvest the plants attained maturity and as a result some leaf of the plants died and senescence occurred. So leaf area index was rescued at harvest. This result is similar to the result found in an experiment done by Haque *et al.* (2006). Ahmed (2006) also found similar results. He found that the LAI of BRRI dhan29 was 1.09, 5.53, 7.52 and 1.75 at 30 DAT, 50 DAT, 70 DAT and at harvest respectively. Islam *et al.* (2009) found the leaf area index of BRRI hybrid dhan1 at 75 DAT (105 DAS) to be 1.08 which 76.05% less than the leaf area index of BRRI hybrid dhan1 found at 90 DAT (102 DAS). Thakur *et al.* (2011) stated that greater leaf area index found in System of Rice Intensification (SRI) is due to the production of greater number of larger leaves compared to standard management practices (SMP).

Table 7. Leaf area index of sixteen *boro* rice varieties at different growth stages grown in system of rice intensification

Treatments	Leaf area index at			
	30 DAT	60 DAT	90 DAT	Harvest
BR3 (V_1)	0.026 b	0.98 ab	5.74	4.28 ab
BR14 (V_2)	0.038 b	0.99 ab	4.06	2.60 de
BR16 (V_3)	0.058 ab	1.47 a	4.75	3.30 a-e
BRRI dhan28 (V_4)	0.020 b	0.87 b	4.11	2.46 e
BRRI dhan29 (V_5)	0.035 b	1.38 ab	5.32	4.01 a-c
BRRI dhan36 (V_6)	0.050 ab	1.38 ab	5.30	3.38 a-e
BRRI dhan45 (V_7)	0.051 ab	1.33 ab	4.49	2.76 c-e
BRRI dhan50 (V_8)	0.049 ab	1.35 ab	4.62	2.88 c-e
Binadhan-6 (V_9)	0.036 b	1.40 ab	4.74	4.37 ab
Bina new line (V_{10})	0.071 ab	1.25 ab	4.63	2.77 c-e
BRRI hybrid dhan1 (V_{11})	0.040 b	1.39 ab	4.51	4.01 a-c
BRRI hybrid dhan2 (V_{12})	0.099 a	1.36 ab	4.79	2.82 c-e
BRRI hybrid dhan3 (V_{13})	0.034 b	0.95 ab	4.14	3.03 b-e
Chamak (V_{14})	0.035 b	1.33 ab	4.95	3.41 a-e
Hira1 (V_{15})	0.045 b	1.50 a	4.86	3.84 a-d
Bhajan (V_{16})	0.045 ab	1.28 ab	5.52	4.45 a
LSD (0.05)	0.091	0.573	NS	1.38
CV (%)	57.51	27.23	24.57	24.34

4.1.8 Time of initial and fifty percent flowering

The sixteen varieties cultivated in *boro* season had statistically significant difference in their time taken to initiate flowering and to complete fifty percent flowering (Appendix XIII). All the varieties completed initial flowering within 97.33 DAS to 113.7 DAS. BRRI dhan29 (113.7 DAS) took longest time to initiate flowering and Binadhan-6 (112.30 DAS) took statistically similar time to it. BRRI dhan45 (97.33 DAS) took shortest time to initiate flowering and BRRI dhan28 took statistically similar time (99.33 DAS). The descending order of the time taken by the sixteen *boro* rice varieties to initiate flowering was BRRI dhan29 > Binadhan-6 > Bhajan > BR3 > BR16 > BRRI hybrid dhan1 > Chamak > BRRI dhan50 > BRRI hybrid dhan2 > Hira1 > BR14 > BRRI hybrid dhan3 > Bina new line > BRRI dhan36 > BRRI dhan28 > BRRI dhan45 (Table 8). For completing fifty percent flowering, BRRI dhan29 (118.70 DAS) again took the longest time and no other variety took statistically similar time to complete fifty percent flowering. BRRI dhan45 (102.70 DAS) took shortest time and not other variety took statistically similar time to complete fifty percent flowering. The descending order of the sixteen varieties was BRRI dhan29 > Binadhan-6 > Hira1 > BR3 > BR16 > BR14 > BRRI dhan50 > BRRI hybrid dhan1 > Chamak > BRRI dhan 2 > Bhajan > BRRI hybrid dhan3 > Bina new line > BRRI dhan36 > BRRI dhan28 > BRRI dhan45 (Table 8). Krishna *et al.* (2009) found that rice plant completed fifty percent flowering early as the age of the transplanted seedling gradually reduces irrespective of the spacing of transplantation. Transplanting 8 days old seedling initiated flowers 8 days earlier than transplanting 25 days old seedlings. This result is similar to the findings under discussion in this experiment. Krishna *et al.*(2008) stated that the rice variety BPT-5204 took 106.0 days for 50 % flowering, in SRI method as compared to 110.4 days in traditional method. They explained that the early flowering in SRI method might be attributed to transplanting of younger seedlings, which might have established quickly in the field and started growing at a faster rate. The number of days taken for 50 percent flowering was decreased significantly with the application of FYM. The probable reason might be application of FYM resulted in the development of efficient photosynthetic structure which enabled the plants to intercept higher quantity of radiant energy resulting in higher dry matter production, early initiation and greater development of reproductive system. Application of RDF enhances the days to 50 per cent flowering compared to other doses of fertilizers. The number of days taken for 50 percent flowering was decreased significantly with the application of FYM. The probable reason might be application of FYM resulted in the development of efficient photosynthetic structure which enabled the plants to intercept higher quantity of radiant energy resulting in higher dry matter production, early initiation and greater development of reproductive system. Application of RDF enhances the days to 50 per cent flowering compared to other doses of fertilizers. Ahmed (2006) stated that among five cultivation methods (sowing sprouted seeds in line, sowing sprouted seeds in broadcast, transplanting nursery seedlings and clonal tiller cultivation), the clonal tillers needed the longest duration for maturity (150 days). It required 3 days more for maturity than that of the nursery seedlings. This might be due to removal of tillers from the mother hill and replanting again (Mollah *et al.*, 1992). The nursery seedlings needed the second highest duration for flowering (111 days) and for maturity (147 days). SRI matured 13 days earlier than that of the nursery seedlings. The lowest duration for flowering (83 days) and for maturity (119 days) was observed in the sprouted seeds in line. The sprouted seeds in line and sprouted seeds broadcast matured 28 and 26 days earlier than that of the nursery seedlings, respectively. Field duration of the crop was considerably reduced in direct seeded rice might be due to the absence of 'transplanting shock'.

Table 8. Days to initial flowering and fifty percent flowering of sixteen *boro* rice varieties grown in system of rice intensification

Treatments	Initiate flowering	Complete Fifty percent flowering
BR3 (V_1)	109.70 c	115.30 bc
BR14 (V_2)	104.00 e-g	112.30 de
BR16 (V_3)	109.30 c	114.00 cd
BRRI dhan28 (V_4)	99.33 ij	106.00 g
BRRI dhan29 (V_5)	113.70 a	118.70 a
BRRI dhan36 (V_6)	100.00 hi	109.30 f
BRRI dhan45 (V_7)	97.33 j	102.70 h
BRRI dhan50 (V_8)	106.00 de	112.30 de
Binadhan-6 (V_9)	112.30 ab	116.30 b
Bina new line (V_{10})	102.00 gh	111.00 ef
BRRI hybrid dhan1 (V_{11})	106.70 d	112.30 de
BRRI hybrid dhan2 (V_{12})	105.00 d-f	111.70 e
BRRI hybrid dhan3 (V_{13})	103.00 fg	111.70 e
Chamak (V_{14})	106.00 de	111.70 e
Hira1 (V_{15})	105.00 d-f	111.70 e
Bhajan (V_{16})	110.00 bc	115.70 bc
LSD (0.05)	2.37	2.045
CV (%)	1.35	1.09

4.1.9 Weed population and weed dry matter

The population of shama m^{-2} had statistically significant differences among them at 30 DAT (Appendix XIV). BRRI hybrid dhan3 (29.00) had the highest population of shama m^{-2} and BRRI dhan50 (3.00) had the lowest population of shama m^{-2}. BRRI hybrid dhan3 had 89.66% higher weed population over BRRI dhan50. The descending order of varieties for shama population m^{-2} was BRRI hybrid dhan3 > BRRI dhan45 > BR14 > Hira1 > BRRI dhan29 > Binadhan-6 > Chamak > BRRI dhan36 > BRRI hybrid dhan2 > Bhajan > BRRI hybrid dhan1 > BR3 > BRRI dhan28 > BR16 > Bina new line > BRRI dhan50 (Table 9) .At 60 DAT, the sixteen varieties had significant difference for population of shama m^{-2} among them (Appendix XIV). At 60 DAT, Chamak (73.67) had the highest population of shama m^{-2}. Hira1 (12.33) had the lowest shama population m^{-2}. But like shama m^{-2} at 30 DAT, BRRI dhan50 also had very low shama population m^{-2} which was statistically similar to Hira1. Chamak had 83.26% higher shama m^{-2} than Hira1. The descending order of the shama population m^{-2} of sixteen varieties at 60 DAT was Chamak > BR14 > BRRI hybrid dhan2 > Binadhan-6 > BRRI hybrid dhan3 > BRRI dhan29 > BRRI dhan36 > BR3 > BR16 > Bhajan > BRRI dhan28 > Bina new line > BRRI dhan45 > BRRI dhan50 > BRRI hybrid dhan1 > Hira1 (table 9). In both 30 DAT and 60 DAT, BRRI dahn50 showed very low number of shama population m^{-2}. BR14 showed higher shama infestation (table 9).

In case of total weed population m^{-2}, the varieties had statistically significant difference among them at both 30 DAT and 60 DAT (Appendix XIV). At 30 DAT, BRRI dhan29 (119.00) had highest total population of weed m^{-2} and BR3 (31.00) had the lowest total weed population m^{-2}. BRRI dhan29 had 73.94% higher weed population m^{-2}. BRRI dhan45, BRRI hybrid dhan3, Hira1 had total weed population m^{-2} statistically similar to BRRI dhan29 and BRRI dhan50, Bina new line, BR16, BRRI hybrid dhan1, Binadhan-6, Chamak had total weed population m^{-2} statistically similar to BR3. The descending order of the varieties for their total weed population m^{-2} was BRRI dhan29 > dhan45 > BRRI hybrid dhan3 > Hira1 > BRRI dhan28 > Bhajan > BR 14 > BRRI dhan36 > BRRI hybrid dhan2 > Chamak > Binadhan-6 > BRRI hybrid dhan1 > BR16 > Bina new line > BRRI dhan50 > BR3 (Table 9). At 60 DAT, the varieties also had statistically significant difference among them for total weed population m^{-2}. Chamak (128) had the highest total weed population m^{-2} and the other varieties but BRRI dhan50 and BRRI hybrid dhan1 had total weed population m^{-2} statistically similar to it. BRRI hybrid dhan1 (36) had the lowest total weed population m^{-2} and all other varieties except Chamak had total weed population m^{-2} statistically similar to it. The descending order of the varieties for their total weed population m^{-2} was Chamak > BR14 > BRRI hybrid dhan2 > BRRI hybrid dhan3 > BRRI dhan29 > Binadhan-6 > Bina new line > BR16 > BR3 > Hira1 > BRRI dhan28 > BRRI dhan45 > Bhajan > BRRI dhan36 > BRRI dhan50 > BRRI hybrid dhan1 (Table 9). Total weed dry matter m^{-2} was measured and the total weed dry matter of the sixteen varieties had statistically significant difference among them at 30 DAT and 60 DAT (appendix XIV). Bina new line (5.99g m^{-2}) had the highest total weed dry weight m^{-2} at 30 DAT. BR3 (1.38 g m^{-2}) had the lowest weed dry weight m^{-2} at 30 DAT. Bina new line had 77.06% higher total weed dry weight than BR3. The descending order of varieties total weed dry weight m^{-2} was Bina new line > BRRI dhan29 > BRRI hybrid dhan3 > Hira1 > BRRI hybrid 2 > BR14 > Chamak > Bhajan > BRRI dhan45 > Binadhan-6 > BRRI hybrid dhan1 > BRRI dhan50 > BR16 > BRRI dhan36 > BRRI dhan28 > BR3 (table 9). At 60 DAT, BRRI dhan29 (24.15 g m^{-2}) had the highest and BRRI hybrid dhan1 (6.780g m^{-2}) had total weed dry matter m^{-2}. BRRI dhan29 had 71.93% higher weed dry matter than BRRI hybrid dhan1. The descending order for total weed dry matter of the sixteen varieties was BRRI dhan29 > BR14 > Chamak > BRRI hybrid dhan2 > BR3 > Bina new line >BR16 > BRRI dhan36 > Bhajan > BRRI dhan45 > Binadhan-6 > BRRI hybrid dhan3 > Hira1 > BRRI dhan50 > BRRI dhan28 > BRRI hybrid dhan1 (table 9). Here, BRRI dhan50 also had very low total weed dry weight m^{-2}. It had the third lowest numerical value. Weed infestation is a major problem in cultivating rice in SRI. SRI promotes combination of best management practices like use of 12 days old single seedlings $hill^{-1}$ with alternate wetting and drying (AWD) in a wider spacing. A major reason of flooding the rice field with water is to control the weed population. Transplanting single seedlings provides ample space, resources like light and water for weed species to germinate and grow without much competition from the rice crop. But SRI encourages AWD. This makes weed infestation worse. Satyanarayana *et al.* (2007) stated that weed is a deterrent to SRI adoption. Kavitha *et al.* (2010) suggested that transplanting 14 days old seedlings with pre emergence application of Pretilachlor at the rate of 0.75 kg a.i. ha^{-1} and one mechanical weeding at 30 DAT and humic acid application as seedling dip (0.3%) and foliar spray twice significantly reduced weed growth and improved growth parameters, yield attributes and yield of rice. Use of mechanical weeder to control weed is a recommended practice in the System of Rice Intensification.

Table 9. Weed population and weed dry weight of sixteen *boro* rice varieties at different stages of growth grown in system of rice intensification

Treatments	Shama population(no.) m^{-2} at		Total weed population (no.) m^{-2} at		Total dry weight ($g\ m^{-2}$) at	
	30 DAT	60 DAT	30 DAT	60 DAT	30 DAT	60 DAT
BR3 (V_1)	7.00 b-d	23.67 bc	31.00 f	64.00 ab	1.36 d	18.09 ab
BR14 (V_2)	20.33 a-c	62.67 ab	74.00 b-d	99.67 ab	4.60 a-d	19.47 ab
BR16 (V_3)	5.67 cd	22.67 bc	54.33 d-f	65.33 ab	2.29 b-d	13.34 a-c
BRRI dhan28 (V_4)	6.67 b-d	21.00 bc	77.67 b-f	62.67 ab	1.72 cd	9.50 bc
BRRI dhan29 (V_5)	14.67 a-d	32.00a-c	119.00 a	83.67 ab	5.08 ab	24.15 a
BRRI dhan36 (V_6)	12.00 b-d	28.00a-c	74.00 b-d	56.67 ab	2.20 b-d	12.44 bc
BRRI dhan45 (V_7)	21.33 ab	16.67 c	117.00 a	61.67 ab	2.92 a-d	10.52 bc
BRRI dhan50 (V_8)	3.00 d	16.00 c	38.00 ef	37.67 b	2.40 b-d	9.99 bc
Binadhan-6 (V_9)	14.33 a-d	47.67a-c	60.67 d-f	79.67 ab	2.65 a-d	10.39 bc
Bina new line (V_{10})	5.33 cd	21.00 bc	53.33 d-f	70.00 ab	5.93 a	14.02 a-c
BRRI hybrid dhan1 (V_{11})	7.67 b-d	14.33 c	58.33 d-f	36.00 b	2.51 b-d	6.78 c
BRRI hybrid dhan2 (V_{12})	11.33 b-d	54.67a-c	64.67 d-f	96.33 ab	4.67 a-d	18.24 ab
BRRI hybrid dhan3 (V_{13})	29.00 a	38.00a-c	106.30c-e	85.33 ab	4.87 a-c	10.37 bc
Chamak (V_{14})	13.00 b-d	73.67 a	63.67 ab	128.00 a	4.28 a-d	18.42 ab
Hiral (V_{15})	17.67 a-d	12.33 c	97.00 a-c	63.00 ab	4.67 a-d	10.22 bc
Bhajan (V_{16})	11.00 b-d	22.67 bc	75.67 b-d	58.33 ab	3.90a-d	12.40 bc
LSD (0.05)	15.17	45.91	33.16	74.81	3.334	11.15
CV (%)	72.76	86.89	27.32	62.67	57.08	48.99

4.1. 10 Number of tillers hill^{-1}

All the sixteen *boro* rice varieties has statistically significant differences among them incase of tillers hill^{-1} at 30, 60, 90 DAT and at harvest (Appendix XV). At 30 DAT, BRRI hybrid dhan2 (2.13) had the highest tillers hill^{-1} and BR14 had the lowest tillers hill^{-1} (1.07). BRRI hybrid dhan2 had 49. 77% higher tillers hill^{-1} than BR14. The descending order of the varieties for their tillers hill^{-1} was BRRI hybrid dhan2 > Bina new line > Hira1 > BRRI dhan50 > BR16 > BRRI dhan45 > BRRI hybrid dhan1 > BR3 > BRRI dhan36 > Bhajan > Chamak > BRRI dhan29 > Binadhan-6 > BRRI dhan28 > BRRI hybrid dhan3 > BR14 (Table 10).

At 60 DAT, Bhajan (22.40) had the highest number of tillers hill^{-1} and BR14 (11.27) had lowest number of tillers hill^{-1}. Bhajan had 49.69% higher number of tillers hill^{-1}. The descending order of the sixteen *boro* rice varieties incase of the number of tillers hill^{-1} at 60 DAT was Bhajan > BR 16 > Hira1 > BRRI dhan45 > BRRI dhan36 > BRRI dhan50 > Binadhan-6 > BRRI hybrid dhan1 > BRRI dhan29 >BRRI hybrid dhan2 > Chamak > BR3 > Binadhan9 > BRRI dhan28 > BR16.

At 90 DAT, BR16 (32.80) had the highest number of tiller hill^{-1} and BR14 (19.13) had the lowest number of tillers hill^{-1}. BR16 had 41.68% higher number of tillers hill^{-1} over BR14. No other variety had statistically similar number of tiller hill^{-1} to BR16 and Chamak, BRRI hybrid dhan2, BRRI dhan28, Bina new line, BRRI hybrid dhan3 had statistically similar number of tillers hill^{-1}to BR14. The descending order of the sixteen *boro* varieties for their number of tillers hill^{-1} at 90 DAT was BR 16 > BRRI dhan29 > Bhajan > BR3 > BRRI dhan36 > BRRI hybrid dhan1 > Hira1 > BRRI dhan50 > Binadhan-6 > BRRI dhan45 > Chamak > BRRI hybrid dhan2 > BRRI dhan28 > Bina new line > BRRI hybrid dhan3 > BR14 (Table 10).

At harvest, the sixteen rice varieties had statistically significant differences among them (Appendix XV). BR16 (26.73) again had the highest number of tillers hill^{-1} and Chamak (17.33) had the lowest number of tillers hill^{-1}. BR 14 had 35.17% higher number of tillers hill^{-1} over Chamak .BRRI dhan29, BRRI dhan36, BRRI dhan45, BRRI hybrid dhan1 and Bhajan had statistically similar number of tillers hill^{-1} to BR14. The descending order of the sixteen *boro* rice varieties in case of their number of tillers hill-1 at harvest was BR 14 > BRRI dhan29 > BRRI dhan36 > BRRI dhan45 > BRRI hybrid dhan1 > Bhajan >Binadhan-6 > Hira1 > BRRI dhan50 > BR3 > BRRI dhan28 > Bina new line > BRRI hybrid dhan3 > BR14 > BRRI hybrid dhan2 > Chamak (Table 10). The tillering of all of the sixteen *boro* rice verities showed a definite pattern in the experiment done under this discussion. The tiller number hill^{-1} increased gradually from 30 DAT up to 90 DAT and then at harvest the tiller number hill^{-1} decreased. This is may be because at harvest, some of the tillers died out or senesce because of disease, natural causes or non-effectiveness. Ahmed (2006) also found this pattern in his experiment. At 90 DAT and at harvest, the inbred varieties like BR16, BRRI dhan29, BRRI dhan36, and BRRI dhan45 showed higher number of tillers hill^{-1} than the hybrid varieties. He also found that SRI produced highest number of tillers hill^{-1} at 50 DAT (46.30), 70 DAT (45.85) and at harvest (42.55) compared to other cultivation practices like sowing sprouted seeds in line, sowing sprouted seeds in broadcast, transplanting nursery seedlings and clonal tiller cultivation.

Table 10. Number of tillers hill^{-1} of sixteen *boro* rice varieties cultivated at different stages of growth grown in the system of rice intensification

Treatments	Tiller hill^{-1} (no.) at			
	30 DAT	60 DAT	90 DAT	Harvest
BR3 (V_1)	1.33 bc	15.47 a-c	25.53 bc	20.80 b-f
BR14 (V_2)	1.07 c	11.27 c	19.13 g	18.20 ef
BR16 (V_3)	1.67 abc	20.40 ab	32.80a	26.73 a
BRRI dhan28 (V_4)	1.13 bc	11.60 a-c	20.13 efg	19.93 b-f
BRRI dhan29 (V_5)	1.13 bc	17.60 a-c	26.60 b	24.13 ab
BRRI dhan36 (V_6)	1.27 bc	18.27 a-c	25.47 bc	23.60 ab
BRRI dhan45 (V_7)	1.53 abc	18.80 a-c	23.60 b-f	22.67 a-c
BRRI dhan50 (V_8)	1.73 abc	18.27 a-c	24.33 b-e	21.27 b-f
Binadhan-6 (V_9)	1.13 bc	17.93 a-c	24.07 b-f	22.13 b-e
Bina new line (V_{10})	1.80 ab	14.80 a-c	19.93 fg	18.47 c-f
BRRI hybrid dhan1 (V_{11})	1.40 bc	17.80 a-c	24.60 b-d	22.60 abc
BRRI hybrid dhan2 (V_{12})	2.13 a	16.60 a-c	21.07 d-g	17.60 f
BRRI hybrid dhan3 (V_{13})	1.13 bc	13.00 bc	19.87 fg	18.33 d-f
Chamak (V_{14})	1.20 bc	15.93 a-c	21.60 c-g	17.33 f
Hiral (V_{15})	1.80 ab	19.33 ab	24.53 b-d	21.40 b-f
Bhajan (V_{16})	1.26 bc	22.40 a	26.13 b	22.53 a-d
LSD (0.05)	0.727	7.664	4.353	4.253
CV (%)	30.67	27.29	11.01	12.08

4.1.11 Time of harvest

BR3 had the earliest maturity and harvest at 147 days compared to expected harvest time of 170 days. BR14 had 20 days of early maturity and harvest time, BR16 had 18 days early maturity and harvest, BRRI dhan28 had 7 days maturity and harvest, BRRI dhan29 had 9 days early maturity and harvest, BRRI dhan36 had 7 days early maturity and harvest, BRRI dhan45 had 12 days early maturity and harvest, BRRI dhan50 had 17 days early maturity and harvest, Binadhan-6 had 9-14 days early maturity and harvest, Bina new line had 17 days early maturity and harvest, BRRI hybrid dhan1 had 4 days early maturity and harvest, BRRI hybrid dhan2 had 3 days early maturity and harvest, BRRI hybrid dhan3 had 3 days early maturity and harvest, Camak had 14 days early maturity and harvest, Hira had 18 days early maturity and harvest, Bhajan had 8 days early maturity and harvest. In this experiment 12 days old seedlings were transplanted, one in each hill with wider spacing of 30cm×30cm. Transplanting early seedling allowed the seedlings to recover the root damage from transplanting early and continue growth and development. This may have resulted in completing the lifecycle in less time them the time needed to complete the lifecycle in recommended rice cultivation practice.

Table 11. Time of harvest of sixteen rice varieties cultivated in *boro* season following system of rice intensification

Treatments	Expected time of harvest (days)	Time of harvest (days)	Early maturity (days)
BR3 (V_1)	170	147	23
BR14 (V_2)	160	142	20
BR16 (V_3)	165	147	18
BRRI dhan28 (V_4)	140	133	7
BRRI dhan29 (V_5)	160	151	9
BRRI dhan36 (V_6)	140	133	7
BRRI dhan45 (V_7)	145	133	12
BRRI dhan50 (V_8)	155	138	17
Binadhan-6 (V_9)	160-165	151	9-14
Bina new line (V_{10})	150	133	17
BRRI hybrid dhan1 (V_{11})	155	151	4
BRRI hybrid dhan2 (V_{12})	145	142	3
BRRI hybrid dhan3 (V_{13})	145	142	3
Chamak (V_{14})	160	142	18
Hiral (V_{15})	160	142	18
Bhajan (V_{16})	155	147	8

4.2 Yield attributing characters

4.2.1 Effective tillers panicle^{-1}

The sixteen varieties had statistically significant difference among their number of effective tillers hill^{-1} (Appendix XVI). BR16 (27.33) had the highest number of effective tillers hill^{-1} and BRRI hybrid dhan3 (19.67) had the lowest number of effective tillers hill^{-1}. BR3 had 2.03% higher effective tillers hill^{-1}. The descending order of the varieties for the number of effective tiller hill^{-1} was BR16> BR3 > BRRI hybrid dhan1 > BRRI dhan50 > Bhajan > Binadhan-6 > BRRI dhan45 > BRRI dhan29 > BRRI dhan36 > Chamak > BRRI dhan28 > Hiral > BR14 > Bina new line > BRRI hybrid dhan3 (table 11) . Oliver *et al.* (2008) reported that BRRI dhan28 produced highest 9.00 effective tiller hill^{-1} and BRRI dhan29 produced 11.00 effective tillers hill^{-1}. BRRI dhan28 and BRRI dhan29 produced 58.33% and 51.7% higher effective tillers in the experiment under discussion. Krishna *et al.* (2008) reported that the increase in the productive tillers with SRI method was to the extent of 217% over traditional method and 20% with recommended fertilizer dose (RDF) over no fertilizer. The suggested that the increase in the productive tillers per plant might be due to the better spacing provided to the plants by planting in square method. This might have facilitated better utilization of resources by the plants converting majority of the tillers into productive tillers.

4.2.2 Non-effective tillers hill^{-1}

The sixteen varieties had statistically significant difference among their number of non-effective tiller hill^{-1} (Appendix XVI). BRRI dhan50 (6.00) produced highest non-effective tillers hill^{-1} and BRRI hybrid dhan2 (3.600) produced lowest non-effective tillers hill^{-1}. BRRI dhan50 produced 40% higher non-effective tillers than BRRI hybrid dhan2. The descending order of the varieties for their non-effective tillers hill^{-1} was BRRI dhan50 > BRRI hybrid dhan1 > Bina new line > Chamak > BR3 > BRRI hybrid dhan3 > BRRI dhan36 > BRRI dhan45 > Binadhan-6 > BRRI dhan28 > Bhajan > BR14 > BRRI dhan29 >

BR16 > Hira1 > BRRI hybrid dhan2 (table 11). Oliver *et al.* (2008) found that BRRI dhan28 produced highest 3.67 and BRRI dhan29 produced highest 11.00 non-effective tiller hill^{-1} BRRI dhan28 and BRRI dhan29 produced respectively 55.56% and 61.27% lower non-effective tiller hill^{-1} in this experiment under discussion.

4.2.3 Panicle length

The sixteen varieties had statistically significant difference among their panicle lengths (Appendix XVI). Bina new line (45.59 cm) had the highest panicle length and BRRI dhan36 (22.59 cm) had the lowest panicle length. Panicle length of Bina new line is 50.45% higher than panicle length of BRRI dhan36. Binadhan-6 (42.48 cm) was statistically similar to Bina new line. BRRI dhan45, BR3, BR16, BRRI dhan29, BRRI dhan28 had statistically similar panicle lengths to BRRI dhan36. The descending order of panicle lengths of the sixteen varieties was Bina new line > Binadhan-6 > BRRI hybrid dhan2 > Hira1 > Bhajan > BRRI hybrid dhan1 > BR14 > Chamak > BRRI hybrid dhan3 > BRRI dhan50 > BRRI dhan45 > BR3 > BR16 > BRRI dhan29 > BRRI dhan28 > BRRI dhan36 (Table 11). Latif *et al.* (2005) found that BRRI dhan29 had 24.48 cm panicle length in SRI practice, 24.12 cm in BRRI recommended practice and 22.32 cm in farmers practice in Vagurapara, Chandina. In matiara, sadar panicle lengths were 24.89 cm, 24.14 cm and 22.28 cm in respectively SRI, BRRI recommended and farmers practice. SRI always resulted in higher panicle lengths than BRRI recommended practices and farmers practices. Thakur *et al.* (2011) found that SRI produced panicles with higher length than in standard management practices. Hossaen *et al.* (2011) found panicle length of BRRI dhan29 in an experiment to be 24.59 cm which is 5.69% higher than the panicle length of BRRI dhan29 in this experiment under discussion.

4.2.4 Total grains panicle^{-1}

The sixteen rice varieties had statistically significant difference total number of grains panicle^{-1} (no.) (appendix XVI). Binadhan-6 (222.7)had highest total gains panicle^{-1} (no) which was .Bina new line, BRRI dhan29, Bhajan, Hira1 had statistically similar grains panicle^{-1} to Binadhan-6. BR16 (127.4) was the variety with lowest number of total grains panicle$^{-1,}$ BR3, BRRI dhan45, BRRI dhan36, BRRI dhan50, BRRI dhan28 were the varieties which had statistically similar total number of grains panicle^{-1}. Bina new line had 42.79% higher total grains panicle^{-1}than BR16. The descending order of the sixteen varieties for total grains panicle^{-1} was Binadhan-6 > Bina new line > BRRI dhan29 > Bhajan > Hira1 > BRRI hybrid dhan2 > BRRI hybrid dhan1 > Chamak > BR14 > BRRI hybrid dhan3 > BRRI dhan28 > BRRI dhan50 > BRRI dhan36 > BRRI dhan45 > BR3 > BRRI dhan16. Oliver *et al.* (2008) found in an experiment that BRRI dhan28 produced 171.0 grains panicle^{-1} and BRRI dhan29 produced 217.67 grains panicle^{-1} in case of in continuous submergence of soil with irrigation water. Both varieties produced higher number of total grains panicle^{-1} compared to the total number of grains panicle^{-1} produced by these two varieties in the experiment under discussion. But Thakur *et al.* (2011) found 151.6 total grains panicle^{-1} in SRI which was 28.83% higher that 107.9 total grains panicle^{-1} in SMP (standard management practices).

4.2.5 Filled grains panicle^{-1}

The sixteen varieties had significant difference in the number of filled grains panicle^{-1} (Appendix XVI). Binadhan-6 (191.0) had the highest number of filled grains panicle^{-1} which is 85.76% of its total grain no. BRRI dhan29 and Bhajan were statistically similar to Binadhan-6. BRRI dhan45 (115.6) had the lowest filled grains panicle^{-1} which was 84.69% of its total grain no. Hira1, Chamak, BRRI hybrid dhan3, BRRI dhan28, BR14, BR3, BRRI dhan36, BRRI dhan50, BR16 were statistically similar to BRRI dhan45. Binadhan-6 had 39.48% higher filled grains panicle^{-1}. The descending order of the sixteen rice varieties for filled grains panicle^{-1} was Binadhan-6 > BRRI dhan28 > Bhajan > Bina new line > BRRI hybrid dhan1 > BRRI hybrid dhan2 > Hira1 > Chamak >

BRRI hybrid dhan3 > BRRI dhan28 > BR14 > BR3 > BRRI dhan36 > BRRI dhan50 > BR16 > BRRI dhan45. Thakur *et al.* (2011) found that cultivation in SRI produced 89.6% filled grains over 79.3% filled grain produced in SMP (standard management practices).

4.2.6 Unfilled grains panicle^{-1}

The sixteen varieties had significant different for number of unfilled grains panicle^{-1} (no) (Appendix XVI). Bina new line (51.67) was the variety with highest unfilled grains panicle^{-1} which was 25.08% of its total no. of grains panicle^{-1}. Hira1 (45.33) had no. of unfilled grains panicle^{-1} similar to Bina new line. BR16 (7.70) was the variety with lowest no. of unfilled grains panicle^{-1} which was only 4.60% of its total no. of grains panicle^{-1} BR3, BRRI dhan28 had statistically similar number of unfilled grains panicle^{-1} to BR16. The descending order of the varieties for no. of unfilled grains panicle^{-1} was Bina new line > Hira1 > BR14 > BRRI hybrid dhan2 > BRRI dhan50 > Binadhan-6 > BRRI hybrid dhan3 > BRRI dhan36 > BRRI hybrid dhan1 > Bhajan > Chamak > BRRI dhan29 > BRRI dhan45 > BRRI dhan28 > BR3 > BR16. Bina new line had 85.1% higher no. of unfilled grains panicle^{-1}. Oliver *et al.* (2008) found in an experiment that BRRI dhan28 produced BRRI dhan28 produced highest number of unfilled grains panicle^{-1} (8.67) when water level fell 30 cm below ground level and in case of BRRI dhan29 highest number of unfilled grains panicle^{-1} (9.33) was produced when the water level fell 10 cm and 20 cm below ground level. Thakur *et al.* (2011) found that cultivation in SRI produced 10.4% filled grains over 20.7% filled grain produced in SMP (standard management practices).

Table 12. Different yield attributing characters of sixteen *boro* rice varieties cultivated in system of rice intensification

Treatments	Effective tiller hill^{-1} (no.)	Non-effective tiller hill^{-1} (no.)	Panicle length (cm)	Total grain/ panicle (no.)	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1} (no.)
BR3 (V_1)	26.73ab	4.93 ab	25.52 g-i	134.40 hi	122.70d-f	11.70 h
BR14 (V_2)	20.33e	4.33 bc	30.74 ef	167.50 c-g	130.00d-f	37.57 bc
BR16 (V_3)	27.33a	4.13 bc	23.54 hi	127.40 i	119.70ef	7.70 h
BRRI dhan28 (V_4)	21.6cde	4.40 bc	23.15 hi	159.00 e-i	131.30d-f	13.73 gh
BRRI dhan29 (V_5)	23.47a-e	4.27 bc	23.19 hi	202.00 ab	180.10 ab	21.30 f
BRRI dhan36 (V_6)	22.73a-e	4.47 bc	22.59 i	149.80 f-i	121.60d-f	28.20d-f
BRRI dhan45 (V_7)	23.93a-e	4.40 bc	27.74f-i	136.50 g-i	115.60f	20.93 fg
BRRI dhan50 (V_8)	26.13a-c	6.00 a	27.90f-h	156.50 e-i	120.70ef	35.73 cd
Binadhan-6 (V_9)	23.93a-e	4.40 bc	42.48 ab	222.70 a	191.00a	31.63c-e
Bina new line (V_{10})	20.13e	5.13 ab	45.59 a	206.00 ab	154.30b-d	51.67 a
BRRI hybrid dhan1 (V_{11})	26.40 ab	5.69 a	32.52 d-f	179.00 b-f	151.70b-e	27.33 ef
BRRI hybrid dhan2 (V_{12})	21.67c-e	3.60 c	37.93 bc	187.60 b-e	151.00b-e	36.63 c
BRRI hybrid dhan3 (V_{13})	19.67e	4.53 bc	29.26e-g	164.70d-h	135.00d-f	30.67c-e
Chamak (V_{14})	22.20b-e	5.13 ab	29.34e-g	169.30 c-f	143.50c-f	25.80 ef
Hira1 (V_{15})	21.13 de	4.07 bc	36.15 cd	193.70 a-d	148.40b-f	45.33 ab
Bhajan (V_{16})	25.20a-d	4.40 bc	34.11c-e	199.20 a-c	172.70a-c	26.50 ef
LSD (0.05)	4.636	1.246	5.222	32.27	33.08	7.824
CV (%)	11.94	16.13	10.19	11.24	13.86	16.57

4.2.7 Grain yield

The sixteen *boro* rice varieties had statically significant difference among them in case of grain yield (Appendix XVII). BR16 (6.86 t ha^{-1}) had the highest grain yield and BR14 (5.18 t ha^{-1}) had the lowest grain yield (Figure 2). BR16 had 24.49% higher grain yield than BR14. The descending order of the varieties for grain yield was BR16 > BRRI dhan45 > BRRI dhan36 > BRRI hybrid dhan1 > Hiral> Bhajan > BRRI hybrid dhan2 > BR3 > Bina new line > BRRI dhan28 > Binadhan-6 > BRRI hybrid dhan3 > BRRI dhan29 > Chamak > BR3 > BR14 (Figure 2). Miah *et al.* (2008) conducted an experiment to compare yield of BRRI dhan28 in SRI and traditional methods. SRI resulted in 7.70 t ha^{-1}, 7.5 t ha^{-1} and 7.00 t ha^{-1} in Kurigram, Gaibandha and Lalmonirhatm, respectively. Traditional method resulted in 5.80 t ha^{-1}, 5.60 t ha^{-1}, and 5.10 t ha^{-1} in Gaibandha, Kurigram and Lalmonirhat. Thakur *et al.* (2011) observed that SRI gave 6.51 t ha^{-1} grain yield over 4.40 t ha^{-1} of grain yield in SMP (standard management practices). Zheng *et al.* (2004) reported that yield of the SRI exceeded 12 t ha-1, 46% higher than in control using field comparison. Ahmed (2006) stated that, the lowest grain yield (7.23 t ha^{-1}) was obtained from the SRI, which might be due to the wider spacing of 40 cm × 40 cm (Mazid *et al.*, 2003).

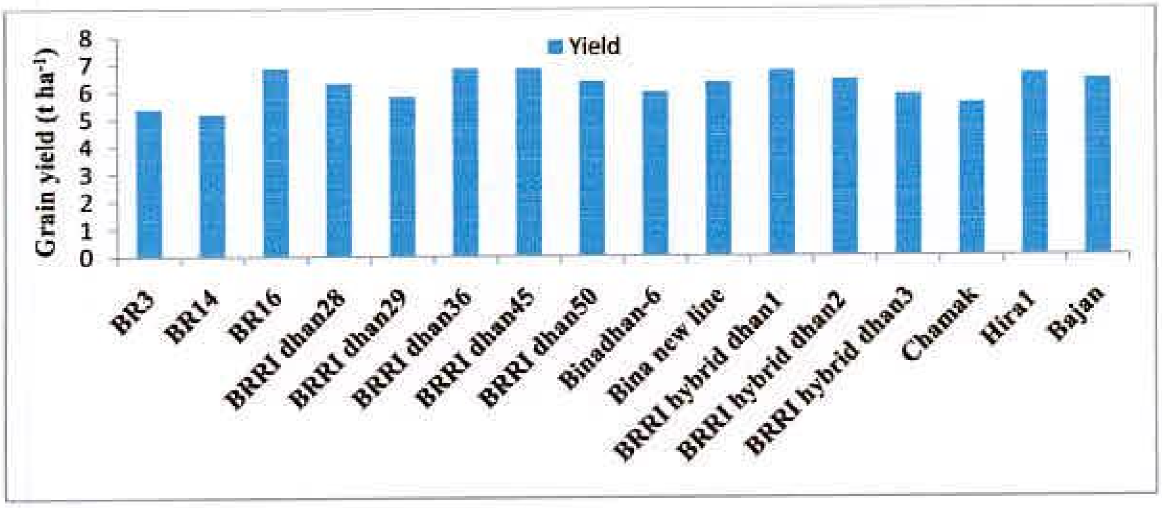

Fig 2. Grain yield of the sixteen *boro* rice varieties cultivated in system of rice intensification [$LSD_{(0.05)}$=0.833]

4.2.8 Weight of 1000 grains

The sixteen *boro* rice varieties had statistically significant difference among their 1000-grain weight (g) (Appendix XVII). BR3 and BR14 had the highest 1000-grain weight (30.63 g). BRRI dhan50 had the lowest 100 grain weight (19.07 g). BR3 and BR14 had 37.74% higher 1000-grain weight (g) than BRRI dhan50. The descending order of the 1000-grain weight (g) of the sixteen *boro* rice varieties were BR3 > BR14 > Bina new line > Chamak > BRRI dhan45 > BRRI hybrid dhan3 > BR16 > Hira1 > BRRI hybrid dhan2 > BRRI hybrid dhan1 > Bhajan > BRRI dhan36 > Binadhan-6 > BRRI dhan28 > BRRI dhan29 > BRRI dhan50 (Table 12). Ahmed (2006) found that the 1000-grain weight (g) of BRRI dhan29 was 23.04 g which is only 1.7 g higher than the thousand grain weight of BRRI dhan29 obtained in the experiment under this discussion. He also found that, although there was no statistically significant difference among the various cultivation methods (sowing sprouted seeds in line, sowing sprouted seeds in broadcast, transplanting nursery seedlings and clonal tiller cultivation), SRI had the maximum numerical value for 1000-grain weight. (Miah *et al.* (2008) found that BRRI dhan28 produced 27 g, 20 g, 40 g 1000-grain weight in SRI and 20g, 19g and 22g in traditional method in Gaiandha, Lalmonirhat and Kurigram, respectively. Thakur *et al.* (2011) found that SRI (System of Rice Intensification) produced 24.7 g 1000-grain weight over 24.0 g of thousand grain weight produced in SMP (standard management practice).

4.2.9 Straw yield

These sixteen varieties had statistically significant difference among their straw yields(Appendix XVII). BRRI hybrid dhan2 (7.797 t ha^{-1}) produced highest dry straw yield and BRRI dhan28 (4.970 t ha^{-1}) had the lowest dry straw yield. BRRI hybrid dhan2 produced 36.26% higher dry straw yield than BRRI dhan28. The descending order of the dry straw yield of the varieties was: BRRI hybrid dhan2 > Hira1 > Chamak > Binadhan-6 > Bhajan > BRRI dhan29 >

BR14 > BR3 > BR16 > BRRI dhan45 > BRRI dhan50 > Bina new line > BRRI dhan28 (Table 12). Das (2003) reported that the System of Rice Intensification (SRI) gave more straw (12%) compared to the hay produced in the FP plot. Hussain *et al.* (2003) conducted SRI trial in two Upazilas of Noakhali district and found 39% higher straw yield in SRI compared to traditional methods. Thakur *et al.* (2011) found that SRI produced 7.28 t ha^{-1}straw yield compared to the 9.17 t ha^{-1}straw yield produced in standard management practices. Ahmed (2006) stated that, the minimum straw yield (7.17 t ha-1) was obtained from the SRI among the various cultivation methods (sowing sprouted seeds in line, sowing sprouted seeds in broadcast, transplanting nursery seedlings and clonal tiller cultivation).

4.2.10 Biologiacal yield

The varieties had sttistically significant difference among their biological yield (Appendix XVII). BRRI hybrid dhan2 (13.24 t ha^{-1}) had the highest and BRRI dhan28 (9.353 t ha^{-1}) had the lowest biological yield. BRRI hybrid2 dhan had 21.81% higher biological yield than BRRI dhan28. The descending order for the numerical value of biological yield of the sixteen *boro* rice varieties was BRRI hybrid dhan2 > Hiral > BRRI hybrid dhan1 > Binadhan-6 > BRRI hybrid dhan3 > Bhajan > Chamak > BRRI dhan29 > BRRI dhan36 > BR14 > BR3 > BRRI dhan50 > BR16 > BRRI dhan45 > Bina new line > BRRI dhan28 (table 12). Uddin *et al.* (2012) found in an experiment that 11.82 t ha^{-1} of biological yield which is slightly higher 11.41 t ha^{-1} of biological yield produced by BRRI dhan29 in this experiment under discussion. Thakur *et al.* (2011) found in an experiment that, SRI produced 13.79 t ha^{-1} biological yield compared to 13.57 t ha^{-1} of biological yield produced in standard management practices (SMP). All though grain yield was much higher in SRI compared to SMP and incase of straw yield it was vice versa (Table 12).

4.2.11 Harvest index

There was statistically significant difference among the harvest index of the sixteen *boro* varieties (Appendix XVII). BRRI dhan50 (49.30) had the highest harvest index and Chamak (39.13) had the lowest harvest index. BRRI dhan50 was 20.63% higher in harvest index than Chamak. The descending order of the varieties for the numeric values of harvest index was BRRI dhan50 > BRRI dhan28 > Bhajan > Bina new line > BRRI hybrid dhan1 > BR16 > BR3 > BR14 > BRRI dhan29 > BRRI dhan45 > BRRI dhan36 > Binadhan-6 > BRRI hybrid dhan3 > Hira1 > BRRI hybrid dhan2 > Chamak (table 12). Thakur *et al.* (2011) found in an experiment that harvest index in SRI was 47.21% over to the harvest index of 32.42%. Hossaen *et al.* (2011) found in an experiment that BRRI dhan29 produced highest harvest index of 48.84%. Ahmed (2006) stated that among five cultaivation methods (sowing sprouted seeds in line, sowing sprouted seeds in broadcast, transplanting nursery seedlings and clonal tiller cultivation), the highest harvest index (52.47) was found from the SRI which was similar to the clonal tillers (50.21) and the harvest index of BRRI dhan29 was found to be 42.65 (Table 12).

Table 13. Different yield attributing characters of sixteen *boro* rice varieties cultivated in system of rice intensification

Treatments	1000 grains weight (g)	Straw yield (t ha^{-1})	Biologiacal yield (t ha^{-1})	Harvest index
BR3 (V_1)	30.63 a	6.22 b-e	11.30 a-e	45.00 a-c
BR14 (V_2)	30.63 a	6.27 a-e	11.33 a-e	44.93 a-c
BR16 (V_3)	28.04 cd	6.03 c-e	10.98 bcde	45.03 a-c
BRRI dhan28 (V_4)	22.11 i	4.97 e	9.35 e	46.48 ab
BRRI dhan29 (V_5)	21.3 i	6.32 a-e	11.41 a-e	44.21 a-c
BRRI dhan36 (V_6)	26.24 gh	6.47 a-e	11.36 a-e	42.99 a-c
BRRI dhan45 (V_7)	28.83 bc	5.98 c-e	10.44 c-e	43.03 a-c
BRRI dhan50 (V_8)	19.07 j	5.73 c-e	11.30 a-e	49.30 a
Binadhan-6 (V_9)	25.51 h	7.06 a-c	12.36 a-c	42.98 a-c
Bina new line (V_{10})	29.27 b	5.32 de	9.85 de	46.03 ab
BRRI hybrid dhan1 (V_{11})	27.02 efg	6.85 a-d	12.51 a-c	45.79 ab
BRRI hybrid dhan2 (V_{12})	27.12 ef	7.70 a	13.24 a	41.09 bc
BRRI hybrid dhan3 (V_{13})	28.19 cd	7.10 a-c	12.27 a-c	42.06 bc
Chamak (V_{14})	28.28 bc	7.15 a-c	11.79 a-d	39.13 c
Hiral (V_{15})	27.74 de	7.58 ab	13.02 ab	41.71 bc
Bhajan (V_{16})	26.78 fg	6.45 a-e	12.05 a-d	46.59 ab
LSD (0.05)	0.8437	1.541	2.247	6.320
CV (%)	1.89	14.31	11.83	8.58

Chapter V

Summary and Conclusion

CHAPTER V

SUMMARY AND CONCLUSION

The field experiment was conducted at the experimental farm of Sher-e-Bangla Agricultural University (SAU), Dhaka, during the period from December 2010 to May 2011 to study the performance of different *boro* rice varieties under the Modhupur tract (AEZ-28). The experiment consisted sixteen treatments viz. Varieties: BR3 (V_1), BR14 (V_2), BR16 (V_3), BRRI dhan28 (V_4), BRRI dhan29 (V_5), BRRI dhan36 (V_6), BRRI dhan45 (V_7), BRRI dhan50 (V_8), Binadhan-6 (V_9), Bina new line (V_{10}), BRRI hybrid dhan1 (V_{11}), BRRI hybrid dhan2 (V_{12}), BRRI hybrid dhan3 (V_{13}), Chamak (V_{14}), Hira1 (V_{15}), Bhajan (V_{16}). The experiment was laid out in a Randomized Complete Block Design with three replications of each treatment.

Crop growth parameters like tiller mortality rate (%), plant height, plant root length, plant shoot length, root length: shoot length, plant dry weight, plant root weight, plant shoot weight, leaf area index (LAI), time of initial and fifty percent flowering, number of tiller hill^{-1}, Shama population m^{-2}, total weed population m^{-2}, total weed dry weight m^{-2} were recorded at different growth stages. Yield attributing characters like effective and non-effective tillers hill^{-1}, panicle length, total number of grains panicle^{-1}, number of filled and unfilled grains panicle^{-1}, grain yield, weigh of 1000 grains and straw yield were recorded after harvest. Data were analyzed using MSTAT package. The mean difference among the treatments were compared by least significant difference (LSD) test at 5% level of significance.

Results showed that BR3 had the lowest plant height through in different growth stages. All though, BRRI dhan50 had the lowest plant height at harvest, BR3 had statistically similar plant height at harvest. BR3 was the variety with the lowest root length: shoot length ration, highest leaf area index (LAI) and highest 1000-grain weight. Total weed population m^{-2} was the lowest in case of BR3. BR14 also had the highest 1000 grain weight, the lowest leaf area index and lowest grain yield. Tiller number hill^{-1}, effective tiller number m^{-2} both were highest in BR16 and the grain yield was the highest among the sixteen varieties. BRRI dhan28 had the lowest biological yield, straw yield and very low grain yield. BRRI dhan29 showed the highest plant dry weight and root dry matter, it took the longest time to initiate flowering and complete fifty percent flowering. Total weed dry matter was also the highest in case of BRRI dhan29. In case of BRRI dhan36, root length, shoot length and panicle length were the shortest. BRRI dhan45 had the lowest plant dry weight, lowest root dry matter and number of filled grains panicle^{-1}. It also took the shortest time to initiate flowering and complete fifty percent flowering. BRRI dhan50 always had very low shama population m^{-2}. All though Hira1 had the lowest Shama population m^{-2}, BRRI dhan50 had shama population m^{-2} which was statistically similar to Hira1. BRRI dhan50 had the highest non effective tillers and harvest index, although its' 1000 grain weight was the lowest among all the sixteen. BRRI hybrid dhan1 had the highest root length, shoot length and root length: shoot length ratio at 90 DAT, the lowest total weed dry weight, and high grain yield. BRRI hybrid dhan2 had the highest shoot dry matter, Biological yield and straw yield and the lowest number of non-effective tillers hill^{-1}. BRRI hybrid dhan3 had the lowest number of effective tillers hill^{-1}.Binadhan-6 had the highest plant height, total grains panicle^{-1} and filled grains panicle^{-1}. Bina new line showed the lowest shoot dry matter and grains panicle^{-1}, highest panicle length and unfilled grains panicle^{-1}. Hira1 had the lowest grains panicle^{-1}. Chamak had the highest total weed population m^{-2}, highest shama population m^{-2}, lowest tiller number hill^{-1} and harvest index. BRRI dhan28, BRRI dhan36, BRRI dhan45 and Bina new line took the shortest time for harvest and Binadhan-6 took longest time to harvest. But for BR3, the actual harvest time was the earliest compared to the expected time of harvest.

The physiochemical analysis of the soil samples reveals that, the organic matter%, totale Nitrogen%, and available potassium and phosphorus increased after application of compost. After harvest is was observed that, soil from the samples of BR3, BRRI dhan28, Binadhan-6 showed the lowest organic matter. BR3 showed the lowest total Nitrogen percentage. BRRI hybrid dhan3 and

BRRI dhan28 showed the least available Potassium BR14 showed the lowest available Phosphorus.

From the above results and discussion it can be concluded that the varieties BR16, BRRI dhan36, BRRI dhan45, BRRI hybrid dhan1, Hira1, Bhajan, BRRI hybrid dhan2 and BRRI dhan50 can be screened to cultivate in *boro* season following System of Rice Intensification. The varieties like BRRI dhan50 and BRRI hybrid dhan1 can be considered as weed suppressive varieties but it should be confirmed by further studies through isolation of allelochemicals of the said varieties.

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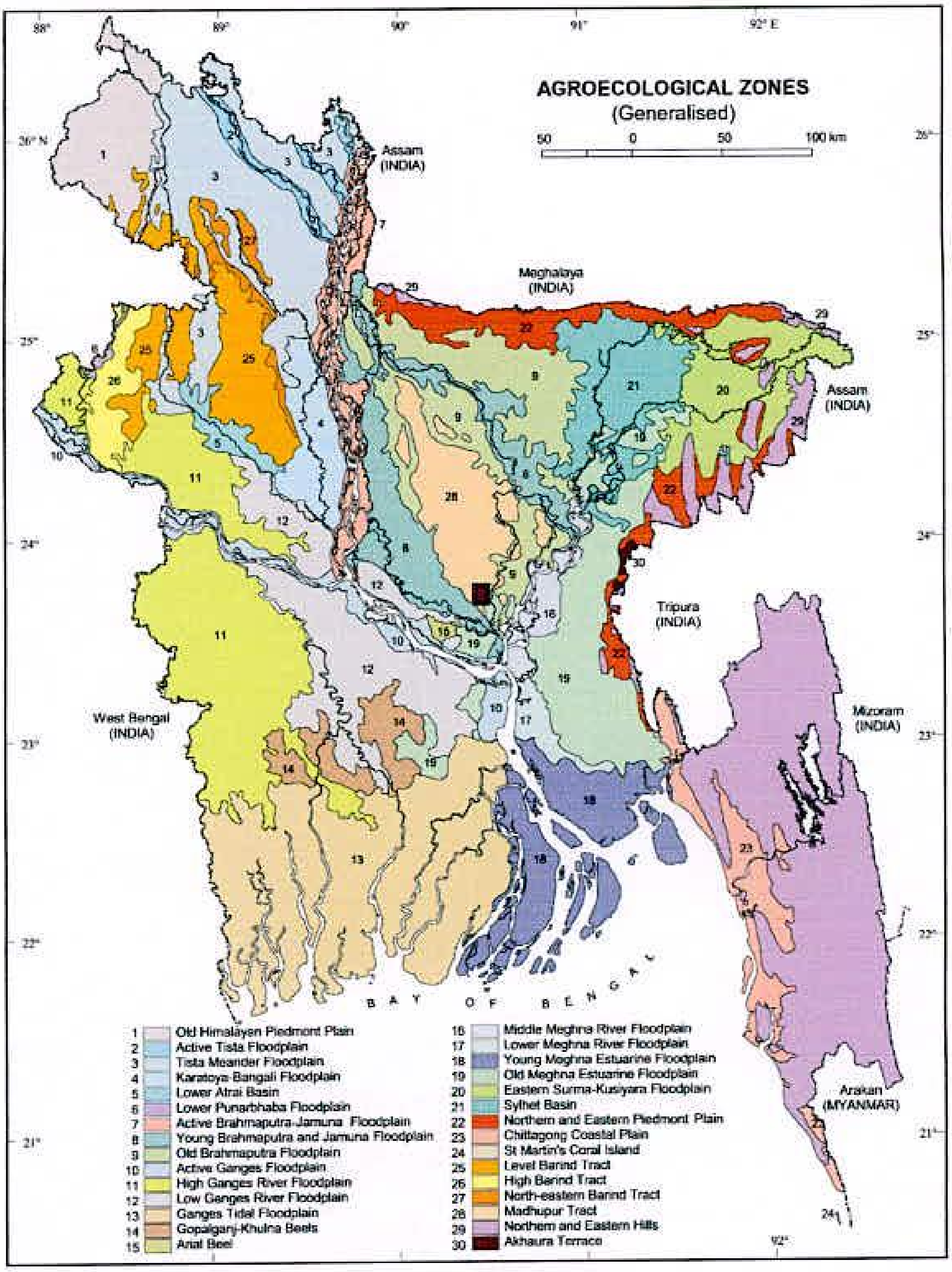
Appendices

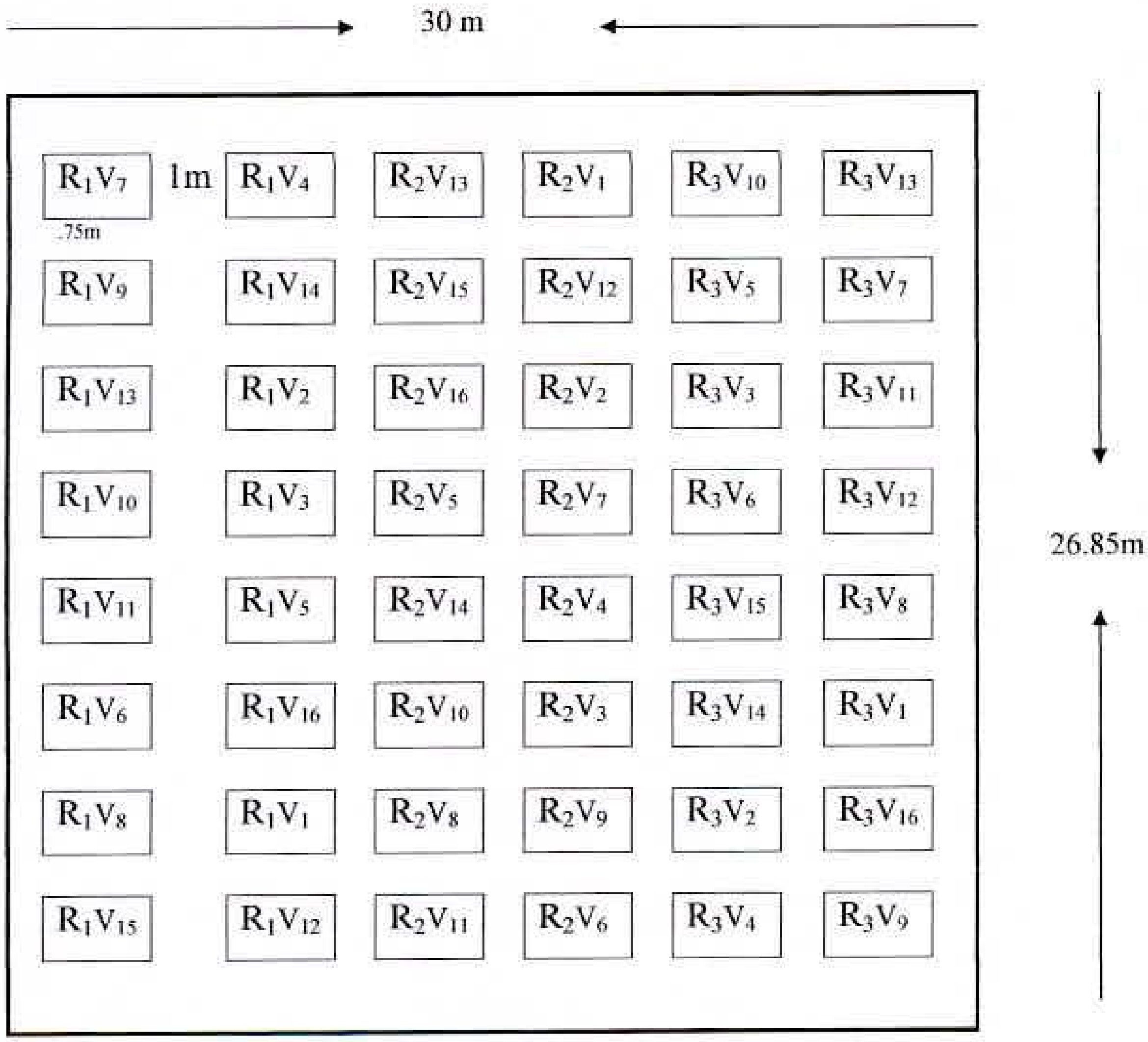
APPENDICES

Appendix I. Map showing the experimental site under study



Experimental sight

Appendix II. layout of the experimental site



Treatments

V_1 = BR3

V_2 = BR14

V_3 = BR16

V_4 = BRRI dhan28

V_5 = BRRI dhan29

V_6 = BRRI dhan36

V_7 = BRRI dhan45

V_8 = BRRI dhan50

V_9 = Binadhan-6

V_{10} = Bina new line

V_{11} = BRRI hybrid dhan1

V_{12} = BRRI hybrid dhan2

V_{13} = BRRI hybrid dhan3

V_{14} = Chamak

V_{15} = Hira1

V_{16} = Bhajan

Appendix III. Monthly average of air temperature, relative humidity and total rainfall of the experimental site during the period from December 2010 to May 2011

Months	Maximum temperature (c^0)	Minimum temperature (c^0)	Relative humidity at 12 pm (%)	Rainfall (mm)
December (2010)	28	16	64	2
January (2011)	26	14	69	0
February (2011)	33	19	51	0
March(2011)	35	22	48	0
April (2011)	36	23	61	184
May (2011)	26	24	62	180

[Source: Bangladesh Meteorological Department, Aaragaon, Dhaka-1212]

Appendix IV. Physiochemical properties of the experimental soil

Soil sample	pH	Organic matter (%)	Total Nitrogen (%)	Available Potassium (mg 100gm^{-1} soil)	Available Phosphorus (µg g^{-1} soil)
Before land preparation (application of compost and fertilizers)					
	6.5 (Slightly acidic)	1.48 (Low)	0.074 (Very low)	0.33 (High)	30.7 (Very high)
After land preparation (application of compost and fertilizers)					
	6.5 (Slightly acidic)	1.61 (Low)	0.08 (Vary low)	0.26(Standard)	91.9 (Very high)
After harvest of crop (sixteen *boro* rice varieties)					
V_1	6.2 (Slightly acidic)	0.74 (Very low)	0.037 (Very low)	0.29 (Standard)	37.5 (Very high)
V_2	6.3 (Slightly acidic)	1.75 (Medium)	0.087 (Very low)	0.25 (Standard)	31.5 (Very high)
V_3	6.3 (Slightly acidic)	1.61 (Low)	0.078 (Very low)	0.22 (Medium)	35.5 (Very high)
V_4	5.6 (Slightly acidic)	0.74 (Very low)	0.037 (Very low)	0.17 (medium)	34.8 (Very high)
V_5	6.2 (Slightly acidic)	1.95 (Medium)	0.097 (Low)	0.26 (standard)	36.1 (Very high)
V_6	6.2 (Slightly acidic)	1.68 (low)	0.084 (Very low)	0.18 (Medium)	35.8 (Very high)
V_7	6.1 (Slightly acidic)	1.61 (low)	0.079 (Very low)	0.21 (medium)	36.1 (Very high)
V_8	5.5 (Very acidic)	1.34 (low)	0.067 (Very low)	0.23 (standard)	37.2 (Very high)
V_9	6.4 (Slightly acidic)	0.74 (Very low)	0.038 (Very low)	0.26 (standard)	38.3 (Very high)
V_{10}	6.3 (Slightly acidic)	1.68 (Low)	0.084 (Very low)	0.33 (High)	39.5 (Very high)
V_{11}	6.1 (Slightly acidic)	1.08 (Low)	0.054 (Very low)	0.20 (Medium)	37.2 (Very high)
V_{12}	6.4 (Slightly acidic)	1.68 (low)	0.084 (Very low)	0.24 (standard)	37.4 (Very high)
V_{13}	6.0 (Slightly acidic)	0.87 (Very low)	0.043 (Very low)	0.17 (Medium)	333.2(Very high)
V_{14}	5.9 (Slightly acidic)	1.61 (Low)	0.080 (Very low)	0.19 (Medium)	39.9 (Very high)
V_{15}	6.2 (Slightly acidic)	1.21 (Low)	0.060 (Very low)	0.18 (Medium)	39.2 (Very high)
V_{16}	6.2 (Slightly acidic)	0.81 (Very low)	0.041 (Very low)	0.20 (Medium)	35.9 (Very high)
	Sloil structure	**Sand (%)**	**Silt (%)**	**Clay (%)**	
Soil from experimenta field	Silt loam	25.60	53.80	20.60	
Soil from other field	Silt loam	25.13	54.00	20.87	

Appendix V. Mean square values for seedling mortality rate of sixteen *boro* ricevarieties at different growth stages

Sources of variation	Degrees of freedom	Seedling mortality rate (%) of *boro* rice at.	
		7 DAT	14 DAT
Replication	2	6.98	90.42
Variety	15	29.53**	15.139**
Error	30	16.67	13.78

Appendix VI. Mean square values for plant height of sixteen *boro* rice varieties at different growth stages

Sources of variation	Degrees of freedom	Plant height (cm) of *boro* rice at different days at			
		30 DAT	60 DAT	90 DAT	harvest
Replication	2	54.231	44.456	24.715	20.429
Variety	15	10.785**	32.430**	222.010**	187.738**
Error	30	8.155	15.862	40.280	19.446

Appendix VII. Mean square values for plant root length of sixteen *boro* rice varieties at different growth stages

Sources of variation	Degrees of freedom	Plant root length (cm) of *boro* rice at			
		30 DAT	60 DAT	90 DAT	harvest
Replication	2	1.538	13.506	50.550	12.255
Variety	15	5.965**	43.904**	44.995**	20.677**
Error	30	4.086	29.001	25.703	6.979

Appendix VIII. Mean square values for plant shoot length of sixteen *boro* rice varieties at different growth stages

Sources of variation	Degrees of freedom	Plant shoot length of *boro* rice at			
		30 DAT	60 DAT	90 DAT	harvest
Replication	2	18.742	1.907	92.948	21.286
Variety	15	26.359**	45.381**	282.698**	203.555**
Error	30	12.668	42.692	104.204	28.320

Appendix IX. Mean square values for plant root length: shoot length of sixteen *boro* rice varieties at different growth stages

Sources of variation	Degrees of freedom	Root length : shoot length of *boro* rice at			
		30 DAT	60 DAT	90 DAT	harvest
Replication	2	0.054	0.090	0.959	0.640
Variety	15	0.426**	0.289**	2.227**	0.597**
Error	30	0.170	0.080	0.824	0.348

Appendix X. Mean square values for plant dry weight of sixteen *boro* rice at different growth stages

Sources of variation	Degrees of freedom	Plant dry weight (g $plant^{-1}$) of *boro* rice at			
		30 DAT	60 DAT	90 DAT	harvest
Replication	2	0.102	60.166	528.675	1227.411
Variety	15	0.024**	93.345**	230.576**	524.992^{NS}
Error	30	0.023	38.218	291.848	856.585

Appendix XI. Mean square values for root and shoot dry weight of sixteen *boro* rice at different growth stages

Sources of variation	Degrees of freedom	At 60 DAT		At 90 DAT		At harvest	
		Root dry matter	Shoot dry weight	Root dry matter	Shoot gry weight	Root dry matter	Shoot dry weight
Replication	2	37.619	17.405	55.033	299.524	282.653	514.894
Variety	15	41.463**	35.459**	60.487**	106.629^{NS}	149.022**	273.980^{NS}
Error	30	13.367	18.960	33.161	150.486	983.326	544.681

Appendix XII. Mean square values for leaf area index of sixteen *boro* rice at different growth stages

Sources of variation	Degrees of freedom	Mean square values for leaf area index of *boro* rice at			
		30 DAT	60 DAT	90 DAT	harvest
Replication	2	0.006	0.492	1.310	0.290
Variety	15	0.003**	0.121**	0.730^{ns}	1.371**
Error	30	0.003	0.118	1.380	0.683

Appendix XIII. Mean square values for days to initial flowering and fifty percent flowering of sixteen *boro* rice varieties

Sources of variation	Degrees of freedom	Days to initial flowering	Days to fifty percent flowering
Replication	2	1.02	3.771
Variety	15	64.733**	44.750**
Error	30	2.021	1.504

Appendix XIV. Mean square values for number of weed population and total weeds dry weight of sixteen *boro* rice varieties at different growth stages

Sources of variation	Degrees of freedom	Shama population m^{-2} at		Total weed population m^{-2} at		Total weeds dry eight m^{-2} at	
		30 DAT	60 DAT	30 DAT	60 DAT	30 DAT	60 DAT
Replication	2	941.68	456.063	1241.33	527.06	6.429	1.811
Variety	15	145.30**	1032.38**	2003.46**	1629.84**	5.835**	66.335**
Error	30	82.710	758.018	395.51	2021.91	3.997	44.700

Appendix XV. Mean square values for tiller $hill^{-1}$ of sixteen *boro* rice varieties cutivated at different growth stages

Sources of variation	Degrees of freedom	Mean square values for leaf area index at			
		30 DAT	60 DAT	90 DAT	harvest
Replication	2	1.191	81.66	21.16	8.40
Variety	15	0.305**	28.12**	35.90**	21.20**
Error	30	0.190	21.13	6.82	6.51

Appendix XVI. Mean square values for different yield attributing characters of sixteen *boro* rice varieties

Sources of variation	Degrees of freedom	Effective tillers $hill^{-1}$ (no.)	Non-effective tillers $hill^{-1}$ (no.)	Panicle length (cm)	Total grain $panicle^{-1}$ (no.)	Filled grains $panicle^{-1}$ (no.)	Unfilled grains $panicle^{-1}$ (no.)
Replication	2	5.27	0.286	15.89	885.53	586.42	40.97
Variety	15	18.90**	1.22**	146.94**	2353.98**	1578.96**	18.92**
Error	30	7.73	0.56	9.81	374.39	393.56	22.01

Appendix XVII. Mean square values for different yield attributing characters of sixteen *boro* rice varieties

Sources of variation	Degrees of freedom	Grain yield (t ha^{-1})	Weight of 1000 grains (g)	Straw yield (t ha^{-1})	Biologiacal yield (t ha^{-1})	Harvest index
Replication	2	0.192	0.596	1.325	2.716	5.811
Variety	15	0.729**	469.917**	1.809**	3.385**	19.390**
Error	30	0.268	0.256	0.854	1.861	14.365

PLATES

Plate 1. Transportation of manures to the experimental plots

Plate 2. Preparation of the experimental plots

Plate 3. Seeds of different rice varieties collected for the experiment

Plate 4. Sprouted rice seeds are in nursery tray

Plate 5. Twelve (12) days old rice seedlings in nursery tray

Plate 6. Twelve days old rice seedlings

Plate 7. Transplantation of young seedlings

Plate 8. Initial view of a plot after few days of transplantation

Plate 9. Soil cracks in plots due to alternate wetting and drying

Plate 10. Field view of a plot at vegetative period

Plate 11. Field view of the Experiment during flowering stage

Plate 12. Root system developed in system of rice intensification