GROWTH AND YIELD OF BORO RICE UNDER SYSTEM OF RICE INTENSIFICATION WITH DIFFERENT WATER REGIME AND MANURAL STATUS

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Dedicated

To My

Beloved Parents

&

Teachers

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CERTIFICATE

This is to certify that thesis entitled, **"GROWTH AND YIELD OF BORO RICE UNDER SYSTEM OF RICE INTENSIFICATION WITH DIFFERENT WATER REGIME AND MANURAL STATUS"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE in AGRONOMY**, embodies the result of a piece of bona fide research work carried out by **MD. JULFIKER RAHMAN,** Registration No. **06-01890** 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:
Place: Dhaka, Bangladesh

Prof. Dr. Parimal Kanti Biswas
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The Author

GROWTH AND YIELD OF BORO RICE UNDER SYSTEM OF RICE INTENSIFICATION WITH DIFFERENT WATER REGIME AND MANURAL STATUS

ABSTRACT

A field experiment was carried out at Agronomy Field, Sher-e-Bangla Agricultural University, Dhaka during the period from December, 2011 to May, 2012 to study the growth and yield of *Boro* rice under system of rice intensification with different water regime and manural status. The experiment consisted of two factor as three water regime viz., waterlogged condition, saturated condition and alternate wet and dry condition in main plot and six manure and fertilizer combinations viz., cowdung 100%, compost 100%, chemical fertilizer 100%, 50% chemical fertilizer + 25% compost + 25% cowdung, 50% chemical fertilizer + 50% cowdung and 50% chemical fertilizer + 50% compost in the sub-plots. The experiment was laid out in split-plot design with three replications. Experimental results showed that water regime had significant effect on growth and yield parameters except total weed population, number of effective tillers m^{-2}, filled grains $panicle^{-1}$, unfilled grains $panicle^{-1}$, weight of 1000-grains, harvest index, flag leaf length and number of rachis branch $panicle^{-1}$. The highest grain yield (5.74 t ha^{-1}) was obtained from the waterlogged condition that was statistically similar with saturated condition (5.69) and alternate wet and dry condition gave the lowest grain yield (4.36 t ha^{-1}). Manural status also significantly influenced the growth and yield attributes except total weed population, unfilled grains $panicle^{-1}$ and 1000-grains weight. The results revealed that the combination of chemical fertilizer, cowdung and compost showed the best performance compared to other manural status. The highest grain yield (5.81 t ha^{-1}) was obtained from chemical fertilizer (50%) + cowdung (25%) + compost (25%) and the lowest grain yield (4.71 t ha^{-1}) was obtained from compost (100%). The highest number of effective tillers $hill^{-1}$ (33.71) was obtained from compost (100%). Chemical fertilizer (50%) + cowdung (25%) + compost (25%) showed the highest harvest index (46.78%). In case of interaction effect of water regime and manural status the highest grain yield was observed in chemical fertilizer (50%) + cowdung (25%) + compost (25%) under saturated condition (6.80 t ha^{-1}) of water. The maximum number of effective tillers m^{-2} (28.80) was obtained from chemical fertilizer (50%) + cowdung (25%) + compost (25%) under waterlogged condition.

LIST OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF PLATES

Chapter 1

Introduction

CHAPTER 1

INTRODUCTION

Rice is the foremost staple food for more than 50% of the world's population (Thakur *et al.*, 2011). There is an upward shift in demand for rice worldwide due to population increase and urbanization, as people change their eating habits (Mishra, 2009), leading to high shelf prices. Between 2006 and 2008, average world prices for rice grew by 217%, compared to wheat which increased by 136%, corn by 125%, and soybeans by 107%. (FAO, 2010; Mittal, 2009). Bangladesh is one of the poorer countries of the world which is densely populated and threatened by floods and storms. About 75% of the total cropped area and more than 80% of the total irrigated area is planted to rice (Hossain and Deb, 2003). Almost all of the 13 million farm families grow rice. It provides nearly 40% of national employment (48% of rural employment), about 70-76% of total calorie supply and 66% of protein intakes of an average person in the country (Anon., 2004a; Hossain and Deb, 2003; Greenfield and Dowling, 1998; Dey *et al.*, 1996). Rice sector contributes one-half of the agricultural GDP and one-sixth of the national income in Bangladesh (Hossain, 2002). Thus, rice plays a vital role in the livelihood of the people.

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

To be able to meet the world's food demand by 2025, it is estimated that rice production has to increase globally by 60% (Fageria, 2007). But there is little scope to increase the area under rice production with the current practices that involve high production costs of fertilizers and protective chemicals (Sinavagari, 2006). Rice crop is also the largest consumer of water in the agricultural sector (Bera, 2009; Mishra, 2009; Prasad and Ravindra, 2009). Thus, innovative ways for reducing inputs like water, chemicals, fertilizers and labor while increasing yields on the same piece of land need to be put in place to ensure sustainable rice production (Bouman *et al*., 2005; Mati and Nyamai, 2009).

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

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

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

Experience with the System of Rice Intensification (SRI) techniques also shows that farmers who grow irrigated rice with continuous flooding have been wasting large volumes of water (Uphoff, 2006). The SRI is a production system that emphasize the use of younger seedlings (< 15 days) planted singly and at wider spacing, together with the adoption of intermittent irrigation, organic fertilization, and active soil aeration to the extent possible (Stoop *et al.*, 2002; Uphoff 2007). The SRI system shows that keeping paddy soils moist but not continuously saturated gives better results, both agronomically and economically, than flooding rice throughout its crop cycle. SRI methods enable farmers to reduce their irrigation by 25-50% while realizing higher and more profitable production (Uphoff and Randriamiharisoa, 2002; Anthofer, 2004; Li, 2001; Sato, 2005; Uphoff, 2006).

Rice is mostly grown under submerged soil conditions by transplanting seedling on puddled soil, which requires much more water compared with other crops. Rice is the single largest user of water, and it alone consumes about 30% of world fresh water consumption and more than 45% of total freshwater used in Asia. Unfortunately, water is becoming scarce with time and the increasing water crisis will threaten the sustainability of irrigated rice culture. Tuong and Bouman (2003) reported that about 20% area of 75 million hectares of Asia's flood irrigated lowland rice crop will experience water scarcity by 2025. The shortage and rising cost of labor and excess water consumption during puddling are the incentives to seek alternatives to transplanting, such as direct seeding.

Traditionally rice is grown under continuously flooded condition and hence most conventional water management practices aim to maintain a standing depth of water in the field throughout the season. Moreover, rice may be grown under continuous submergence or intermittent or variable water regime conditions depending on the farmer's choice and water resources. Traditional flood irrigated rice ecosystem not only causes wastage of water but also leads to environmental degradation and reduces fertilizer use efficiency. The utility of keeping the field under continuous waterlogged condition has been questioned by several researchers. Rice develops well in submerged condition, but recent development shows that rice can thrive well in dry soil also. During the last few decades, various new cultivation practices for growing rice have been tried worldwide. The different technologies developed so far to reduce water loss as well as increase water use efficiency of the rice crop are alternate wetting and drying, system of rice intensification, and saturated soil culture, which partially or totally suppress the need for water in rice field. All these systems have been reported to show high water productivity with no or little compromise on yield. These new water wise approaches revolutionize the longstanding concept that rice is an aquatic cereal. The present study was therefore carried out to study the growth and yield of *Boro* rice under system of rice intensification with different water regime and manural status with the following objectives:

a) Validation of SRI technology for higher rice productivity
b) To find out the optimum water level in SRI concept for optimum yield
c) Identification of SRI effectiveness in respect of fertilizer management and yield increase

Chapter 2
Review of literature

CHAPTER 2

REVIEW OF LITERATURE

2.1 Effect on growth parameters

According to De Datta (1981) the height of rice plant is directly related to the depth of water and generally increases with increasing water depth.

Khaliq and Cheema (2005) carried out an experiment and found that plant height during early tillering stage was not much affected by different water regimes. This might be due to few and small tillers being produced up to this growth stage, which minimized competition for available water for growth even under field capacity condition With advancing plant age, water requirement increased and reducing water to field capacity condition significantly reduced plant height especially at maturity as well as tiller production during later growth stages. Beyrouty *et al.* (1994) also observed reduction in plant height but not tiller production when flood was delayed.

Krishna *et al.* (2008) conducted an investigation to evaluate the influence of system of rice intensification (SRI) on seed yield and quality in rice variety BPT-5204 was conducted at Agricultural Research Station (Paddy), Sirsi during kharif 2004-05. SRI method of cultivation, application of FYM and RDF significantly increased the number of tillers. The treatment combinations with SRI method showed more number of productive tillers. Chakrabarty *et al.* (1993) reported that chemical fertilizer performed the highest number of total tillers hill^{-1} with organic manure.

Saina (2001) reported that in SRI practice fifty tillers per plant were easily obtained, and farmers who had mastered the methods and understand the principles had been able to get over 100 tillers from single tiny seedling. Garcia *et al.* (1995) found that uninhibited growth of direct seeded rice during the vegetative stage led to superior tiller number at maturity to that of transplanted rice.

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.

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.

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

Longxing *et al.* (2002) studied the physiological effects of different rice crop management systems by comparing the results associated with traditional methods of flooded rice irrigation to non-flooded rice farming with young seedlings and wider spacing (SRI). In SRI, they observed, forms high biomass by larger individual plants, and dry mater accumulation after heading accounted for 40% of the total dry matter. More than 45% of the material from stem and sheath was contributed to grain yield in SRI. However, Moody (1992) said that a water depth greater than 15 cm may delay maturity of rice.

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

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.

Latif *et al.* (2005) conducted an experiment 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.

There is a concern that the AWD method of water management promotes greater weed populations, thus requiring more labor for weed management. Rakotomalala (1997) reported that SRI methodology required approximately 38–54% more labor than conventional methods. According to him 62% of the extra labor was needed for weed management while 17% was for transplanting. However, Anthofer (2004) found no difference in labor inputs between SRI and conventional cultivation. Furthermore, Sinha and Talati (2007) documented an 8% reduction in labor needed per hectare in SRI compared to the conventional, with a corresponding 67% increase in net income. No difference in weed-labor input between AWD and conventional plot in this experiment could be the combined effect of standing water on the field for a fortnight after transplanting, and use of herbicide 10 days after transplanting.

According to Uddin (2006) application of cow dung helps in improving soil structure, soil aeration and therefore improves the activities of soil micro-organisms. That increased the nutrient uptake of plant.

2.2 Effect on yield contributing characters

Previous research shown yield increases in between 50-100% while irrigation water inputs were reduced by between 25% and 50% with SRI, even on some of the poorest soils (Berkelaar, 2001; Sarath and Thilak, 2004; WBI, 2008).

Bhuiyan and Tuong (1995) concluded that a standing depth of water throughout the season is not needed for high rice yields. They added that about 40–45 percent of the water normally used in irrigating the rice crop in the dry season was saved by applying water in small quantities only to keep the soil saturated throughout the growing season, without sacrificing rice yields. A similar result was obtained by Sato and Uphoff (2007) with the use of intermittent irrigation in SRI management. Similarly, Hatta (1967), Tabbal *et al.* (1992), and Singh *et al.* (1996) reported that maintaining a very thin water layer, at saturated soil condition, or alternate wetting and drying can reduce water applied to the field by about 40–70 percent compared with the traditional practice of continuous shallow submergence, without a significant yield loss. Keisuke *et al.* (2007) also reported a reduced irrigation water requirement for non-flooded rice by 20–50 percent than for flooded rice, with the difference strongly dependent on soil type, rainfall, and water management practices. Borell *et al.* (1997), however, reported a decrease in rice yields under non-flooded conditions that was proportional to the level of water stress experienced by the plants.

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

Anon. (2004a) 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 against 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.

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

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.

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.

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, by 84% increase.

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.

Higher number of panicles under flooded condition produced high grain yield of rice, which was comparable with saturated condition. This finding is in line with George *et al*. (2002) and Kato *et al*. (2006). Keeping soil under saturated condition shows a good result in terms of rice growth and yield with 50% less water use.

Latif *et al.* (2005) conducted a series of experiments in eastern Bangladesh to investigate the System of Rice Intensification (SRI). SRI always resulted in higher panicle lengths than BRRI recommended practices and farmers practices.

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}).

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 (AWD) on the yield, water use and water use efficiency (WUE) of *Boro* rice. The experimental layout was furniture using split plot design (SPD) with two modern varieties (MV) of rice viz. BRRI dhan28 and BRRI dhan29, 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 (GL). They found that BRRI dhan28 produced highest 9.00 effective tillers hill^{-1} and BRRI dhan29 produced 11.00 effective tillers hill^{-1} having 171.0 and 217.67 grains panicle^{-1} respectively 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.

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. 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}.

Miah *et al.* (2008) conducted an experiment in 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) was obtained from SRI planting method in Gaibandha. On the other hand, the lowest 1000- grain weight (19.00g) was produced at Lalmonirhat.

Das (2003) reported that the System of Rice Intensification (SRI) gave more rice yield compared to the farmers practice (FP). The farmers from their SRI plots received 19% higher yield compared to their FP plots during *Boro* season in 2003. 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 that 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 dry material from stem and sheath was contributed to grain yield in SRI. Das also stated that soils with high fertility influence the grain yield. He found that yield of *Boro* rice was significantly influenced by organic matter, cation exchange capacity, nitrogen, phosphorus and potassium.

Mazid *et al.* (2003) found that conventional practices of rice cultivation gave significantly higher grain yield compared to the SRI method of crop establishment.

According to Barrett *et al.* (2004), manure increased organic matter content, water holding capacity and plant nutrients. It also increased the efficiency of mineral fertilizer by improving the physical properties of the soil helps to improve plant growth and yield. Soil incorporated with cowdung contains enough suitable phosphoric acid, potash and lime (Dobermann, 2004).

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. They found that 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. The harvest index in SRI was 47.21% over the harvest index of 32.42% in SMP.

Bouman and Toung (2001) found highest biological yield in combination of the chemical fertilizer and saturated condition.

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.

After reviewing all this information in this section, it was pointed out that SRI technology gave maximum yield. On the other hand, use of organic and inorganic fertilizer as well as maintaining optimum water level is an important option to increase the growth and yield of rice plant. Therefore, the present research work was conducted to determine the growth and yield of *boro* rice under system of rice intensification with different water regime and manural status.

Chapter 3

Materials and Methods

CHAPTER 3
MATERIALS AND METHODS

The experiment was conducted at the Agronomy field, 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 latitude and 90°33′E longitude at an altitude of 8.6 meter above the sea level.

3.1.2 Agro-Ecological Region

The experimental field belongs to the Agro-ecological zone of “The Modhupur Tract”, AEZ-28. This was a region of complex relief and soils developed over the Modhupur clay, where floodplain sediments buried the dissected edges of the Modhupur Tract leaving small hillocks of red soils as ‘islands’ surrounded by floodplain (Anon., 1988). 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 was 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 clay loam in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. Soil pH ranged from 6.1-6.5 and had organic matter 1.29%. The experimental area was flat having available irrigation and drainage system and above flood level.

3.2 Details of the experiment

3.2.1 Treatments

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

(A) Main plot (Water regime): 3

i. Waterlogged (W_1)
ii. Saturated (W_2)
iii. alternate wet & dry (W_3)

(B) Sub-plot (Manural status): 6

i. Cowdung (100%) (F_1)
ii. Compost (100%) (F_2)
iii. Chemical fertilizer (100%) (F_3)
iv. Chemical fertilizer (50%) + cowdung (25%) + compost (25%) (F_4)
v. Chemical fertilizer (50%) + cowdung (50%) (F_5) and
vi. Chemical fertilizer (50%) + compost (50%) (F_6)

3.2.2 Experimental design

The experiment was laid out in a split-plot design with three replications having water regime in the main plots and manural status in the sub-plots. There were 18 treatment combinations. The total numbers of unit plots were 54. The size of unit plot was 3.5 m by 2.5 m (8.75 m^2). The distances between each plots and replications were 1 m. The layout of the experiment has been shown in Appendix II.

3.3 Planting material

BRRI dhan45 was used as plant material.

3.3.1 Description of variety: BRRI dhan45 is short durated (140-145 days) crop with medium bold grain. Plant height is about 95 to 100 cm. Average yield is 6.0-6.5 t h^{-1}.

3.4 Crop management

3.4.1 Seedling raising

3.4.1.1 Seed collection

Seeds of BRRI dhan45 were collected from Genetic Resource and Seed Division, BRRI, Joydebpur, Gazipur, Bangladesh.

3.4.1.2 Seed sprouting

Seeds were selected by following specific gravity method. Seeds were immersed into 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 6 portable trays containing soil and cow dung. 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 28, 2011. Sprouted seeds were sown uniformly as possible.

3.4.2 Preparation of experimental land

The experimental field was first ploughed on December 23, 2011 with the help of a tractor drawn disc plough on January 1, 2012. The land was irrigated and prepared by three successive ploughings and cross ploughings with a tractor drawn plough and subsequently leveled by laddering. All weeds and other plant residues of previous crop were removed from the field. Immediately after final land preparation, the field layout was made on January 4, 2012 according to experimental specification. Individual plots were cleaned and finally leveled with the help of wooden plank so that no water pocket could remain in the puddled field.

3.4.6.3 Application of irrigation water

Three water regimes namely, waterlogged, saturated and Alternate Wet and Dry (AWD) were used as main plot treatment.

- Waterlogged: The level of water in each plot was maintained at about 5 cm above the soil surface throughout the growing period of the crop until near maturity. Irrigation was scheduled at 4 day intervals starting 7 days after transplanting (DAT). Plots were equipped with drainage irrigation system for continuous flood irrigation (up to 5-6 cm depth) throughout the rice-growing season.

- Saturated: Water was applied just to saturate the soil (no flood) throughout the growing period of the crop. For maintaining field capacity, periodic irrigation was applied to maintain the soil at about field capacity from transplanting to maturity. Plots were watered every day in the morning by sprinkling.

- Alternate Wet and Dry (AWD): Alternate Wet and Dry (AWD) is a water management system where rice fields are not kept continuously submerged but are allowed to dry intermittently during the rice growing stage. Intermittent irrigation was scheduled at 10 day intervals starting 7 days after transplanting (DAT) up to maturity. Water level was maintained about 5 cm above from soil ground during the wetting period. Water level was decreased in such a level that hairline cracks were develop in the field.

3.4.5 Uprooting and transplanting of seedlings

The 12 days old seedlings were uprooted from the trays and transplanted on January 10, 2012. The trays were brought to the main field and seedlings were planted in the prepared plot just after uprooting and this process was completed within one minute.

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 25 days after transplanting followed by second weeding at 30 days after first weeding, and weeds were removed mechanically with the help of a Japanese rice weeder.

3.4.7 Fertilizer application

Different manural status was used as sub-plot treatment.

- Cowdung (100%): The selected plots were applied with 10000 kg ha^{-1} cowdung. The entire amount of cow dung was applied as basal dose at final land preparation.

- Compost (100%): The 10000 kg ha^{-1} compost was applied to the selected plots. The entire amount of compost was also applied as basal dose at final land preparation.

- Chemical fertilizer (100%): The experimental plots were fertilized with 195, 95, 65, 70 and 10 kg ha^{-1} Urea, TSP, MOP, 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 four equal installments. First installment was done after seedling recovery and the rest three installments were done at 20 days interval.

- Chemical fertilizer (50%) + cowdung (25%) + compost (25%): The 2500 kg ha^{-1} cowdung and compost was applied to the selected plots. The entire amounts of cowdung and compost were applied as basal dose at final land preparation. The plots were fertilized with 97.5, 47.5, 32.5,35 and 5 kg ha^{-1} Urea, TSP, MOP, 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 four equal installments. First installment was done after seedling recovery and the rest three installments were done at 20 days interval.

- Chemical fertilizer (50%) + cowdung (50%): The 5000 kg ha^{-1} cowdung and 47.5, 32.5, 35 and 5 kg ha^{-1} TSP, MP, Gypsum and zinc sulphate, respectively were entirely applied as basal dose at final land preparation to the selected plots.

The 97.5 kg ha^{-1} Urea was top-dressed in four equal installments. First installment was done after seedling recovery and the rest three installments were done at 20 days interval.

- Chemical fertilizer (50%) + compost (50%): 5000 kg ha^{-1} compost and 47.5, 32.5,35 and 5 kg ha^{-1}TSP, MP, Gypsum and zinc sulphate, respectively were entirely applied as basal dose at final land preparation to the selected plots. 97.5 kg ha^{-1} Urea was top-dressed in four equal installments. First installment was done after seedling recovery and the rest three installments were done at 20 days interval.

3.4.8 Plant protection measures

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 properly, especially during morning and afternoon.

3.4.9 Harvesting and post harvest operation

Maturity of crop was determined when 90% of the grains become golden yellow in color. The harvesting was done on May 12, 2012, 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% grained moisture level. Straw was also sun dried properly. Finally grain and straw yields $plot^{-1}$ were determined and converted to ton ha^{-1}.

3.4.10 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 parameters

i. Plant height (cm) at 25 days interval
ii. Number of tillers $hill^{-1}$ at 25 days interval
iii. Leaf area index at 25 days interval
iv. Dry weight of plant at 30 days interval
v. Time of flowering and maturity
vi. Weed population m^{-2} and weed dry matter m^{-2} at 25 and 55 DAT

B. Yield and other parameters

i. Number of effective tillers $hill^{-1}$
ii. Number of ineffective tillers $hill^{-1}$
iii. Length of panicle (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 (%)
xii. Flag leaf length
xiii. No. of rachis per panicle

3.4.11 Detailed procedures of recording data

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

A. Crop growth parameters

i. Plant height (cm)

Plant height was measured at 35, 60, 85 DAT and at harvest. The height of the plant was determined by measuring the distance from the soil surface to the tip of the leaf height before heading, and to the tip of panicle after heading.

ii. Number of tillers hill^{-1} (no.)

Number of tillers hill^{-1} were counted at 35, 60, 85 DAT and at harvest from ten randomly pre-selected hills and was expressed as number hill^{-1}. Only those tillers having three or more leaves were used for counting.

iii. Leaf area index (LAI)

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

iv. Dry weight of plant (g)

The sub-samples of 5 hills plot^{-1} uprooted from second line were oven dried until a constant leveled from which the weights of above ground dry matter were recorded at 30 day intervals and at harvest.

v. Time of flowering

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

vi. Weed population and weed dry matter

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

vii. Time of harvest

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

C. Yield and yield components

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

The panicles which had at least one grain was considered as effective tillers. The number of effective tillers of 10 hill was recorded and expressed as effective tillers hill^{-1}.

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

The tillers having no panicle were regarded as ineffective tillers. The number of ineffective tillers 10 hills^{-1} was recorded and was expressed as ineffective tillers hill^{-1}.

iii. Panicle length (cm)

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

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

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

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

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

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

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

vii. Weight of 1000 grains (g)

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

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

Grain yield was determined from the central 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.

ix. 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}**.**

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

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

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

xi. Harvest index (%)

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

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

Xii. Flag leaf length

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

Xiii. No. of rachis per panicle

The number of total rachis present on ten panicles were recorded and finally averaged.

3.4.12 Statistical analysis

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

Chapter 4

Results and Discussion

CHAPTER 4

RESULTS AND DISCUSSION

Results obtained from the present study regarding the effects of water levels and manural status and their interactions on the yield and yield components of rice have been presented, discussed and compared in this chapter. The analytical results have been presented in Table 1 through 10, Figure 1 through 21 and Appendix IV through XIII. A general view of the experimental plots and treatments has been shown in plates 8 through 14.

4.1 Crop growth parameters

4.1.1 Plant height

i. Effect of water regime

The plant height of *Boro* rice was significantly influenced by different water regime at 35, 60 and 85 days after transplanting (DAT) and harvest (Appendix IV and Table 1). The result revealed that at 35, 60 and 85 DAT, waterlogged condition produced the tallest plant (18.84, 39.98, 72.62 cm respectively). But at 60 DAT waterlogged condition was statistically similar with the saturated condition (39.15 cm) and alternate wet and dry condition gave the shortest plant (15.27, 34.12, 60.30 cm respectively). However, at harvest, the highest plant height (77.07 cm) was obtained from the waterlogged condition which was statistically similar with the saturated condition (75.32 cm) and the lowest height (71.33 cm) was recorded in alternate wet and dry condition. In the initial stage of growth, the increase of plant height was very slow and rapid increase of plant height was observed from 35 to 85 DAT. The height of rice plant is directly related to the depth of water and generally increases with increasing water depth (De Datta, 1981). Khaliq and Cheema, (2005) also observed tallest plant in the waterlogged condition and shortest plant height in alternate wet and dry condition.

With advancing plant age, water requirement increased and reducing water to field capacity condition significantly reduced plant height especially at maturity as well as tiller production during later growth stages. Beyrouty *et al.* (1994) also observed reduction in plant height but not tiller production when flood was delayed.

ii. Effect of manural status

Significant variation of plant height was found due to different manural status in all the growth stages (Appendix IV and Table 1). The results revealed that at 35, 60 and 85 DAT, 100% chemical fertilizer produced the tallest plant. At 35 DAT, the tallest plant was 18.11 cm which was statistically similar with the compost (100%), (17.13 cm), chemical fertilizer (50%) + cowdung (50%) (17.24cm) and chemical fertilizer (50%) + compost (50%) (16.96cm). The shortest plant height (16.28 cm) was obtained from cowdung (100%), that was statistically similar with compost (100%) (17.13 cm), chemical fertilizer (50%) + cowdung (25%) + compost (25%) (16.60 cm), chemical fertilizer (50%) + cowdung (50%) (17.24 cm) and chemical fertilizer (50%) + compost (50%) (16.96cm). The tallest plant height (41.87 cm) was recorded at 60 DAT from the chemical fertilizer (100%) followed by the chemical fertilizer (50%) + compost (50%) (39.76 cm). At 85 DAT the tallest plant height was (73.00 cm). The initial establishment of the transplanted crop depended on seedling vigor and in general, the plants from vegetative propagated tillers established better as the initial advantage in their height and dry weight resulting in better growth and faster acclimatization to the soil (Sharma, 1995). At harvest, the tallest plant (78.13 cm) was obtained from the chemical fertilizer (100%), which was statistically similar with the chemical fertilizer (50%) + compost (50%) (76.69 cm) and the shortest plant height was obtained from cowdung (100%) (70.71 cm) that was similar with compost (100%), chemical fertilizer (50%) + cowdung (25%) + compost (25%) and chemical fertilizer (50%) + cowdung (50%). Younger seedlings have more vigor, root growth and lesser transplant shock because of lesser leaf area during initial growth stages which stimulate increased cell division causing more stem elongation which might increase plant height of SRI (Sangsu *et al.*, 1999). Shrirame *et al.* (2000) reported that the number of functional leaves, leaf area and total number of tillers hill^{-1} were higher at wider spacing which increased the photosynthetic rate leading to taller plants. Shortening of plants in tiller crop at harvest might be due to shortage of time for proper vegetative growth and development. Similar results were also reported by Mollah *et al.* (1992). This result confirms the result obtained by Uddin (2006) who found inorganic fertilizer increased height of rice plant.

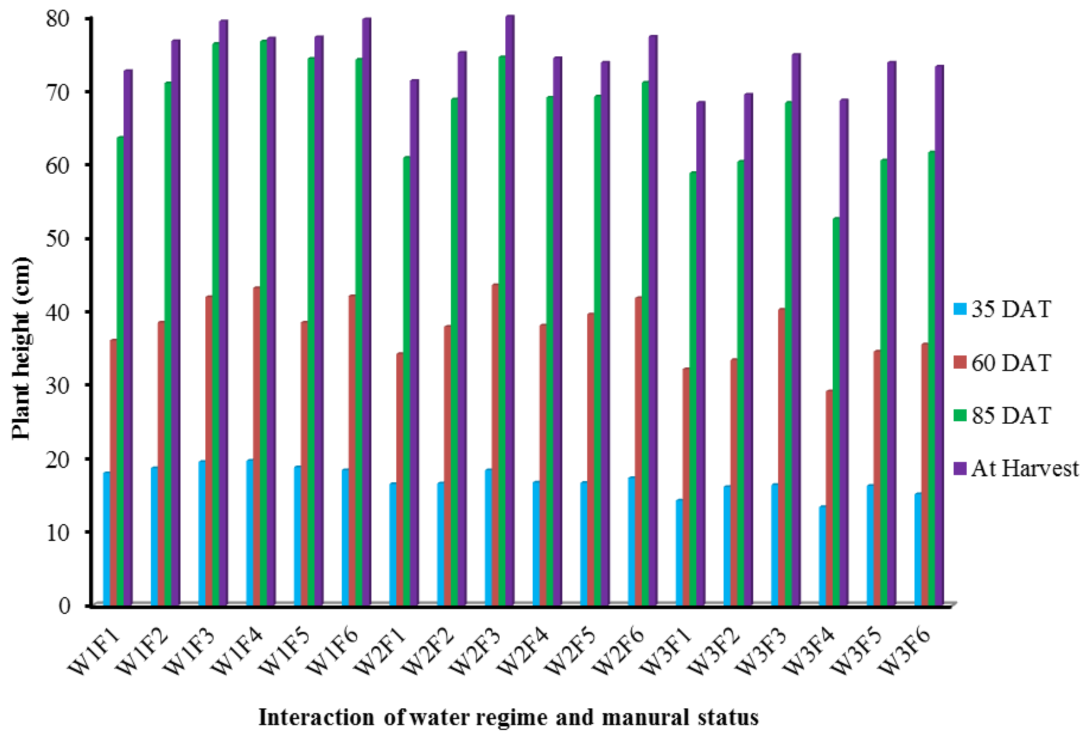
Table 1. Influence of water regime and manural status on plant height at different growth stages of *Boro* rice transplanted in SRI

Treatments	Plant height (cm) at different days after transplanting			
	35	60	85	At harvest
Water regime				
W_1	18.84a	39.98a	72.62a	77.07a
W_2	17.04b	39.15a	68.86b	75.32a
W_3	15.27c	34.12b	60.30c	71.33b
LSD $_{(0.05)}$	1.160	2.917	5.598	3.026
CV (%)	7.35	8.351	8.99	4.39
Manural status				
F_1	16.28b	34.09e	61.02c	70.71d
F_2	17.13ab	36.56cde	66.64b	73.71bcd
F_3	18.11a	41.87a	73.00a	78.13a
F_4	16.60b	36.75cd	66.04b	73.31cd
F_5	17.24ab	37.50bc	67.96b	74.89bc
F_6	16.96ab	39.76ab	68.89b	76.69ab
LSD $_{(0.05)}$	1.363	2.577	3.091	3.148
CV (%)	8.31	7.04	4.77	4.17

W_1 = Waterlogged, W_2 = Saturated, W_2 = Alternate wet and dry, F_1 = Cowdung (100%), F_2 = Compost (100%), F_3 = Chemical fertilizer (100%), F_4 = Chemical fertilizer (50%) + Cowdung (25%) + Compost (25%), F_5 = Chemical fertilizer (50%) + Cowdung (50%) and F_6 = Chemical fertilizer (50%) + compost (50%)

iii. Interaction effect of water regime and manural status

Significant interaction effect between the water regime and manural status was observed at 35, 60, 85 DAT and at harvest (Appendix IV and Figure 1). At 35 DAT the tallest plant (19.67 cm) was obtained from chemical fertilizer (50%) + cowdung (25%) + compost (25%) at the waterlogged condition followed by the cowdung (100%), compost (100%), chemical fertilizer (100%), chemical fertilizer (50%) + cowdung (50%) and chemical fertilizer (50%) + compost (50%) at same condition and chemical fertilizer (100%) and chemical fertilizer (50%) + compost (50%) at saturated condition. The shortest (13.40 cm) was obtained from chemical fertilizer (50%) + cowdung (25%) + compost (25%) at alternate wet and dry condition which was statistically similar with cow dung (100%) and chemical fertilizer (50%) + compost (50%) at alternate wet and dry condition. At 60 DAT, the tallest plant (43.52 cm) was obtained from chemical fertilizer (100%) at saturated condition followed by chemical fertilizer (100%), chemical fertilizer (50%) + cowdung (25%) + compost (25%) and chemical fertilizer (50%) + compost (50%) at waterlogged condition, chemical fertilizer (100%), chemical fertilizer (50%) + compost (50%) at saturated condition and chemical fertilizer (100%) at alternate wet and dry condition. The shortest (17.24 cm) was obtained from cowdung (100%) at alternate wet and dry condition, statistically similar with compost (100%) at alternate wet and dry condition. At 85 DAT, the tallest plant (76.60 cm) was obtained from chemical fertilizer (50%) + cowdung (25%) + compost (25%) at waterlogged condition similar with chemical fertilizer (100%) at same condition, chemical fertilizer (50%) + cowdung (50%), chemical fertilizer (50%) + compost (50%) and chemical fertilizer (100%) at saturated condition and the shortest (52.53 cm) was obtained from chemical fertilizer (50%) + cowdung (25%) + compost (25%) at alternate wet and dry condition. At harvest, the tallest plant (80.27 cm) was obtained from chemical fertilizer (100%) at saturated condition similar with compost (100%), chemical fertilizer (100%), chemical fertilizer (50%) + cowdung (25%) + compost (25%), chemical fertilizer (50%) + cowdung (50%) and chemical fertilizer (50%) + compost (50%) at water logged condition and chemical fertilizer (50%) + compost (50%) at saturated condition. The shortest plant (68.27 cm) was recorded from cowdung (100%) at alternate wet and dry condition which is statistically similar with cowdung (100%) at waterlogged condition, cowdung (100%) at saturated condition, chemical fertilizer (100%) at saturated condition, chemical fertilizer (50%) + cowdung (25%) + compost (25%) at alternate wet and dry condition and chemical fertilizer (50%) + Compost (50%) at alternate wet and dry condition. Longxing *et al.* (2002) reported that plant height of the hybrid rice with SRI methods was higher than with traditional method.



W_1 = Waterlogged, W_2 = Saturated, W_2 = Alternate wet and dry, F_1 = Cowdung (100%), F_2 = Compost (100%), F_3 = Chemical fertilizer (100%), F_4 = Chemical fertilizer (50%) + Cowdung (25%) + Compost (25%), F_5 = Chemical fertilizer (50%) + Cowdung (50%) and F_6 = Chemical fertilizer (50%) + compost (50%)

Figure 1. Interaction effect of water regime and manural status on plant height (cm) at different growth stages of *Boro* rice transplanted in SRI ($LSD_{0.05}$ at 35, 60, 85 DAT and harvest = 2.361, 4.429, 5.354 and 5.452 respectively)

4.1.2 Number of tillers hill^{-1} at different crop growth stage

i. Effect of water regime

The production of total number of tillers hill^{-1} of *Boro* rice was significantly influenced by different water regime at 35, 60 and 85 DAT (Appendix V and Table 2). At 35 DAT the highest tiller numbers hill^{-1} was observed in the saturated condition (2.42) which was statistically similar with the waterlogged condition (2.09cm) and the lowest tiller numbers hill^{-1} was obtained from alternate wet and dry condition (1.68). At 60 and 85 DAT the highest tiller numbers hill^{-1} was observed in waterlogged condition and the lowest tiller numbers hill^{-1} was obtained from alternate wet and dry condition. At harvest there is no significant relationship among the different water regime. Rice growth under flooded condition gave higher number of tiller than under field capacity, comparable with saturated condition. This finding is in agreement with Anwar *et al.* 2010. Bouman and Toung (2001) also found the highest number of tillers hill^{-1} in the saturated condition. With advancing plant age, water requirement increased and reducing water to field capacity condition significantly reduced plant height especially at maturity as well as tiller production during later growth stages. Beyrouty *et al.* (1994) also observed reduction in plant height but not tiller production when flood was delayed.

ii. Effect of manural status

The production of total tillers hill^{-1} was significantly influenced by different manural status at 60, 85 DAT and harvest (Appendix V and Table 2). At 30 DAT significant relationship was not found. At 60 DAT significantly highest number (21.60) of tillers hill^{-1} was recorded from chemical fertilizer (100%) and the lowest (12.49) number was from compost (100%), which was similar to cowdung (100%). At 85 DAT and harvest, compost (100%) produced significantly highest number (40.16 and 38.20 respectively) of tillers hill^{-1} which was statistically similar with chemical fertilizer (50%) + cowdung (25%) + compost (25%) (34.04). The lower number of tillers hill^{-1} was observed from cowdung (100%) (34.64) at 85 DAT and chemical fertilizer (50%) + cowdung (50%) (28.98) at harvest.

These results were agreement with the findings of Chakrabarty *et al.* (1993), who reported that S chemical fertilizer produced the highest number of total tillers hill^{-1} with organic manure.

iii. Interaction effect of water regime and manural status

Interaction effect of water regime and manural status significantly influenced the production of total tillers hill^{-1} at 35, 60, 85 DAT and at harvest (Appendix V and Figure 2). At 35 DAT, the highest number of tillers hill^{-1} (2.93) was obtained from chemical fertilizer (50%) + compost (50%) at saturated condition which was similar to the chemical fertilizer (100%) at waterlogged condition, chemical fertilizer (50%) + cow dung (25%) + compost (25%) at waterlogged condition, chemical fertilizer

(50%) + cowdung (50%) at waterlogged condition and chemical fertilizer (50%) + compost (50%) at saturated condition. At 60 the highest number of tillers $hill^{-1}$ (26.93)

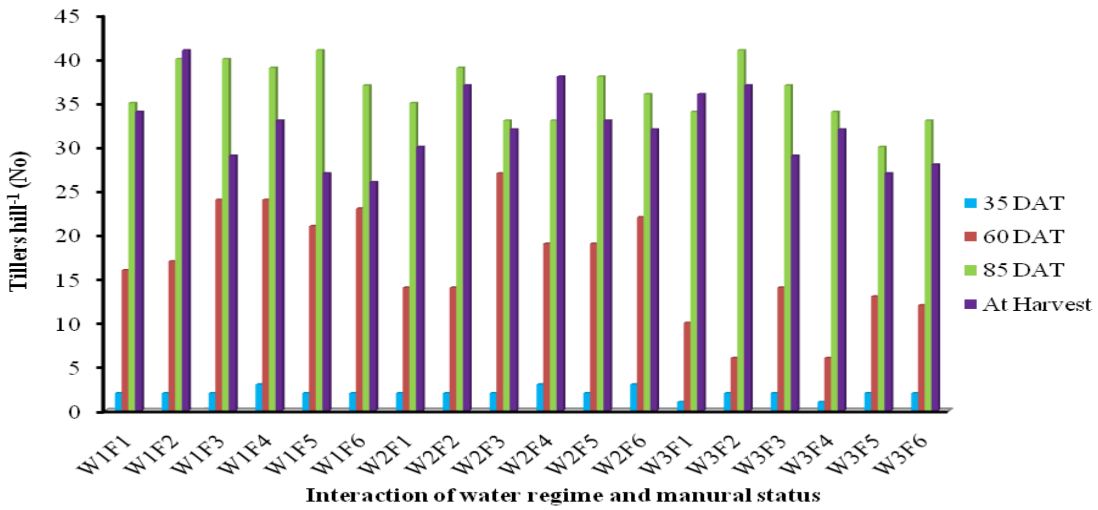
Table 2. Influence of water regime and manural status on tiller numbers $hill^{-1}$ at different growth stages of *Boro* rice transplanted in SRI

Treatments	Number of tillers $hill^{-1}$ at different days after transplanting			
	35	60	85	At harvest
Water regime				
W_1	2.09a	20.77a	38.67a	31.81
W_2	2.42a	19.02b	35.79b	33.57
W_3	1.68b	10.20c	34.81b	31.44
$LSD_{(0.05)}$	0.333	3.667	2.388	NS
CV (%)	17.45	23.79	7.08	16.54
Manural status				
F_1	1.82	13.24cd	34.64b	33.44b
F_2	1.91	12.49d	40.16a	38.20a
F_3	2.24	21.60a	36.69b	29.93bc
F_4	2.22	16.38bc	35.16b	34.04ab
F_5	2.02	17.42b	36.53b	28.98c
F_6	2.15	18.84b	35.73b	29.04c
$LSD_{(0.05)}$	NS	3.242	2.314	4.354
CV (%)	25.01	20.21	6.60	14.00

W_1 = Waterlogged, W_2 = Saturated, W_2 = Alternate wet and dry, F_1 = Cowdung (100%), F_2 = Compost (100%), F_3 = Chemical fertilizer (100%), F_4 = Chemical fertilizer (50%) + Cowdung (25%) + Compost (25%), F_5 = Chemical fertilizer (50%) + Cowdung (50%) and F_6 = Chemical fertilizer (50%) + compost (50%)

was obtained from the chemical fertilizer (100%) at saturated condition similar with chemical fertilizer (100%), chemical fertilizer (50%) + cowdung (25%) + compost

(25%) and chemical fertilizer (50%) + compost (50%) at waterlogged condition and chemical fertilizer (50%) + compost (50%) at saturated condition. The lowest number of tillers hill^{-1} (6.40) was obtained from compost (100%) at alternate wet and dry condition. At 85 DAT, the highest number of tillers hill^{-1} (41.33) was obtained from compost (100%) at alternate wet and dry condition similar with compost (100%), chemical fertilizer (100%), chemical fertilizer (50%) + cowdung (25%) + compost (25%), chemical fertilizer (50%) + cow dung (50%) and chemical fertilizer (50%) + compost (50%) at waterlogged condition, compost (100%) and chemical fertilizer (50%) + cowdung (50%) at saturated condition. The lowest number of tillers hill^{-1} (30.07) was obtained from chemical fertilizer (50%) + cow dung (50%) at alternate wet and dry condition and at harvest, the highest number of tillers hill^{-1} (41.27) was obtained from compost (100%) at waterlogged condition followed by cowdung (100%) at water logged condition, compost (100%) at saturated condition, chemical fertilizer (50%) + cowdung (25%) + compost (25%) at saturated condition, cowdung (100%) at alternate wet and dry condition and compost (100%) at alternate wet and dry condition. The lowest number of tillers hill^{-1} (26.33) was obtained from chemical fertilizer (50%) + compost (50%) at waterlogged condition. Choudhary and Mclean (1963) indicated that waterlogged condition with chemical fertilizer had a more vigorous tillering potential and good regulation of leaf and tiller growth.



W_1 = Waterlogged, W_2 = Saturated, W_2 = Alternate wet and dry, F_1 = Cowdung (100%), F_2 = Compost (100%), F_3 = Chemical fertilizer (100%), F_4 = Chemical fertilizer (50%) + Cowdung (25%) + Compost (25%), F_5 = Chemical fertilizer (50%) + Cowdung (50%) and F_6 = Chemical fertilizer (50%) + compost (50%)

Figure 2. Interaction effect of water regime and manural status on tiller numbers hill^{-1} at different growth stages of *Boro* rice transplanted in SRI (LSD$_{0.05}$ at 35, 60, 85 DAT and harvest = 0.860, 5.616, 4.007 and 7.542 respectively)

4.1.3 Leaf area index (LAI) at different crop growth stage

The leaf area of plant is one of the major determinants of its growth. It is the ratio 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 it declines due to increased senescence (Katiya, 1980).

i. Effect of water regime

Effect of water regime significantly influenced leaf area index (LAI) of boro rice at 35, 65, 95 DAT and at harvest (Appendix VI and Table 3). At 35 and 95 DAT the highest leaf area index (0.036 and 3.86, respectively) was found in waterlogged condition and the lowest leaf area index (0.02 and 2.64, respectively) was found in Alternate wet and dry condition. At 65 DAT and harvest, the highest leaf area index (1.08 and 3.06, respectively) was found in waterlogged condition and statistically similar with saturated condition and the lowest leaf area index (0.42and 2.22, respectively) was found in alternate wet and dry condition. This result confirmed the findings of Yambao and Ingram (1988) who reported maximum leaf area at 70 DAT for IR 64. Results also indicated that the leaf started to decrease at 58 DAT onwards in all the treatments irrespective of water depth.

ii. Effect of manural status

Effect of manural status significantly influenced leaf area index (LAI) of boro rice at 35, 65, 95 DAT and at harvest (Appendix VI and Table 3). However, at 35 DAT chemical fertilizer (100%) produced the highest leaf area index (0.032) and the lowest (0.026) was found from compost (100%). At 65 DAT chemical fertilizer (100%) produced the highest leaf area index (1.26) and the lowest (0.513) was found from compost (100%). At 95 DAT, chemical fertilizer (100%) produced the highest leaf area index (4.69) and cowdung (100%) produced the lowest leaf area index (2.62). At harvest, chemical fertilizer (100%) produced the highest leaf area index (3.35) and the lowest (2.24) was found from cowdung (100%) and compost (100%). This result might be due to the higher number of leaves m^{-2} in this treatment. Dobermann and Fairhurst, (2000) reported that application of chemical fertilizer with cowdung produces higher LAI.

Table 3. Influence of water regime and manural status on LAI at different growth stages of *Boro* rice transplanted in SRI

Treatments	Leaf area index at different days after transplanting			
	35	65	95	At harvest
Water regime				
W_1	0.036a	1.086a	3.867a	3.062a
W_2	0.030b	1.074a	3.147b	2.582a
W_3	0.020c	0.426b	2.648c	2.222b
LSD $_{(0.05)}$	0.002	0.122	0.474	0.521
CV (%)	6.88	15.30	15.89	21.48
Manural status				
F_1	0.028bc	0.615e	2.627c	2.240d
F_2	0.026c	0.513f	2.668c	2.241d
F_3	0.032a	1.261a	4.693a	3.350a
F_4	0.028bc	0.923c	2.808c	2.394cd
F_5	0.028bc	0.799d	3.282b	2.849b
F_6	0.030ab	1.062b	3.244b	2.656bc
LSD $_{(0.05)}$	0.003	0.086	0.238	0.282
CV (%)	9.35	10.36	7.67	11.19

W_1 = Waterlogged, W_2 = Saturated, W_2 = Alternate wet and dry, F_1 = Cowdung (100%), F_2 = Compost (100%), F_3 = Chemical fertilizer (100%), F_4 = Chemical fertilizer (50%) + Cowdung (25%) + Compost (25%), F_5 = Chemical fertilizer (50%) + Cowdung (50%) and F_6 = Chemical fertilizer (50%) + compost (50%)

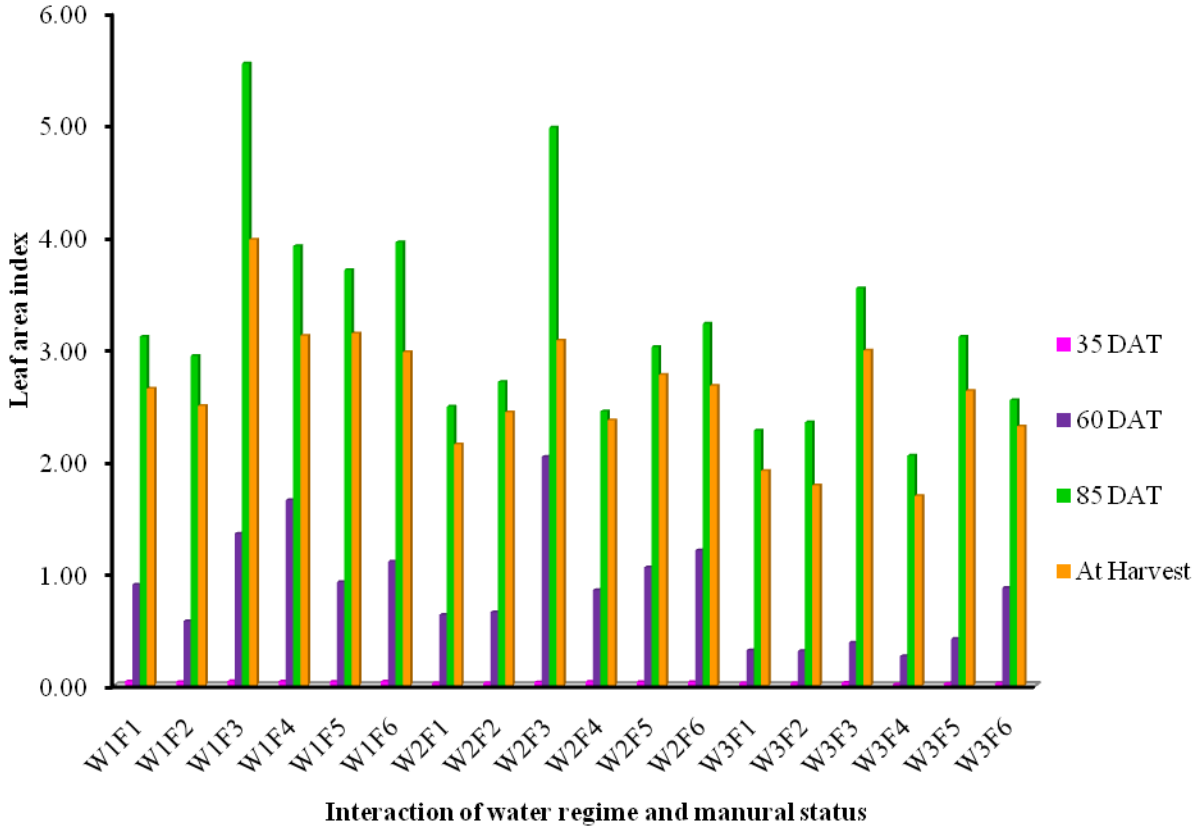
iii. Interaction effect of water regime and manural status

Interaction effect of water regime and manural status significantly influenced leaf area index (LAI) of boro rice at 35, 65, 95 DAT and at harvest (Appendix VI and Figure 3). At 35 DAT chemical fertilizer (50%) + cowdung (25%) + compost (25%) at saturated condition produced the highest leaf area index (0.036) that was similar with chemical fertilizer (100%), chemical fertilizer (50%) + cowdung (25%) + compost (25%) and chemical fertilizer (50%) + compost (50%) at waterlogged condition. The lowest LAI (0.012) was produced from chemical fertilizer (50%) + cowdung (25%) + compost (25%) at alternate wet and dry condition. At 65 DAT, chemical fertilizer (100%) at saturated condition produced the highest leaf area index (2.042), lowest LAI (0.263) was produced from chemical fertilizer (50%) + cowdung (25%) + compost (25%) at alternate wet and dry condition. At 95 DAT chemical fertilizer (100%) at waterlogged condition produced the highest (5.553) leaf area index and chemical fertilizer (50%) + cowdung (25%) + compost (25%) at alternate wet and dry condition produced the lowest leaf area index (2.053). At harvest, chemical fertilizer (100%) at waterlogged condition produced the highest leaf area index (3.390) and chemical fertilizer (50%) + cowdung (25%) + compost (25%) at alternate wet and dry condition produced the lowest leaf area index (1.690).

4.1.4 Dry matter production

i. Effect of water regime

Different water regime significantly influenced the dry matter production at 35, 65, 95 DAT and at harvest (Appendix VII and Table 4). At 35 DAT, saturated condition produced the highest dry weight (6.86 g m^{-2}). At 65 DAT, waterlogged condition produced the highest dry weight (137.54 g m^{-2}) which was statistically similar with saturated condition and At 95 DAT, the highest dry weight (137.54 g m^{-2}) was produced by saturated condition which was statistically similar with waterlogged condition. At harvest, waterlogged condition produced the maximum dry weight (1095.11 g m^{-2}). However at 35, 65, 95 DAT and at harvest the lowest dry weights were produced by alternate wet and dry condition.



W_1 = Waterlogged, W_2 = Saturated, W_2 = Alternate wet and dry, F_1 = Cowdung (100%), F_2 = Compost (100%), F_3 = Chemical fertilizer (100%), F_4 = Chemical fertilizer (50%) + Cowdung (25%) + Compost (25%), F_5 = Chemical fertilizer (50%) + Cowdung (50%) and F_6 = Chemical fertilizer (50%) + compost (50%)

Figure 3. Interaction effect of water regime and manural status on Leaf Area Index (LAI) at different growth stages of *Boro* rice transplanted in SRI ($LSD_{0.05}$ at 35, 60, 85 DAT and harvest = 0.004, 0.149, 0.412 and 0.489 respectively)

ii. Effect of manural status

The total dry weight of plant was significantly influenced by manural status at 35, 65, 95 DAT and harvest (Appendix VII and Table 4). At 35 and 65 DAT, the highest dry weights (7.21 and 135.76 g m^{-2}, respectively) were recorded in chemical fertilizer (100%) and the lowest dry weight was recorded in compost (100%) (3.97 g m^{-2}) and cowdung (100%) (66.66 g m^{-2}), respectively. At 95 DAT, chemical fertilizer (100%) produced the highest dry weight (694.83 g m^{-2}) which was statistically similar with the chemical fertilizer (50%) + cowdung (25%) + compost (25%) (656.16 g m^{-2}) and cowdung (100%) produced the lowest dry weight (429.01 g m^{-2}) which was statistically similar with the compost (100%) (510.70 g m^{-2}). At harvest, chemical fertilizer (100%) produced the highest dry weight (1213.89 g m^{-2}) and the lowest dry weight (752.22 gm^{-2}) was obtained from cowdung (100%).

Table 4. Influence of water regime and manural status on total dry matter (g m^{-2}) at different growth stages of *Boro* rice transplanted in SRI

Treatments	Total dry weight (g m^{-2}) at different days after transplanting			
	35	65	95	At harvest
Water regime				
W_1	5.93b	137.52a	656.39a	1095.11a
W_2	6.86a	129.15a	657.45a	1056.00b
W_3	3.95c	39.10b	421.74b	738.17c
LSD $_{(0.05)}$	0.217	16.094	70.896	82.996
CV (%)	4.20	17.06	13.24	9.31
Manural status				
F_1	5.14d	66.66d	429.01d	752.22e
F_2	3.97f	75.10d	510.70cd	831.44d
F_3	7.21a	135.76a	694.83a	1213.89a
F_4	5.56c	116.10b	656.16ab	1033.00b
F_5	4.69e	104.21c	599.43b	980.78c
F_6	6.92b	113.77bc	581.02bc	967.22c
LSD $_{(0.05)}$	0.122	11.350	87.622	42.129
CV (%)	2.27	11.57	15.73	4.54

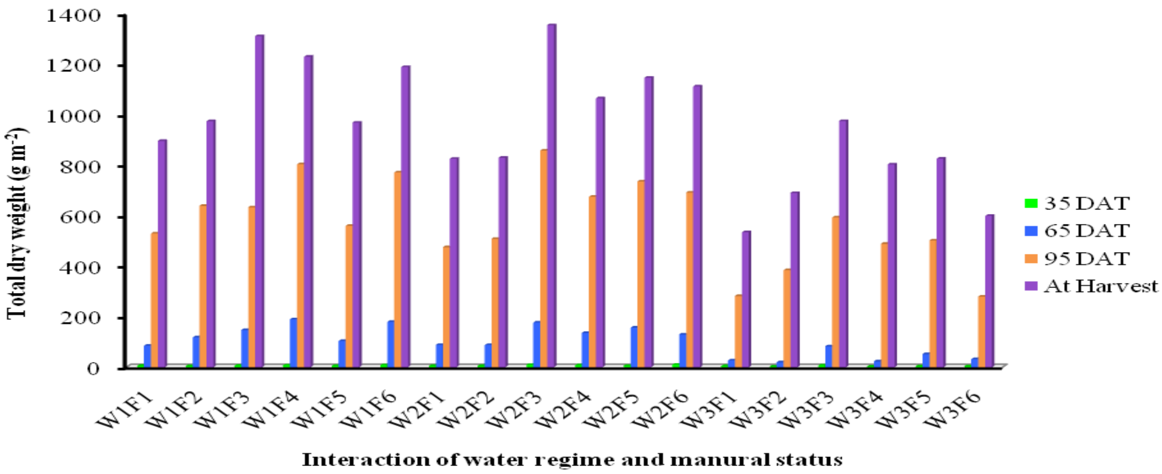
W_1 = Waterlogged, W_2 = Saturated, W_2 = Alternate wet and dry, F_1 = Cowdung (100%), F_2 = Compost (100%), F_3 = Chemical fertilizer (100%), F_4 = Chemical fertilizer (50%) + Cowdung (25%) + Compost (25%), F_5 = Chemical fertilizer (50%) + Cowdung (50%) and F_6 = Chemical fertilizer (50%) + compost (50%)

iii. Interaction effect of water regime and manural status

Interaction effect of water regime and manural status influenced the dry matter production of boro rice at 35, 65, 95 DAT and at harvest (Appendix VII and Figure 4). At 35 DAT, the highest dry weight (9.55 g m^{-2}) was observed in chemical fertilizer (50%) + compost (50%) at saturated condition and the lowest dry weight (2.41 g m^{-2})

was observed in chemical fertilizer (50%) + cowdung (25%) + compost (25%) at alternate wet and dry condition. At 65 DAT, the highest dry weight (189.91 g m^{-2}) was obtained from the chemical fertilizer (100%) at saturated condition which was similar with chemical fertilizer (50%) + compost (50%) at waterlogged condition and chemical fertilizer (100%) at saturated condition. The lowest dry weight (19.07 g m^{-2}) was observed in compost (100%) at alternate wet and dry condition statistically similar with cowdung (100%) at alternate wet and dry condition and chemical fertilizer (50%) + compost (50%) at alternate wet and dry condition. Again at 95 DAT, maximum dry weight (857.95 g m^{-2}) was produced by chemical fertilizer (100%) at saturated condition similar with chemical fertilizer (50%) + compost (50%) at waterlogged condition, chemical fertilizer (50%) + cowdung (25%) + compost (25%) at waterlogged condition and chemical fertilizer (50%) + cowdung (50%) at saturated condition. The lowest dry weight (281.94 g m^{-2}) was observed in cowdung (100%) at alternate wet and dry condition similar with compost (100%) at alternate wet and dry condition.

At harvest, chemical fertilizer (100%) at saturated condition produced the highest dry weight (1355.00 g m^{-2}) which was similar with chemical fertilizer (100%) at waterlogged condition whereas, the lowest dry weight (534.67 g m^{-2}) was produced by cowdung (100%) under alternate wet and dry condition.



W_1 = Waterlogged, W_2 = Saturated, W_2 = Alternate wet and dry, F_1 = Cowdung (100%), F_2 = Compost (100%), F_3 = Chemical fertilizer (100%), F_4 = Chemical fertilizer (50%) + Cowdung (25%) + Compost (25%), F_5 = Chemical fertilizer (50%) + Cowdung (50%) and F_6 = Chemical fertilizer (50%) + compost (50%)

Figure 4. Interaction effect of water regime and manural status on total dry weight (gm m^{-2}) at different growth stages of *Boro* rice($LSD_{0.05}$ at 35, 60, 85 DAT and harvest = 0.212, 19.659, 151.765 and 72.969, respectively)

4.1.5 Days to flowering and maturity

i. Effect of water regime

The flowering and maturity dates significantly varied among the water regime (Appendix VIII and Table 5), where alternate wet and dry condition showed the longest duration for flowering (89.78 days) and maturity (115.11 days) and waterlogged condition had shortest duration for flowering (85 days). In case of maturity waterlogged condition also showed shortest duration (111.83 days) which was statistically similar with saturated condition. A water depth greater than 15 cm may delay maturity of rice (Moody, 1992).

ii. Effect of manural status

Various manural status affected flowering and maturity time (Appendix VIII and Table 5). The chemical fertilizer (50%) + cowdung (50%) needed the longest duration for flowering (87.67 days) and chemical fertilizer (100%) needed the shortest duration (85.67 days) which was statistically similar with compost (100%) and chemical fertilizer (50%) + compost (50%). For maturity cowdung (100%) needed the longest duration (115 days) and chemical fertilizer (100%) needed the shortest duration (111.11 days).

iii. Interaction effect of water regime and manural status

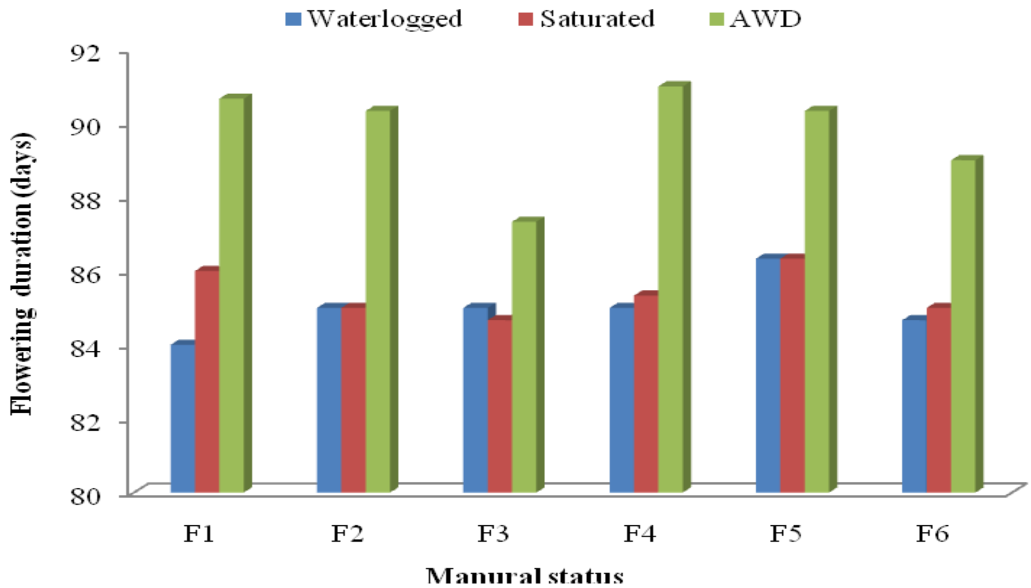
Interaction effect of water regime and manural status significantly influenced the flowering and maturity duration (Appendix VIII, Figure 5 & Figure 6). Chemical Fertilizer (50%) +Cowdung (25%) +Compost (25%) at alternate wet and dry condition required the highest duration for flowering (91 days) which is similar with cowdung (100%), compost (100%) and chemical fertilizer (50%) +cowdung (50%) at the same condition and cowdung (100%) at waterlogged condition needed the shortest duration for flowering (84 days). In maturity, compost (100%) at alternate wet and dry condition needed the longest duration (117 days) that was statistically similar with cowdung (100%), chemical fertilizer (50%) + cowdung (25%) + compost (25%) and chemical fertilizer (50%) + compost (50%) at same condition, cowdung (100%) at saturated condition and chemical fertilizer (100%) and chemical fertilizer (50%) + cowdung (25%) + compost (25%) at waterlogged condition. Chemical fertilizer (100%) at saturated condition required the shortest duration (111 days) statistically

Table 5. Influence of water regime and manural status on flowering and maturity duration of *Boro* rice transplanted in SRI

Treatments	Days to flowering	Days to maturity
Water regime		
W_1	85.00c	111.83b
W_2	85.39b	112.67b
W_3	89.78a	115.11a
LSD $_{(0.05)}$	0.155	1.076
CV (%)	0.19	1.03
Manural status		
F_1	86.89ab	115.00a
F_2	86.78abc	113.89b
F_3	85.67c	111.11c
F_4	87.11ab	112.89b
F_5	87.67a	113.33b
F_6	86.22bc	113.00b
LSD $_{(0.05)}$	1.198	1.028
CV (%)	1.44	0.94

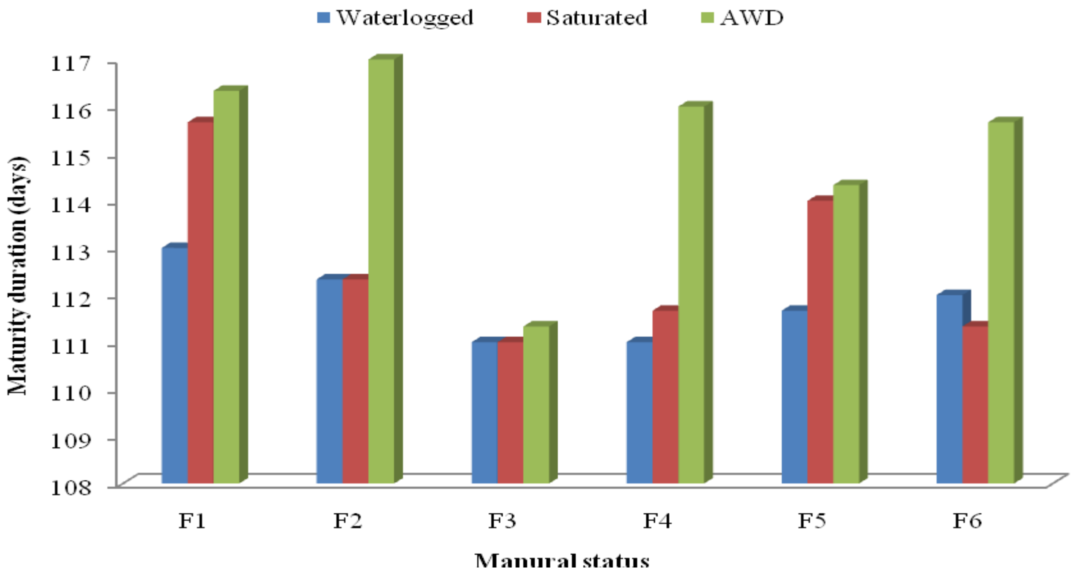
W_1 = Waterlogged, W_2 = Saturated, W_2 = Alternate wet and dry, F_1 = Cowdung (100%), F_2 = Compost (100%), F_3 = Chemical fertilizer (100%), F_4 = Chemical fertilizer (50%) + Cowdung (25%) + Compost (25%), F_5 = Chemical fertilizer (50%) + Cowdung (50%) and F_6 = Chemical fertilizer (50%) + compost (50%)

similar with compost (100%), chemical fertilizer (50%) + cowdung (50%) and chemical fertilizer (50%) + compost (50%) at waterlogged condition, compost (100%), chemical fertilizer (50%) + cowdung (25%) + compost (25%) and chemical fertilizer (50%) + compost (50%) at saturated condition and chemical fertilizer (100%) of alternate wet and dry condition.



W_1 = Waterlogged, W_2 = Saturated, W_2 = Alternate wet and dry, F_1 = Cowdung (100%), F_2 = Compost (100%), F_3 = Chemical fertilizer (100%), F_4 = Chemical fertilizer (50%) + Cowdung (25%) + Compost (25%), F_5 = Chemical fertilizer (50%) + Cowdung (50%) and F_6 = Chemical fertilizer (50%) + compost (50%)

Figure 5. Interaction effect of water regime and manural status on flowering duration (days) of *Boro* rice transplanted in SRI ($LSD_{0.05}$ = 2.075)



W_1 = Waterlogged, W_2 = Saturated, W_2 = Alternate wet and dry, F_1 = Cowdung (100%), F_2 = Compost (100%), F_3 = Chemical fertilizer (100%), F_4 = Chemical fertilizer (50%) + Cowdung (25%) + Compost (25%), F_5 = Chemical fertilizer (50%) + Cowdung (50%) and F_6 = Chemical fertilizer (50%) + compost (50%)

Figure 6. Interaction effect of water regime and manural status on maturity duration (days) of *Boro* rice transplanted in SRI ($LSD_{0.05}$ = 1.781)

4.1.6 Total weed population

i. Effect of water regime

Water regime did not show any significant effect on total weed population (Appendix IX and Table 6) at 25 DAT but at 55 DAT the highest weed population (55.17 m^{-2}) was found from alternate wet and dry condition. The lowest weed population (18.67 m^{-2}) was found from waterlogged condition. A major reason of flooding the rice field with water is to control the weed population. Transplanting single seedling provides ample space, resources like light and water for weed species to germinate and grow without much competition from the rice crop. But SRI facilitates AWD that makes weed infestation worse. Satyanarayana *et al.*(2007) stated the weed as 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.

ii. Effect of manural status

Total weed population also not significantly influenced by different manural status (Appendix IX and Table 6) at 25 DAT but at 55 DAT the highest weed population (50.33 m^{-2}) was found from chemical fertilizer (50%) + cowdung (25%) + compost (25%) and chemical fertilizer (50%) + cowdung (50%). The lowest weed population (22.56 m^{-2}) was found from cowdung (100%) which was similar to compost (100%) and chemical fertilizer (50%) +compost (50%).

iii. Interaction effect of water regime and manural status

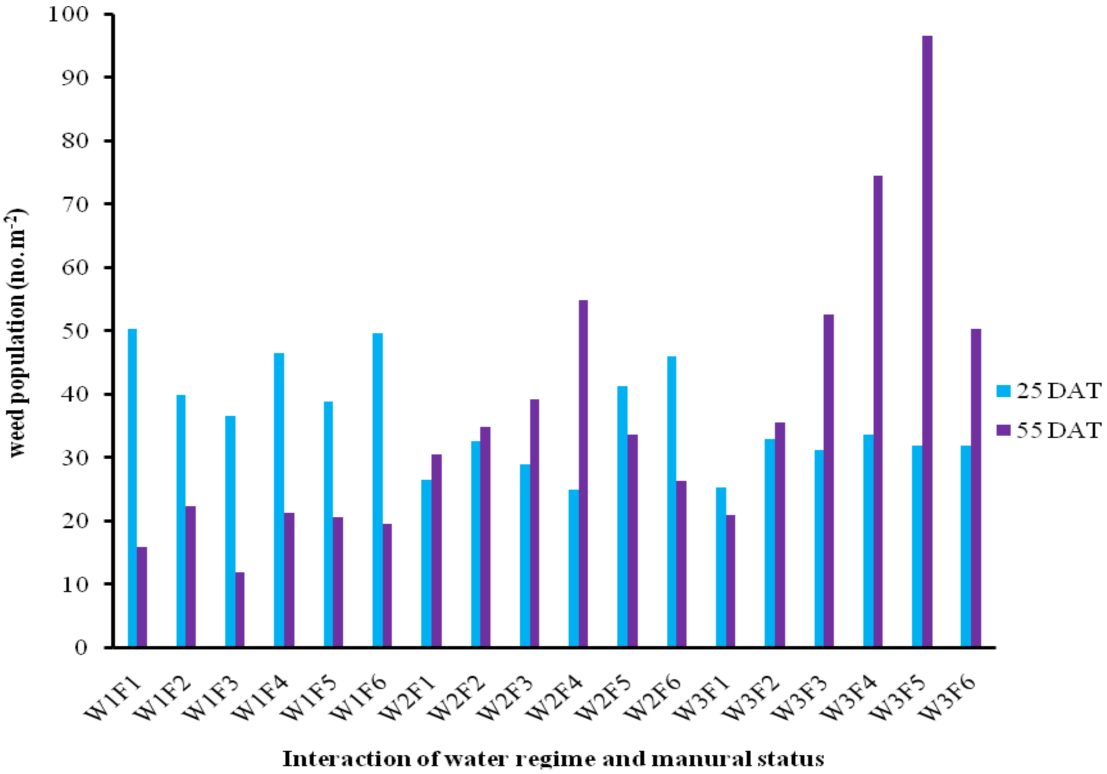
Total weed population was significantly influenced by the interaction effect between water regime and manural status (Appendix IX and Figure 7). At 25 DAT, the maximum (50.33 m^{-2}) number of weed population was obtained from cowdung (100%) at water logged condition which was similar with all other interaction effect of water regime and manural status except cowdung (100%) at alternate wet and dry condition and cowdung (100%) at saturated condition and the minimum (25.00 m^{-2})

Table 6. Influence of water regime and manural status on weed population (no. m^{-2}) and dry weight (g m^{-2}) of *Boro* rice transplanted in SRI

Treatment	Total weed population (no. m^{-2}) at		Total dry weight (g m^{-2}) at	
	25 DAT	55 DAT	25 DAT	55 DAT
Water level				
W_1	43.72	18.67c	0.83a	1.71c
W_2	33.44	36.67b	0.74b	3.84a
W_3	31.22	55.17a	0.57c	3.16b
LSD $_{(0.05)}$	NS	14.621	0.083	0.612
CV (%)	55	42.88	12.51	22.57
Manural status				
F_1	34.11	22.56c	0.77b	1.63c
F_2	35.22	31.00bc	0.70bc	2.61c
F_3	32.33	34.67b	0.57c	4.08a
F_4	35.11	50.33a	0.58c	2.66c
F_5	37.44	50.33a	0.58c	3.46b
F_6	42.56	32.11bc	1.10a	3.00bc
LSD $_{(0.05)}$	NS	10.761	0.132	0.532
CV (%)	37.28	30.33	19.28	19.08

W_1 = Waterlogged, W_2 = Saturated, W_2 = Alternate wet and dry, F_1 = Cowdung (100%), F_2 = Compost (100%), F_3 = Chemical fertilizer (100%), F_4 = Chemical fertilizer (50%) + Cowdung (25%) + Compost (25%), F_5 = Chemical fertilizer (50%) + Cowdung (50%) and F_6 = Chemical fertilizer (50%) + compost (50%)

number of weed population was obtained from compost (100%) at saturated condition which was similar with all other interaction effect of water regime and manural status. At 55 DAT, the maximum (96.67 m^{-2}) number of weed population was obtained from chemical fertilizer (50%) + cowdung (50%) at alternate wet and dry condition and the minimum (12.00 m^{-2}) number was obtained from chemical fertilizer (100%) at water logged condition statistically similar with cowdung (100%), compost (100%) chemical fertilizer (50%) + cowdung (25%) + compost (25%), chemical fertilizer (50%) + cowdung (50%) and chemical fertilizer (50%) + compost (50%) at waterlogged condition, chemical fertilizer (50%) + compost (50%) at saturated condition and cowdung (100%) at alternate wet and dry condition.



W_1 = Waterlogged, W_2 = Saturated, W_2 = Alternate wet and dry, F_1 = Cowdung (100%), F_2 = Compost (100%), F_3 = Chemical fertilizer (100%), F_4 = Chemical fertilizer (50%) + Cowdung (25%) + Compost (25%), F_5 = Chemical fertilizer (50%) + Cowdung (50%) and F_6 = Chemical fertilizer (50%) + compost (50%)

Figure 7. Interaction effect of water regime and manural status on weed population (no.) m^{-2} of *Boro* rice transplanted in SRI ($LSD_{0.05}$ at 25 and 55 DAT = 22.459 and 18.629 respectively)

4.1.7 Total dry weight of weed population

i. Effect of water regime

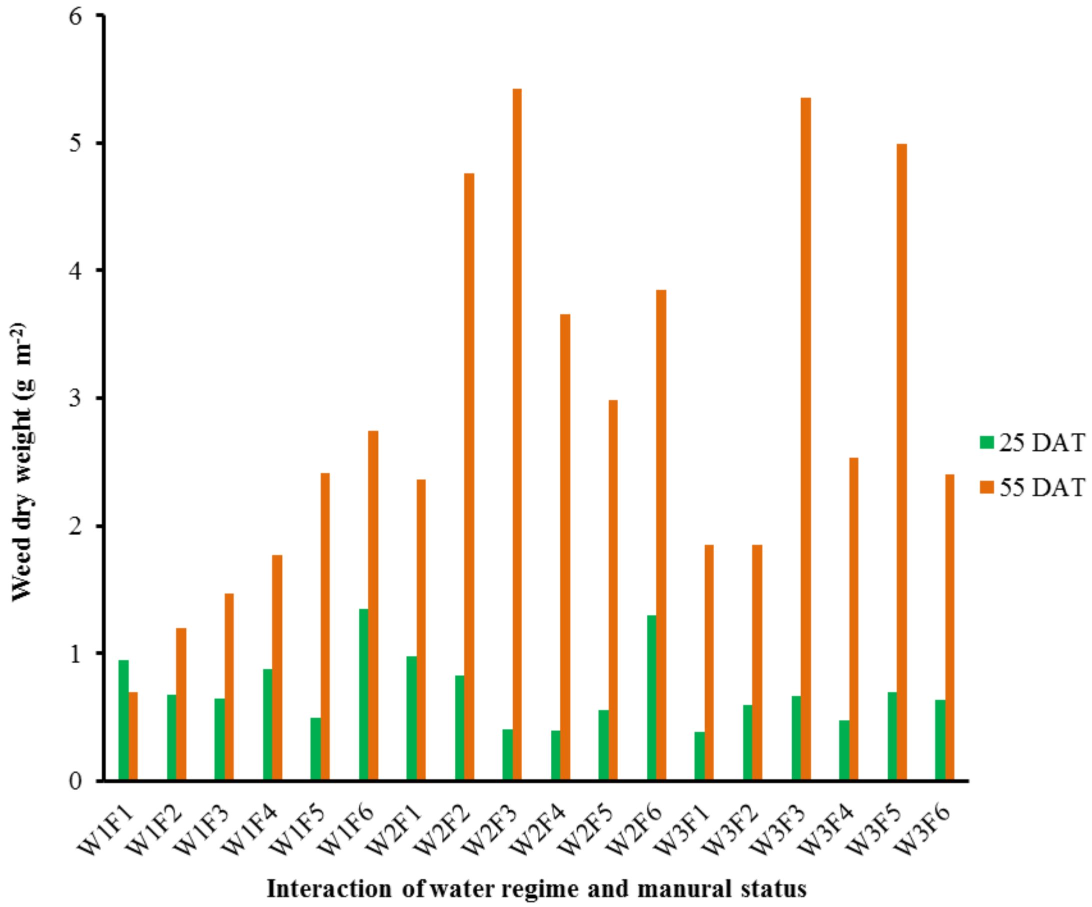
Water regime showed significant effect on total dry weight of weed population (Appendix IX and Table 6) at 25 DAT and at 55 DAT. At 25 DAT the highest dry weight of weed population (0.83 g m^{-2}) was found from water loggedcondition. The lowest dry weight of weed population (0.57 g m^{-2}) was found from alternate wet and dry condition and at 55 DAT the highest dry weight of weed population (3.84 g m^{-2}) was found from saturated condition. The lowest dry weight of weed population (1.71 g m^{-2}) was found from waterlogged condition.

ii. Effect of manural status

Total dry weight of weed also significantly influenced by different manural status (Appendix IX and Table 6). At 25 DAT the highest dry weight of weed population (1.10 g m^{-2}) was found from chemical fertilizer (50%) + compost (50%). The lowest dry weight of weed population (0.57 g m^{-2}) was found from chemical fertilizer (100%) which was similar to compost (100%), chemical fertilizer (50%) + cowdung (25%) + compost (25%) and chemical fertilizer (50%) cowdung (50%). But at 55 DAT the highest dry weight of weed population (4.08 g m^{-2}) was found from chemical fertilizer (100%) and the lowest dry weight of weed population (1.63 g m^{-2}) was found from cowdung (100%) which was similar to compost (100%), chemical fertilizer (50%) + cowdung (25%) + compost (25%) and chemical fertilizer (50%) + compost (50%).

iii. Interaction effect of water regime and manural status

Interaction effect between water regime and manural status was significant in respect of total dry weight of weed population at 25 and 55 DAT (Appendix IX and Figure 8). At 25 DAT the highest dry weight of weed population (1.35 g m^{-2}) was recorded in chemical fertilizer (50%) + compost (50%) at waterlogged condition statistically similar with chemical fertilizer (50%) + compost (50%) at saturated condition. The lowest dry weight of weed population (0.37 g m^{-2}) was found in cowdung (100%) at alternate wet and dry condition similar with chemical fertilizer (50%) + cowdung (50%) at waterlogged condition, chemical fertilizer (100%), compost (100%) and chemical fertilizer (50%) + cowdung (50%) at saturated condition, compost (100%) and chemical fertilizer (50%) + cowdung (25%) + compost (25%) at alternate wet and dry condition. Again at 55 DAT maximum dry weight of weed population (1.35 g m^{-2}) was recorded from chemical fertilizer (100%) at saturated condition which is statistically similar with compost (100%) at same condition, chemical fertilizer (100%) and chemical fertilizer (50%) + cowdung (50%) at alternate wet and dry condition. The minimum dry weight of weed population (0.69 g m^{-2}) was found in cowdung (100%) at waterlogged condition similar with compost (100%) and chemical fertilizer (100%) at same water regime.



W_1 = Waterlogged, W_2 = Saturated, W_2 = Alternate wet and dry, F_1 = Cowdung (100%), F_2 = Compost (100%), F_3 = Chemical fertilizer (100%), F_4 = Chemical fertilizer (50%) + Cowdung (25%) + Compost (25%), F_5 = Chemical fertilizer (50%) + Cowdung (50%) and F_6 = Chemical fertilizer (50%) + compost (50%)

Figure 8. Interaction effect of water regime and manural status on weed dry weight (g m^{-2}) of *Boro* rice transplanted in SRI ($LSD_{0.05}$ = 25 and 55 DAT 0.229 and 0.320 respectively)

4.2 Yield and other parameters

4.2.1 Number of effective tillers $hill^{-1}$

i. Effect of water regime

The number of effective tillers hill^{-1} was not significantly influenced by water regime (Appendix X and Table 7). The numerical maximum number of effective tillers hill^{-1} (30.50) was given by saturated condition and the minimum (26.92) in waterlogged condition.

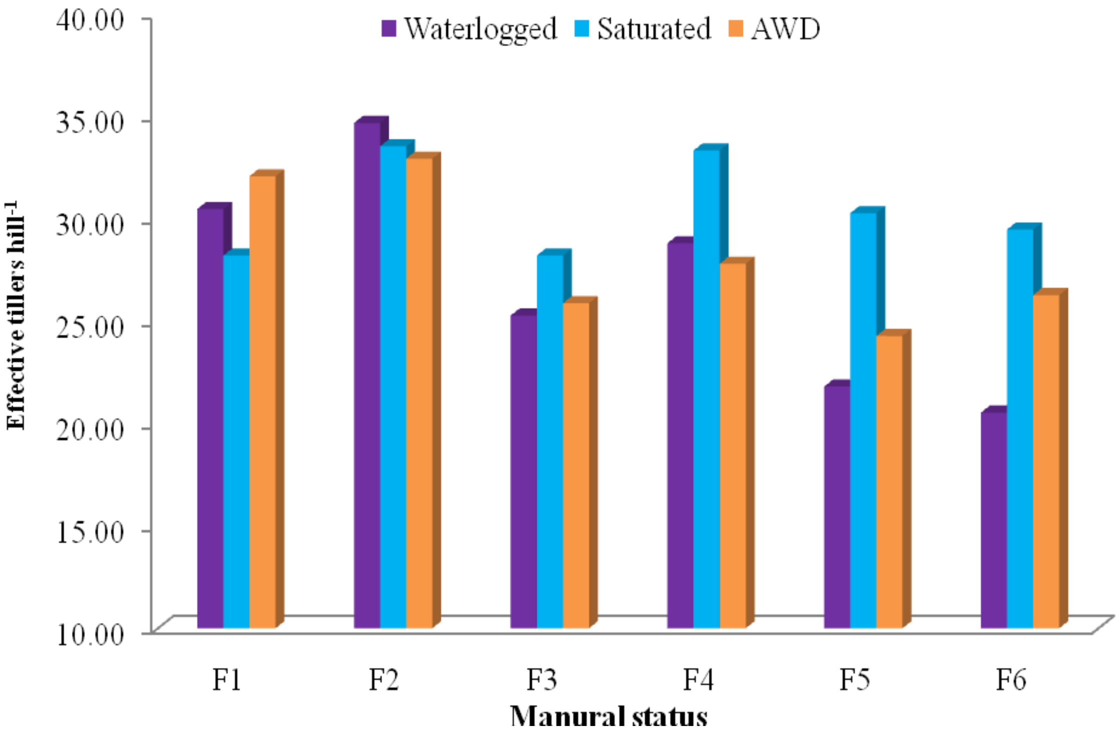
Table 7. Influence of water regime and manural status on effective and ineffective tillers hill^{-1} of *Boro* rice transplanted in SRI

Treatments	Effective tiller no. hill^{-1}	Ineffective tiller no. hill^{-1}
Water regime		
W_1	26.92	4.89a
W_2	30.50	3.07b
W_3	28.20	3.24b
LSD $_{(0.05)}$	NS	1.521
CV (%)	16.48	44.01
Manural status		
F_1	30.24ab	3.20b
F_2	33.71a	4.49a
F_3	26.44cd	3.50ab
F_4	29.98bc	4.07ab
F_5	25.44d	3.53ab
F_6	25.42d	3.62ab
LSD $_{(0.05)}$	3.563	1.197
CV (%)	13.70	33.00

W_1 = Waterlogged, W_2 = Saturated, W_2 = Alternate wet and dry, F_1 = Cowdung (100%), F_2 = Compost (100%), F_3 = Chemical fertilizer (100%), F_4 = Chemical fertilizer (50%) + Cowdung (25%) + Compost (25%), F_5 = Chemical fertilizer (50%) + Cowdung (50%) and F_6 = Chemical fertilizer (50%) + compost (50%)

ii. Effect of manural status

Manural status significantly influenced the number of effective tillers hill^{-1} (Appendix X and Table 7). The highest number of effective tillers hill^{-1} (33.71) was obtained from compost (100%) which was statistically similar with cowdung (100%). The lowest effective tillers hill^{-1} (25.42) was obtained from chemical fertilizer (50%) + compost (50%) that was statistically similar with chemical fertilizer (100%) and chemical fertilizer (50%) + cowdung (50%). Hossaen *et al.* (2011) conducted an experiment to evaluate the efficacy of different organic manure and inorganic fertilizer and recorded maximum number of effective tillers hill^{-1} from the treatment of 70% NPKS + 2.4 t manure ha^{-1}.



W_1 = Waterlogged, W_2 = Saturated, W_2 = Alternate wet and dry, F_1 = Cowdung (100%), F_2 = Compost (100%), F_3 = Chemical fertilizer (100%), F_4 = Chemical fertilizer (50%) + Cowdung (25%) + Compost (25%), F_5 = Chemical fertilizer (50%) + Cowdung (50%) and F_6 = Chemical fertilizer (50%) + compost (50%)

Figure 9. Interaction effect of water regime and manural status on number of effective tillers hill^{-1} of *Boro* rice transplanted in SRI ($LSD_{0.05}$ = 6.171)

iii. Interaction effect of water regime and manural status

The number of effective tillers hill^{-1} was significantly influenced by the interaction effect of water regime and manural status (Appendix X and Figure 9). The maximum number of effective tillers hill^{-1} (28.80) was obtained from chemical fertilizer (50%) + cowdung (25%) + compost (25%) of waterlogged condition which was similar with cow dung (100%) and compost (100%) at same condition, compost (100%), chemical fertilizer (50%) + cowdung (50%) and chemical fertilizer (50%) +compost (50%) of saturated condition, cowdung (100%) and compost (100%) of alternate wet and dry condition. The lowest number of effective tillers hill^{-1} (20.53) was obtained from chemical fertilizer (50%) + compost (50%) of waterlogged condition.

4.2.2 Number of Ineffective tillers hill^{-1}

i. Effect of water regime

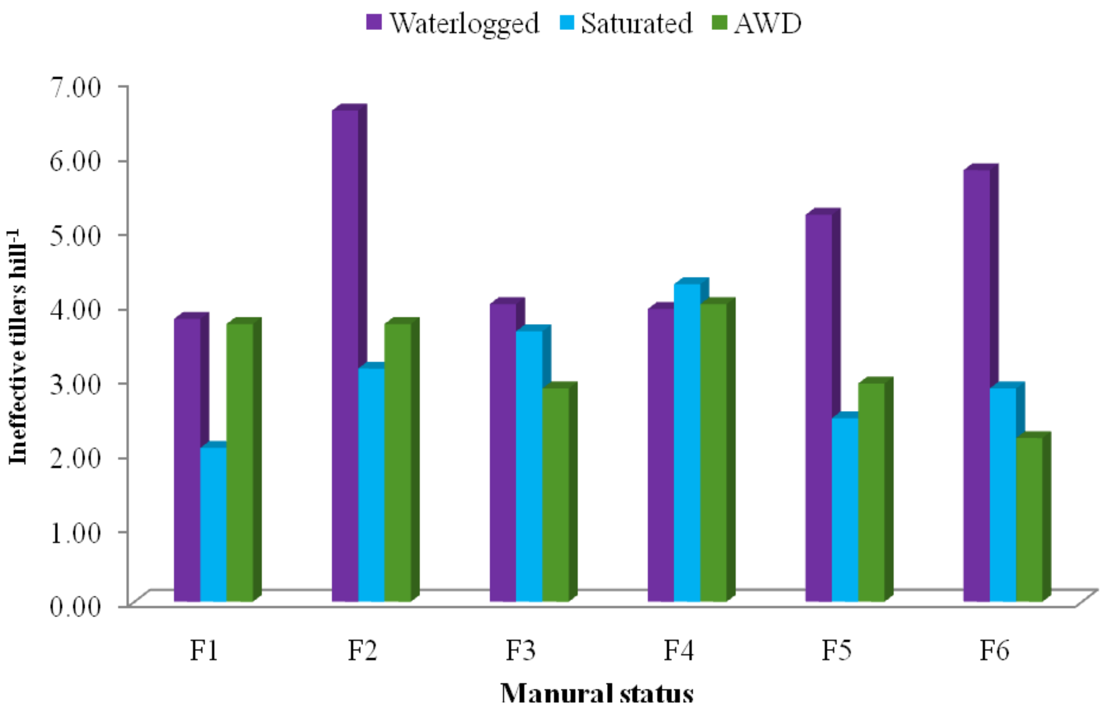
The number of ineffective tillers hill^{-1} was significantly influenced by water regime (Appendix X and Table 7). The maximum number of ineffective tillers hill^{-1} (4.89) was found from waterlogged condition and the minimum number of ineffective tillers hill^{-1} (3.07) was observed in saturated condition that was statistically similar with alternate wet and dry condition.

ii. Effect of manural status

Manural status significantly influenced the number of ineffective tillers hill^{-1} (Appendix X and Table 7). The highest number of ineffective tillers hill^{-1} (4.49) was observed in Compost (100%) which was similar with all other treatments except cowdung (100%). The lowest number of ineffective tillers hill^{-1} (3.20) was observed in cowdung (100%). Differences among the treatments might be due to the intraplant competition for light, nutrient, space etc.

iii. Interaction effect of water regime and manural status

The number of ineffective tillers hill^{-1} from maximum tillering stage to harvesting was significantly influenced by the interaction effect of water regime and manural status (Appendix X Figure 10). The highest number of ineffective tillers hill^{-1} (6.60) was observed from compost (100%) at waterlogged condition which was statistically similar with chemical fertilizer (50%) + cowdung (50%) at waterlogged condition and chemical fertilizer (50%) + compost (50%) at waterlogged condition. Cowdung (100%) at saturated condition showed the lowest ineffective tillers hill^{-1} (2.07).



W_1 = Waterlogged, W_2 = Saturated, W_2 = Alternate wet and dry, F_1 = Cowdung (100%), F_2 = Compost (100%), F_3 = Chemical fertilizer (100%), F_4 = Chemical fertilizer (50%) + Cowdung (25%) + Compost (25%), F_5 = Chemical fertilizer (50%) + Cowdung (50%) and F_6 = Chemical fertilizer (50%) + compost (50%)

Figure 10. Interaction effect of water regime and manural status on number of ineffective tillers hill^{-2} of *Boro* rice transplanted in SRI ($LSD_{0.05}$ = 2.073)

4.2.3 Panicle length

i. Effect of water regime

The panicle length was varied significantly due to different water regime (Appendix XI and Table 8). The highest (21.20 cm) panicle length was obtained from waterlogged condition and lowest (19.55cm) was obtained from alternate wet and dry condition that was statistically similar with saturated condition. Latif *et al.* (2005) conducted a series of experiments in eastern Bangladesh to investigate the System of Rice Intensification (SRI) and reported the higher panicle lengths in SRI than BRRI recommended practices and farmers practices.

ii. Effect of manural status

There was significant difference in panicle length observed due to manural status (Appendix XI and Table 8). The highest (30.38 cm) panicle length was observed in chemical fertilizer (100%) that statistically similar with cowdung (100%) and compost (100%). 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 reported the highest grain yield in SRI planting methods mostly due to the outcome of higher total number of tillers hill^{-1} and the highest panicle length.

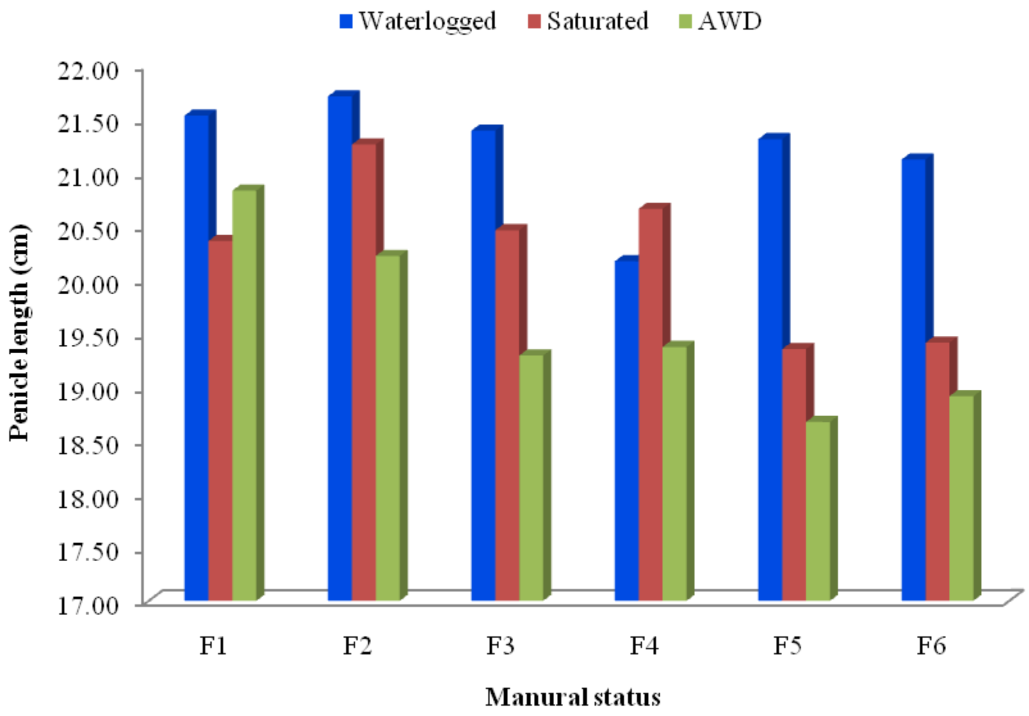
Table 8. Influence of water regime and manural status on different yield contributing characters of *Boro* rice transplanted in SRI

Treatments	Panicle length (cm)	Total grains panicle^{-1} (No.)	Filled grains panicle^{-1} (No.)	Unfilled grains panicle^{-1} (No.)	1000-grain weight (g)
Water level					
W_1	21.20a	96.22a	75.61	18.70	22.58
W_2	20.25b	95.82a	74.70	17.61	22.63
W_3	19.55b	82.98b	71.76	17.87	22.18
LSD $_{(0.05)}$	0.894	10.706	NS	NS	NS
CV (%)	4.75	12.59	6.24	14.27	5.36
Manural status					
F_1	20.91a	80.02c	84.78a	17.20	22.44
F_2	20.06a	86.80bc	72.80bc	19.07	22.73
F_3	30.38ab	107.98a	74.27abc	17.84	22.18
F_4	20.07b	95.73b	79.84ab	19.69	22.51
F_5	19.77b	91.00b	65.51c	15.96	22.38
F_6	19.81b	89.91b	66.93c	18.60	22.53
LSD $_{(0.05)}$	0.757	9.392	11.489	NS	NS
CV (%)	4.00	10.62	16.00	22.83	3.00

W_1 = Waterlogged, W_2 = Saturated, W_2 = Alternate wet and dry, F_1 = Cowdung (100%), F_2 = Compost (100%), F_3 = Chemical fertilizer (100%), F_4 = Chemical fertilizer (50%) + Cowdung (25%) + Compost (25%), F_5 = Chemical fertilizer (50%) + Cowdung (50%) and F_6 = Chemical fertilizer (50%) + compost (50%)

iii. Interaction effect of water regime and manural status

Panicle length was significantly affected by the interaction effect of water regime and manural status (Appendix XI and Figure 11). The highest panicle length (21.71 cm) was obtained from the compost (100%) at waterlogged condition similar with cowdung (100%), chemical fertilizer (100%), chemical fertilizer (50%) + cowdung (50%) and chemical fertilizer (50%) + compost (50%) at waterlogged condition, compost (100%), chemical fertilizer (100%) and compost (100%) at saturated condition and cowdung (100%) at alternate wet and dry condition and the lowest panicle length (18.67 cm) was obtained from chemical fertilizer (50%) + cowdung (50%) at alternate wet and dry condition.



W_1 = Waterlogged, W_2 = Saturated, W_2 = Alternate wet and dry, F_1 = Cowdung (100%), F_2 = Compost (100%), F_3 = Chemical fertilizer (100%), F_4 = Chemical fertilizer (50%) + Cowdung (25%) + Compost (25%), F_5 = Chemical fertilizer (50%) + Cowdung (50%) and F_6 = Chemical fertilizer (50%) + compost (50%)

Figure 11. Interaction effect of water regime and manural status on panicle length (cm) of *Boro* rice transplanted in SRI ($LSD_{0.05}$ = 1.311)

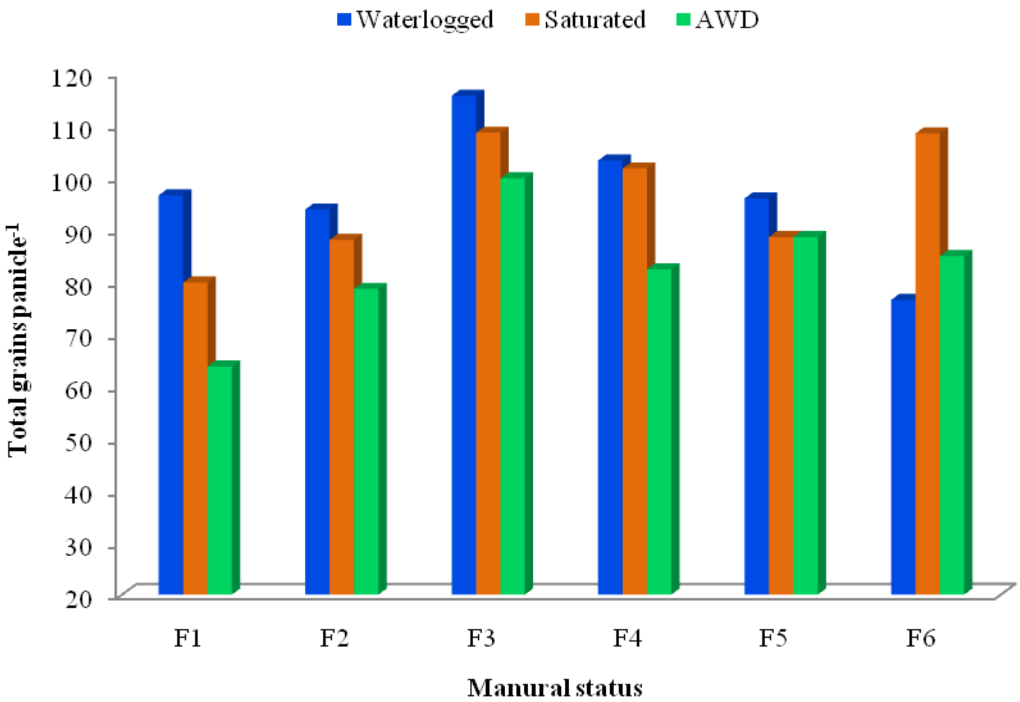
4.2.4 Total number of grains panicle^{-1}

i. Effect of water regime

The total number of grains panicle^{-1} was significantly influenced by water regime (Appendix XI and Table 8). The highest number of grains panicle^{-1} (96.22) was obtained from water logged condition statistically similar with saturated condition and the lowest number of grains panicle^{-1} (82.98) was obtained from alternate wet and dry condition. This result was similar with Bouman, *et al*. (2005).

ii. Effect of manural status

The grains panicle^{-1} was significantly affected by the manural status (Appendix XI and Table 8). The highest number of total grains panicle^{-1} (107.98) was obtained from chemical fertilizer (100%) and the lowest number of grains panicle^{-1} (86.80) was recorded from cowdung (100%) that was similar to compost (100%). 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 where the highest grain yield was found in SRI planting methods mostly due to the outcome of highest number of grains panicle^{-1}.



W_1 = Waterlogged, W_2 = Saturated, W_2 = Alternate wet and dry, F_1 = Cowdung (100%), F_2 = Compost (100%), F_3 = Chemical fertilizer (100%), F_4 = Chemical fertilizer (50%) + Cowdung (25%) + Compost (25%), F_5 = Chemical fertilizer (50%) + Cowdung (50%) and F_6 = Chemical fertilizer (50%) + compost (50%)

Figure 12. Interaction effect of water regime and manural status on total number of grains panicle^{-1} of Boro rice transplanted in SRI ($LSD_{0.05}$ = 26.282)

iii. Interaction effect of water regime and manural status

The total number of grains panicle^{-1} was significantly influenced by the interaction effect between water regime and manural status (Appendix XI and Figure 12). The highest (115.60) number of grains panicle^{-1} was obtained from chemical fertilizer (100%) at waterlogged condition statistically similar with chemical fertilizer (50%) + cowdung (25%) + compost (25%) at wate logged condition, chemical fertilizer (100%), compost (100%) and chemical fertilizer (50%) + compost (50%) at saturated condition and the lowest (63.73) number of grains panicle^{-1} was obtained from cowdung (100%) at alternate wet and dry condition which was similar with chemical fertilizer (50%) + compost (50%) at waterlogged condition, cowdung (100%) at saturated condition and compost (100%) at alternate wet and dry condition.

4.2.5 Filled grains panicle^{-1}

i. Effect of water regime

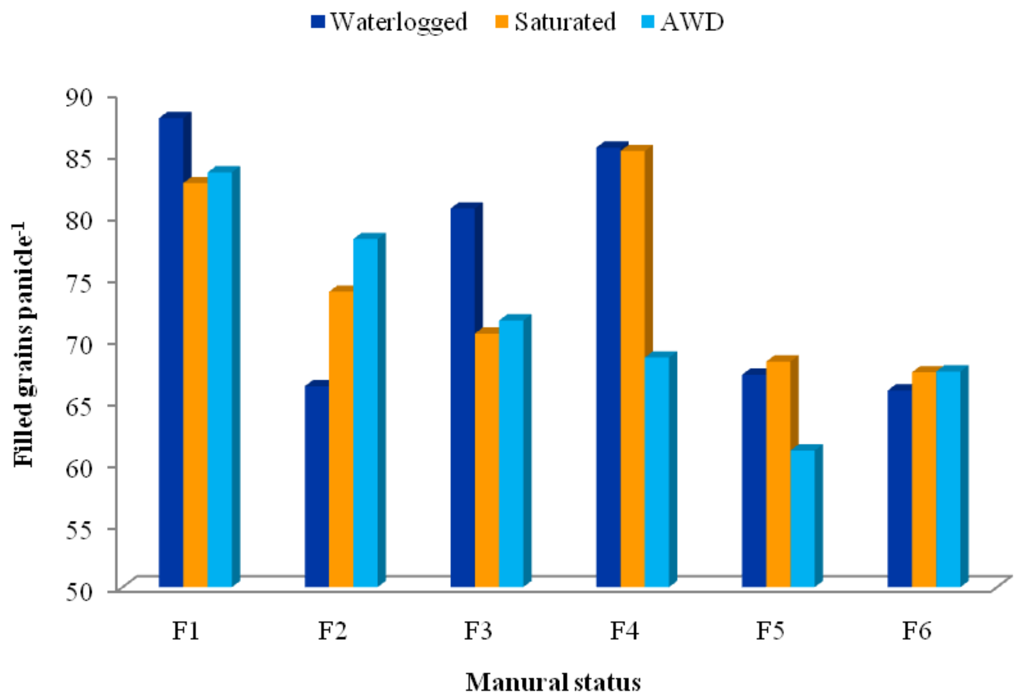
Water regime did not show any significant effect on filled grains panicle^{-1} (Appendix XI and Table 8). The numerically maximum number of filled grains panicle^{-1} (75.61) was observed at waterlogged condition and the minimum (71.76) in alternate wet and dry condition.

ii. Effect of manural status

Different manural status showed significant variation on the number of filled grains panicle^{-1} (Appendix XI and Table 8). The highest number of filled grains panicle^{-1} (84.78) was obtained from cowdung (100%) that similar to the chemical fertilizer (100%) and chemical fertilizer (50%) + cowdung (25%) + compost (25%) and the lowest number of filled grains panicle^{-1} (65.51) was obtained from chemical fertilizer (50%) + cowdung (50%). Basunia (2005) reported that frequent combined application of cowdung plus inorganic fertilizer rates increased production from successive filled grains panicle^{-1}.

iii. Interaction effect of water regime and manural status

Interaction effect between water regime and manural status was significant in respect of filled grains panicle^{-1} (Appendix XI and Figure 13). The highest number of filled grains panicle^{-1} (88.00) was obtained from the cow dung (100%) at waterlogged condition followed by chemical fertilizer (100%) and compost (100%) at saturated condition, cowdung (100%), compost (100%), chemical fertilizer (100%), chemical fertilizer (50%) + cowdung (25%) + compost (25%), chemical fertilizer (50%) + cowdung (50%) at waterlogged condition and cowdung (100%), compost (100%), chemical fertilizer (100%), chemical fertilizer (50%) + cowdung (25%) + compost (25%) at alternate wet and dry condition and the lowest number of filled grains panicle^{-1} (61.07) was obtained from chemical fertilizer (50%) + cowdung (50%) at alternate wet and dry condition.



W_1 = Waterlogged, W_2 = Saturated, W_2 = Alternate wet and dry, F_1 = Cowdung (100%), F_2 = Compost (100%), F_3 = Chemical fertilizer (100%), F_4 = Chemical fertilizer (50%) + Cowdung (25%) + Compost (25%), F_5 = Chemical fertilizer (50%) + Cowdung (50%) and F_6 = Chemical fertilizer (50%) + compost (50%)

Figure 13. Interaction effect of water regime and manural status on number of filled grains panicle^{-1} of *Boro* rice transplanted in SRI ($LSD_{0.05}$ = 19.899)

4.2.6 Unfilled grains panicle^{-1}

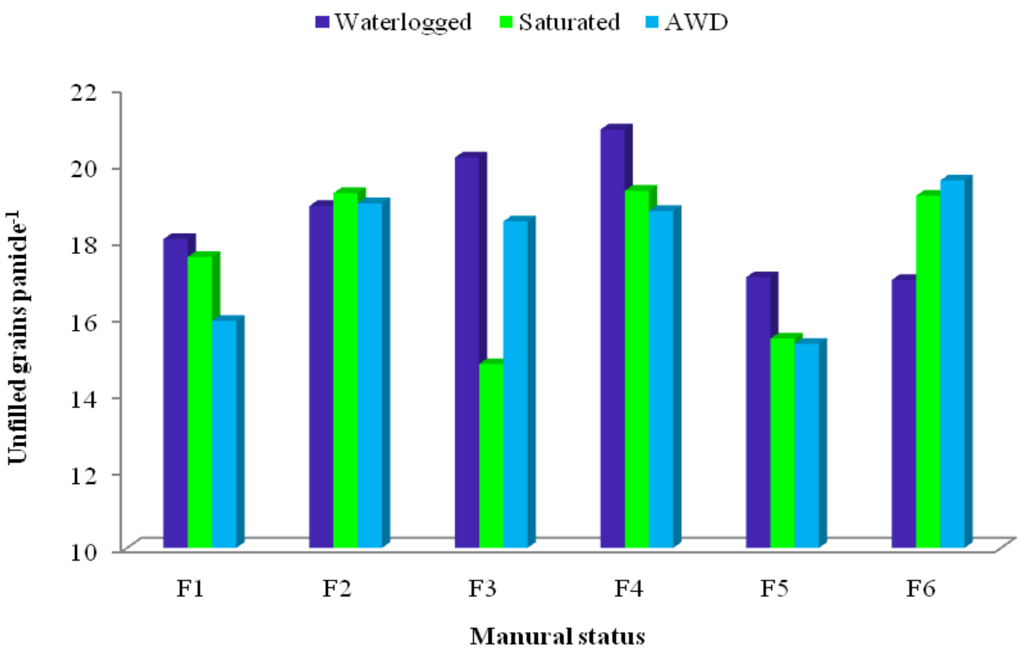
i. Effect of water regime

The unfilled grains panicle^{-1} was not significantly affected by water regime (Appendix XI and Table 8). The numerically maximum number of unfilled grains panicle^{-1} (18.70) was observed in waterlogged condition and the minimum (17.61) in saturated condition.

ii. Effect of manural status

Analysis of variance showed that number of unfilled grains panicle^{-1} was not statistically differed due to the different manural status (Appendix XI and Table 8).

The numerically maximum number of unfilled grains panicle^{-1} (19.69) was observed at compost (100%) and the minimum (15.96) in chemical fertilizer (50%) + cowdung (50%).



W_1 = Waterlogged, W_2 = Saturated, W_2 = Alternate wet and dry, F_1 = Cowdung (100%), F_2 = Compost (100%), F_3 = Chemical fertilizer (100%), F_4 = Chemical fertilizer (50%) + Cowdung (25%) + Compost (25%), F_5 = Chemical fertilizer (50%) + Cowdung (50%) and F_6 = Chemical fertilizer (50%) + compost (50%)

Figure 14. Interaction effect of water regime and manural status on number of unfilled grains panicle^{-1} of *Boro* rice transplanted in SRI ($LSD_{0.05}$ = 6.874)

iii. Interaction effect of water regime and manural status

Unfilled grains panicle^{-1} was not statistically influenced by interaction effect of water regime and manural status (Appendix XI and Figure 14). But the numerically maximum number of unfilled grains panicle^{-1} (20.93) was observed in chemical fertilizer (50%) + cowdung (25%) + compost (25%) at waterlogged condition and the minimum (14.80) in chemical fertilizer (100%) of saturated condition.

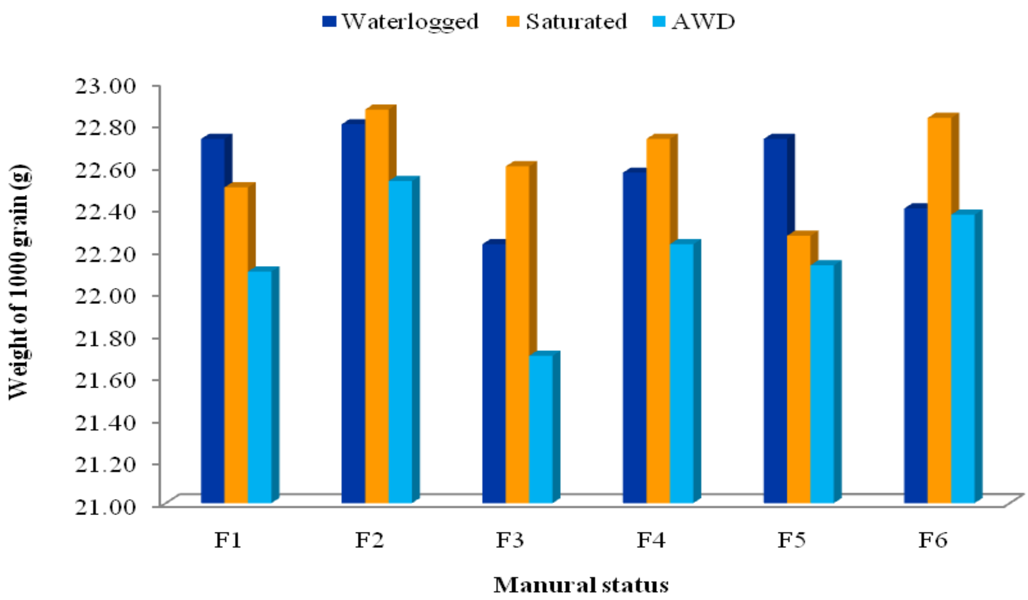
4.2.7 Weight of 1000-grains

i. Effect of water regime

The weight of 1000-grains was not significantly influenced by water regime (Appendix XI and Table 8). The numerically maximum 1000-grains weight (22.63g) was observed in saturated condition and the minimum (22.18g) in alternate wet and dry condition.

ii. Effect of manural status

There was no significant effect among the different manural status in respect of weight of 1000-grains (Appendix XI and Table 8) though the numerically maximum 1000-grains weight (22.73g) was observed at compost (100%) and the minimum (22.18) in chemical fertilizer (100%).



W_1 = Waterlogged, W_2 = Saturated, W_2 = Alternate wet and dry, F_1 = Cowdung (100%), F_2 = Compost (100%), F_3 = Chemical fertilizer (100%), F_4 = Chemical fertilizer (50%) + Cowdung (25%) + Compost (25%), F_5 = Chemical fertilizer (50%) + Cowdung (50%) and F_6 = Chemical fertilizer (50%) + compost (50%)

Figure 15. Interaction effect of water regime and manural status on weight of 1000-grains (g) of *Boro* rice transplanted in SRI ($LSD_{0.05}$ = 1.139)

iii. Interaction effect of water regime and manural status

Interaction effect between water regime and manural status was found significant in respect of weight of 1000-grains (Appendix XI and Figure 15). The highest weight of

1000-grains (22.87 g) was obtained from compost (100%) at saturated condition, which was similar with all other interaction effect of water regime and manural status except chemical fertilizer (100%) at alternate wet and dry condition. The lowest weight of 1000-grains (21.70 g) was obtained from chemical fertilizer (100%) at alternate wet and dry condition, which was similar to the all other interaction effect of water regime and manural status except compost (100%) at saturated condition

4.2.8 Grain yield

i. Effect of water regime

Grain yield was significantly influenced by the water regime (Appendix XII and Table 9). The highest grain yield (5.74 t ha^{-1}) was obtained from the waterlogged condition that was statistically similar with saturated condition (5.69 t ha^{-1}) and the lowest (4.36 t ha^{-1}) was from alternate wet and dry condition.

Bouman and Tuong (2001) suggested that there is a reduction in the grain yield in alternate wetting and drying when compared with rice grown with standing water. Grain yield, however decreased significantly when water was reduced to field capacity condition and this was in agreement with previous findings (Beyrouty *et al.*,1994; Grigg *et al.*, 2000). In contrast many researchers have observed no differences or increases in grain yield with alternate wetting and drying (Dowe, 2005).

ii. Effect of manural status

Manural status has significant effect on grain yield (Appendix XII and Table 9). Chemical Fertilizer (50%) + cowdung (25%) + compost (25%), produced significantly the highest grain yield (5.81 t ha^{-1}) that was statistically similar to chemical fertilizer (100%). The lowest (4.71 t ha^{-1}) grain yield was from compost (100%) that was similar to cowdung (100%).

Das (2003) earlier stated that soils with high fertility influence the grain yield. He (2003) found that yield of boro rice was significantly influenced by organic matter, cation exchange capacity, nitrogen, phosphorus and potassium.

Table 9. Influence of water regime and manural status on yield and harvest index of *Boro* rice transplanted in SRI

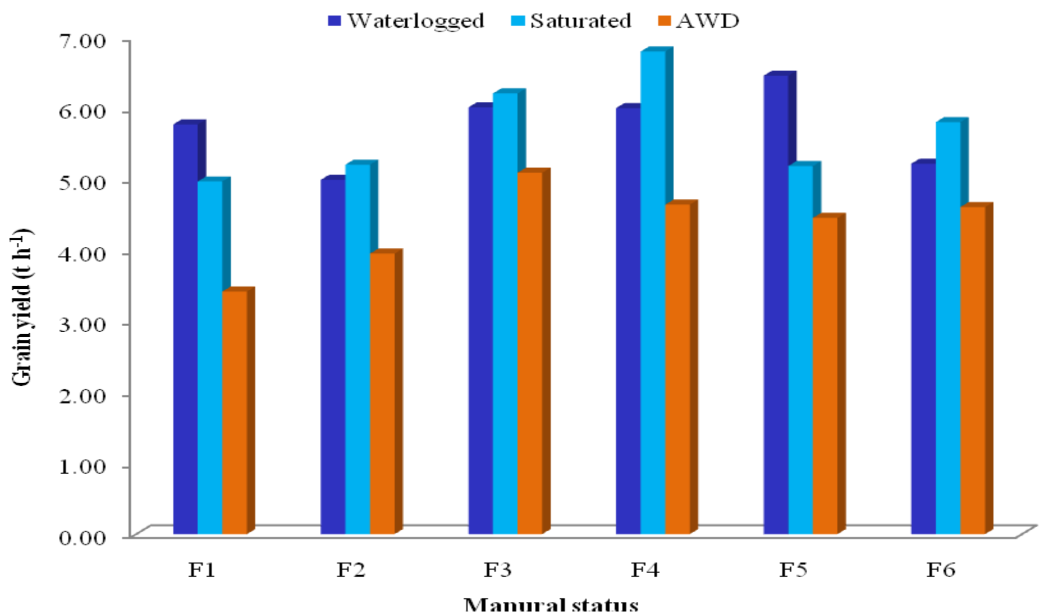
Treatments	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
Water level				
W_1	5.74a	6.74a	12.48a	46.02
W_2	5.69a	6.65a	12.33a	46.16
W_3	4.36b	5.22b	9.59b	45.55
LSD $_{(0.05)}$	0.383	0.458	0.819	NS
CV (%)	7.86	7.98	7.71	2.04
Manural status				
F_1	4.72c	5.43c	10.13c	46.28ab
F_2	4.71c	5.43c	10.16c	46.37ab
F_3	5.77a	6.80a	12.56a	45.92ab
F_4	5.81a	6.64ab	12.48a	46.78a
F_5	5.36b	6.26b	11.64b	46.04ab
F_6	5.21b	6.66ab	11.84b	44.06b
LSD $_{(0.05)}$	0.355	0.463	0.578	2.597
CV (%)	7.01	7.77	5.23	5.88

W_1 = Waterlogged, W_2 = Saturated, W_2 = Alternate wet and dry, F_1 = Cowdung (100%), F_2 = Compost (100%), F_3 = Chemical fertilizer (100%), F_4 = Chemical fertilizer (50%) + Cowdung (25%) + Compost (25%), F_5 = Chemical fertilizer (50%) + Cowdung (50%) and F_6 = Chemical fertilizer (50%) + compost (50%)

iii. Interaction effect of water regime and manural status

Interaction between water regime and manural status played an important role for promoting the yield. Grain yield was significantly influenced by the interaction effect of water regime and manural status (Appendix XII and Figure 16). Among the treatments, the highest grain yield was observed in chemical fertilizer (50%) + cowdung (25%) + compost (25%) at saturated condition (6.80 t ha^{-1}) which was similar with chemical fertilizer (100%) at same condition and chemical fertilizer (50%) + cowdung (50%) at water logged condition.

The lowest yield (3.42 t ha^{-1}) was observed in cow dung (100%) at alternate wet and dry condition that similar with compost (100%) at same condition. Miah *et al.* (2008) conducted an experiment in northern district Kurigram during 2006-07 cropping season under Agro-ecological zone-2 (Active Tista Floodplain) of Bangladesh. An attempt 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.



W_1 = Waterlogged, W_2 = Saturated, W_2 = Alternate wet and dry, F_1 = Cowdung (100%), F_2 = Compost (100%), F_3 = Chemical fertilizer (100%), F_4 = Chemical fertilizer (50%) + Cowdung (25%) + Compost (25%), F_5 = Chemical fertilizer (50%) + Cowdung (50%) and F_6 = Chemical fertilizer (50%) + compost (50%)

Figure 16. Interaction effect of water regime and manural status on grain yield at harvest of *Boro* rice transplanted in SRI ($LSD_{0.05}$ = 0.615)

4.2.9 Straw yield

i. Effect of water regime

Straw yield was significantly affected by the water regime (Appendix XII and Table 9). The highest straw yield (6.74 t ha^{-1}) was obtained from the waterlogged condition that was statistically similar with saturated condition and the lowest (5.22 t ha^{-1}) was from alternate wet and dry condition.

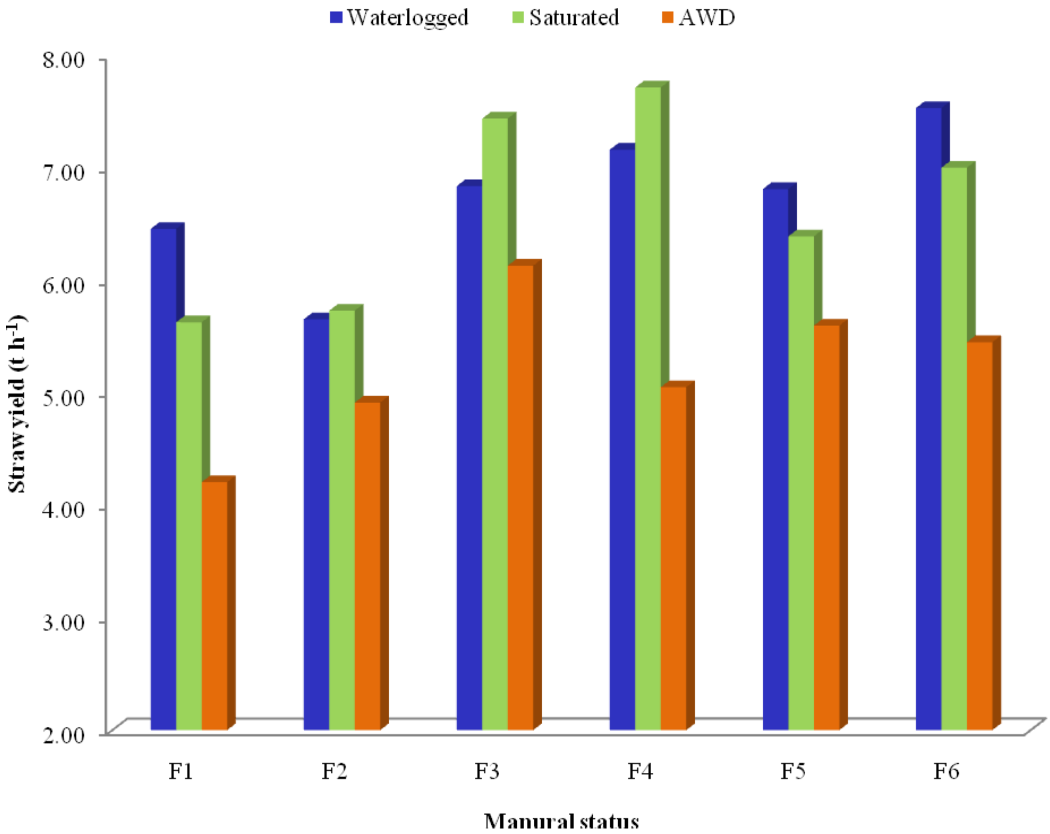
ii. Effect of manural status

There was significant difference observed among the different manural status in respect of straw yield (Appendix XII and Table 9). The highest straw yield (6.80 t ha^{-1}) was obtained from chemical fertilizer (100%) similar with chemical fertilizer (50%) + cowdung (25%) + compost (25%) and chemical fertilizer (50%) + compost (50%). The probable reasons of increased straw yield in the chemical fertilizer (100%) might be due to higher total number of tillers m^{-2} and taller plants. The lowest straw yield (5.43 t ha^{-1}) was obtained from cowdung (100%) and compost (100%).

Hossain *et al*. (2003) conducted an experiment at the Agronomy Field Laboratory of Bangladesh Agricultural University, Mymensingh to study the performance of BRRI dhan32 in SRI and conventional methods and showed that conventional method produced the lowest straw yield (4.29 t ha^{-1}).

iii. Interaction effect of water regime and manural status

Interaction effect between water regime and manural status was significant in respect of straw yield (Appendix XII and Figure 17). The highest straw yield (7.71t ha^{-1}) was recorded in chemical fertilizer (50%) +cowdung (25%) + compost (25%) at saturated condition similar with chemical fertilizer (50%) + cowdung (25%) + compost (25%) and chemical fertilizer (50%) + compost (50%) at waterlogged condition, chemical fertilizer (100%) and chemical fertilizer (50%) + compost (50%) at saturated condition. The lowest straw yield (4.20 t ha^{-1}) was found in cowdung (100%) at alternate wet and dry condition which was statistically identical with compost (100%) at same condition. Akbar (2004) found highest straw yield in the combination of inbred variety and 15 day old seedlings.



W_1 = Waterlogged, W_2 = Saturated, W_2 = Alternate wet and dry, F_1 = Cowdung (100%), F_2 = Compost (100%), F_3 = Chemical fertilizer (100%), F_4 = Chemical fertilizer (50%) + Cowdung (25%) + Compost (25%), F_5 = Chemical fertilizer (50%) + Cowdung (50%) and F_6 = Chemical fertilizer (50%) + compost (50%)

Figure 17. Interaction effect of water regime and manural status on straw yield at harvest of *Boro* rice transplanted in SRI ($LSD_{0.05}$ = 0.803)

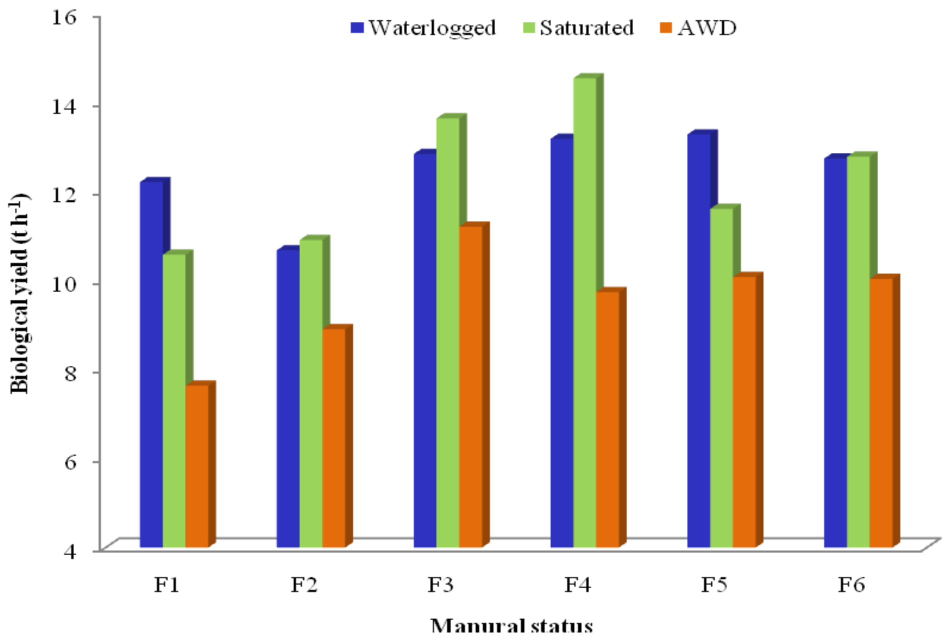
4.2.10 Biological yield

i. Effect of water regime

Water regime had significant effect on biological yield (Appendix XII and Table 9). The highest biological yield (12.48 t ha^{-1}) was found from waterlogged condition and the lowest biological yield (9.59 t ha^{-1}) was found from alternate wet and dry condition. The maintanance of saturated condition on lowland rice also showed a better response by Tabbal *et al.* (2002).

ii. Effect of manural status

There was significant difference among the manural status observed in respect of biological yield (Appendix XII and Table 9). The highest biological yield(12.56 t ha^{-1}) was found from Chemical Fertilizer (100%) which was similar with chemical fertilizer (50%) + cowdung (25%) + compost (25%). The lowest biological yield (10.13 t ha^{-1}) was found from cowdung (100%) statistically similar with compost (100%).



W_1 = Waterlogged, W_2 = Saturated, W_2 = Alternate wet and dry, F_1 = Cowdung (100%), F_2 = Compost (100%), F_3 = Chemical fertilizer (100%), F_4 = Chemical fertilizer (50%) + Cowdung (25%) + Compost (25%), F_5 = Chemical fertilizer (50%) + Cowdung (50%) and F_6 = Chemical fertilizer (50%) + compost (50%)

Figure 18. Interaction effect of water regime and manural status on biological yield at harvest of *Boro* rice transplanted in SRI ($LSD_{0.05}$ = 1.001)

iii. Interaction effect of water regime and manural status

Interaction effect between water regime and manural status was significant in respect of biological yield (Appendix XII and Figure 18). The highest biological yield (14.53 t ha^{-1}) was recorded in chemical fertilizer (50%) + cowdung (25%) + compost (25%) at saturated condition similar with chemical fertilizer (100%) at saturated condition . The lowest biological yield (7.63 t ha^{-1}) was found in cowdung (100%) at alternate wet and dry condition. Bouman and Toung (2001) found highest biological yield in combination of the chemical fertilizer and saturated condition.

4.2.11 Harvest index

i. Effect of water regime

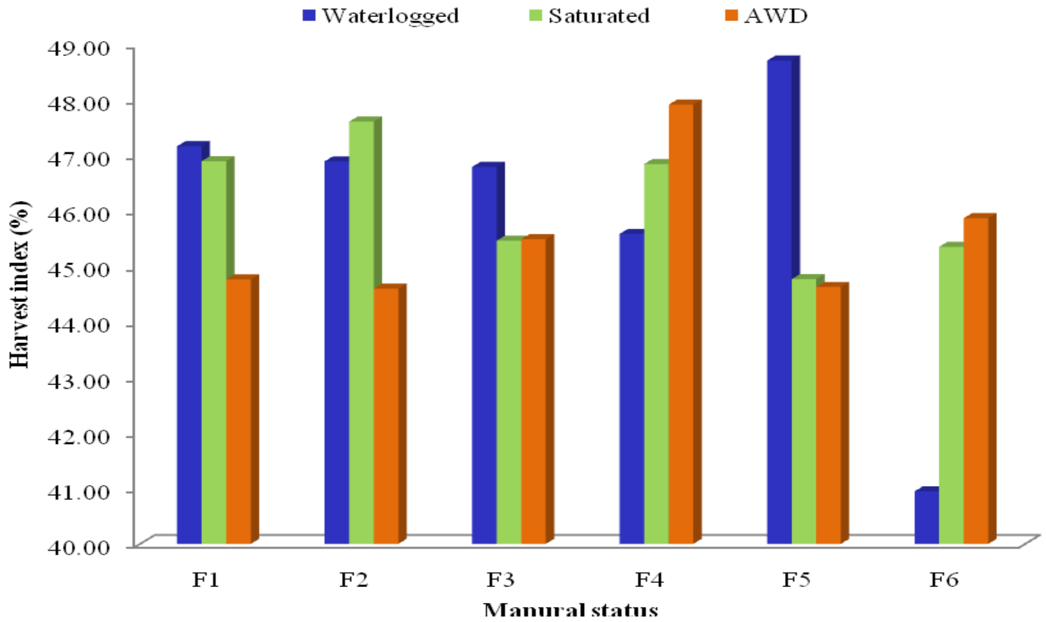
Harvest index was not significantly influenced by different water regime (Appendix XII and Table 9). The numerically highest harvest index (46.16%) was found from saturated condition and the lowest harvest index (45.55%) was found from alternate wet and dry condition. According to Thakur *et al.* (2010) the harvest index was 47.21% in alternate wetting and drying (AWD) compared to 32.42% in waterlogged condition. Stoop (2005) and Hossain *et al.* (2003) also found higher harvest index in SRI comparing the conventional method, though, Barison (2003) found no difference for the same.

ii. Effect of manural status

Manural status produced significant differences in respect of harvest index (Appendix XII and Table 9). The highest harvest index (46.78%) was found from chemical fertilizer (50%) + cowdung (25%) + compost (25%) that was similar with all other treatments and the lowest (44.06%) was from chemical fertilizer (50%) + compost (50%).

iii. Interaction effect of water regime and manural status

Interaction effect between water regime and manural status was significant in respect of harvest index (Appendix XII and Figure 19). The highest harvest index (48.71%) was recorded in chemical fertilizer (50%) + cowdung (50%) at waterlogged condition that followed by all other treatments. The lowest harvest index (44.60%) was found in compost (100%) at alternate wet and dry condition.



W_1 = Waterlogged, W_2 = Saturated, W_2 = Alternate wet and dry, F_1 = Cowdung (100%), F_2 = Compost (100%), F_3 = Chemical fertilizer (100%), F_4 = Chemical fertilizer (50%) + Cowdung (25%) + Compost (25%), F_5 = Chemical fertilizer (50%) + Cowdung (50%) and F_6 = Chemical fertilizer (50%) + compost (50%)

Figure 19. Interaction effect of water regime and manural status on harvest index of *Boro* rice transplanted in SRI ($LSD_{0.05}$ = 4.498)

4.2.12 Flag leaf length

i. Effect of water regime

Flag leaf length was not significantly influenced by different water regime (Appendix XIII and Table 10). The numerically maximum flag leaf length (22.72 cm) was found from waterlogged condition and the minimum length (21.16 cm) was found from alternate wet and dry condition.

ii. Effect of manural status

Manural status produced significant differences in respect of flag leaf length (Appendix XIII and Table 10). The highest flag leaf length (22.77 cm) was found from chemical fertilizer (50%) + compost (50%) which was similar to chemical fertilizer (100%), chemical fertilizer (50%) + cowdung (25%) + compost (25%) and chemical fertilizer (50%) + cowdung (50%). The lowest flag leaf length (20.75 cm) was found from cowdung (100%) that similar to the compost (100%).

Table 10. Influence of water regime and manural status on flag leaf length and rachis branch number of *Boro* rice transplanted in SRI

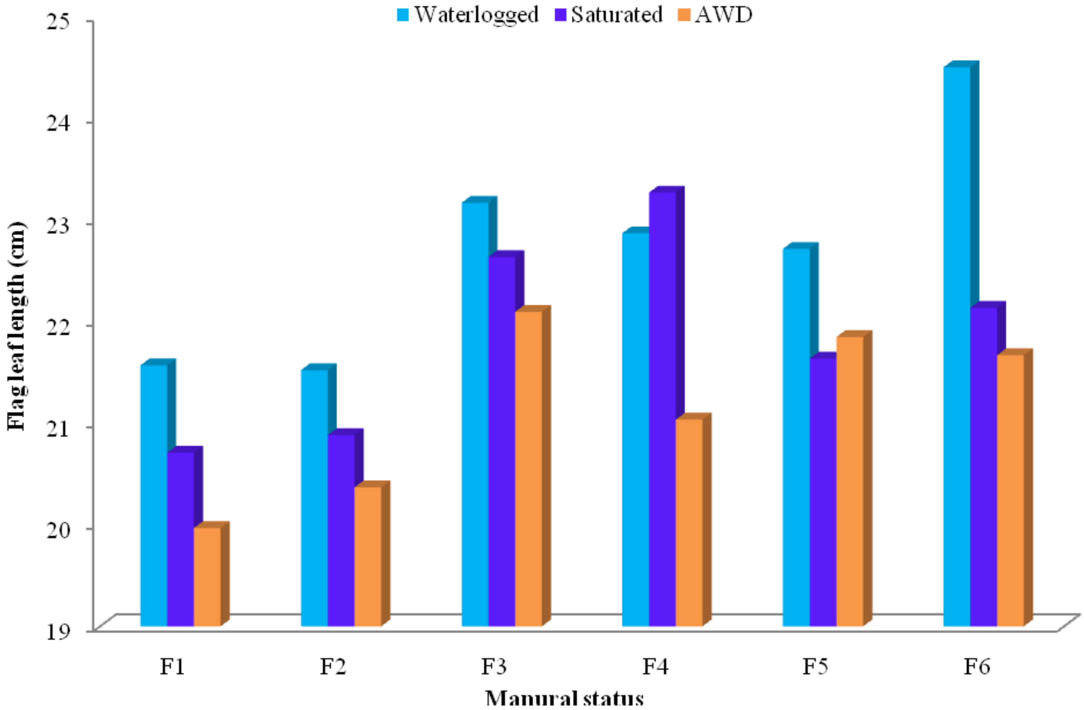
Treatments	Flag leaf length (cm)	No. of rachis branch panicle^{-1}
Water regime		
W_1	22.72	7.38
W_2	21.88	7.40
W_3	21.16	7.16
LSD $_{(0.05)}$	NS	NS
CV (%)	7.96	6.03
Manural status		
F_1	20.75c	6.78d
F_2	20.92bc	6.96d
F_3	22.63a	8.04a
F_4	22.39a	7.58b
F_5	22.06ab	7.40bc
F_6	22.77a	7.11d
LSD $_{(0.05)}$	1.142	0.369
CV (%)	5.41	5.24

W_1 = Waterlogged, W_2 = Saturated, W_2 = Alternate wet and dry, F_1 = Cowdung (100%), F_2 = Compost (100%), F_3 = Chemical fertilizer (100%), F_4 = Chemical fertilizer (50%) + Cowdung (25%) + Compost (25%), F_5 = Chemical fertilizer (50%) + Cowdung (50%) and F_6 = Chemical fertilizer (50%) + compost (50%)

iii. Interaction effect of water regime and manural status

Interaction effect between water regime and manural status was significant in respect of harvest index (Appendix XIII and Figure 20). The highest flag leaf length (24.50 cm) was recorded in chemical fertilizer (50%) + compost (50%) at waterlogged condition followed by chemical fertilizer (100%), chemical fertilizer (50%) +

cowdung (25%) + compost (25%) and chemical fertilizer (50%) + cowdung (50%) at waterlogged condition and chemical fertilizer (100%), compost (100%) at saturated condition . The lowest flag leaf length (19.97 cm) was found in cowdung (100%) of alternate wet and dry condition.



W_1 = Waterlogged, W_2 = Saturated, W_2 = Alternate wet and dry, F_1 = Cowdung (100%), F_2 = Compost (100%), F_3 = Chemical fertilizer (100%), F_4 = Chemical fertilizer (50%) + Cowdung (25%) + Compost (25%), F_5 = Chemical fertilizer (50%) + Cowdung (50%) and F_6 = Chemical fertilizer (50%) + compost (50%)

Figure 20. Interaction effect of water regime and manural status on flag leaf length of *Boro* rice transplanted in SRI ($LSD_{0.05}$ = 1.978)

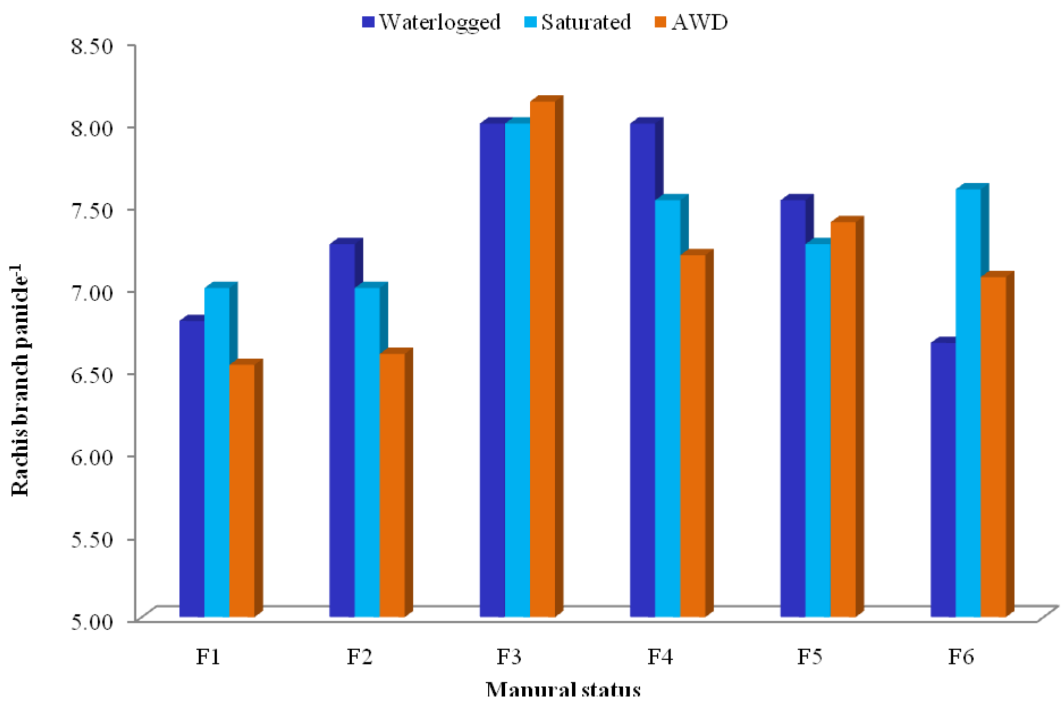
4.2.13 Number of rachis branch panicle^{-1}

i. Effect of water regime

Number of rachis branch panicle^{-1} was not significantly influenced by different water regime (Appendix XIII and Table 10). The numerically maximum number of rachis branch panicle^{-1} (7.40) was found from saturated condition and the minimum number of rachis branch panicle^{-1} (7.16) was found from alternate wet and dry condition.

ii. Effect of manural status

Manural status produced significant differences in respect of number of rachis branch panicle^{-1} (Appendix XIII and Table 10).The highest number of rachis branch panicle^{-1} (8.04) was found from chemical fertilizer (100%). The lowest Number of rachis branch panicle^{-1} (6.78) was found from cowdung (100%) similar to the compost (100%) and chemical fertilizer (50%) + compost (50%).



W_1 = Waterlogged, W_2 = Saturated, W_2 = Alternate wet and dry, F_1 = Cowdung (100%), F_2 = Compost (100%), F_3 = Chemical fertilizer (100%), F_4 = Chemical fertilizer (50%) + Cowdung (25%) + Compost (25%), F_5 = Chemical fertilizer (50%) + Cowdung (50%) and F_6 = Chemical fertilizer (50%) + compost (50%)

Figure 21. Interaction effect of water regime and manural status on rachis branch number panicle^{-1} of *Boro* rice transplanted in SRI ($LSD_{0.05}$ = 0.640)

iii. Interaction effect of water regime and manural status

The number of rachis branch panicle^{-1}was significantly influenced by the interaction effect between water regime and manural status (Appendix XIII and Figure 21). The maximum (8.13) number of rachis branch panicle^{-1}was obtained from chemical fertilizer (100%) at alternate wet and dry condition similar with chemical fertilizer (100%), chemical fertilizer (50%) + cowdung (25%) + compost (25%) and chemical fertilizer (50%) + cowdung (50%) at waterlogged condition, chemical fertilizer (100%), chemical fertilizer (50%) + cowdung (25%) + compost (25%) and chemical fertilizer (50%) + compost (50%) at saturated condition. The minimum (6.53) number of rachis branch panicle^{-1}was obtained from cowdung (100%) at alternate wet and dry condition which was similar with cowdung (100%), chemical fertilizer (50%) + compost (50%) at waterlogged condition, cowdung (100%), compost (100%) at saturated condition, compost (100%) and chemical fertilizer (50%) + compost (50%) at alternate wet and dry condition.

Chapter 5

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, 2011 to May, 2012 to study the growth and yield of *Boro* rice under system of rice intensification with different water regime and manural status under the Modhupur Tract (AEZ-28). The experiment consisted of two level of treatments viz. A. Water regime (3): waterlogged, saturated and alternate wet & dry B. Manural status (6): Cowdung (100%), Compost (100%), Chemical fertilizer (100%), Chemical fertilizer (50%) + cowdung (25%) + compost (25%), Chemical fertilizer (50%) + cowdung (50%) and Chemical fertilizer (50%) + compost (50%). The experiment was laid out in a split-plot design with three replications. The water regimes were assigned in the main plot and manural status in the sub-plot.

The data on crop growth parameters like plant height, number of tillers hill^{-1}, leaf area index, dry weight and time of flowering and maturity were recorded at different growth stages. Yield parameters like number of effective and ineffective tillers m^{-2}, panicle length, number of grains panicle^{-1}, filled and unfilled grains panicle^{-1}, 1000-grain weight, grain and straw yield, biological yield, harvest index, flag leaf length, number of rachis branch panicle^{-1} were recorded after harvest. Data were analyzed using IRRISTAT package. The mean differences among the treatments were compared by least significant difference test at 5% level of significance.

Results showed that water regime had significant effect on growth and yield parameters except total weed population, number of effective tillers m^{-2}, filled grains panicle^{-1}, unfilled grains panicle^{-1}, weight of 1000-grains, harvest index, flag leaf length and number of rachis branch panicle^{-1}. The rapid increase of plant height, number of tillers hill^{-1} was observed from 35 DAT to 85 DAT of growth stages which was higher in the waterlogged condition compared to the other water regime, however, at harvest plant height was also higher in the waterlogged condition but number of tillers hill^{-1} had no significant effect on water regime. The higher LAI at all the growth stages and harvest was found in waterlogged condition. Again, the higher dry matter production at all the growth stages was found in saturated condition but at harvest, it was higher in waterlogged condition. Waterlogged condition needed shorter duration for flowering and maturity compared to the other treatments. The longer panicle (21.20 cm), higher number of grains panicle^{-1} (96.22), the higher grain yield (5.74 t ha^{-1}), straw yield (6.74 t ha^{-1}) and biological yield (12.48 t ha^{-1}) were produced in waterlogged condition but statistically similar with saturated condition and the shorter panicle (19.55 cm), lower number of grains panicle^{-1} (82.98), grain yield (44.36 t ha^{-1}), straw yield (5.22 t ha^{-1}) and biological yield (9.59 t ha^{-1}) were obtained from alternate wet and dry condition.

Manural status also significantly influenced all growth and yield attributes except total weed population, unfilled grains panicle^{-1} and 1000-grains weight. The results revealed that the 100% chemical fertilizer produced the tallest plant height and maximum dry weight at all the growth stages and at harvest. At all growth stage and harvest, the maximum leaf area index was obtained from the chemical fertilizer (100%). Compost (100%) produced maximum tillers hill^{-1} at 85 days of crop stage and at harvest. The chemical fertilizer (50%) + cowdung (50%) and cowdung (100%) needed the longest duration for flowering and maturity respectively, whereas, the lowest duration for flowering and maturity was observed in the chemical fertilizer (100%). The highest dry weight of weed population (4.08) was found from chemical fertilizer (100%) and the lowest dry weight of weed population (1.63) was found from cowdung (100%). The highest number of effective tillers hill^{-1} (33.71) was obtained from compost (100%). Chemical fertilizer (50%) + cowdung (25%) + compost (25%) produced significantly the highest grain yield (5.81 t ha^{-1}) and the lowest (4.71 t ha^{-1}) grain yield was from compost (100%). The highest number of panicle length (30.38 cm) grains panicle^{-1} (107.98), straw yield (6.80 t ha^{-1}), biological yield (12.56 t ha^{-1}) and number of rachis branch panicle^{-1} (8.04) was obtained from chemical fertilizer (100%) and the lowest number of grains panicle^{-1} (86.80), straw yield (5.43 t ha^{-1}), biological yield (10.13 t ha^{-1}) and number of rachis branch panicle^{-1} (6.78) was recorded from cowdung (100%). The highest number of filled grains panicle^{-1} (84.78) was obtained from cowdung (100%) and the lowest number of filled grains panicle^{-1} (65.51) was obtained from chemical fertilizer (50%) + cowdung (50%). The highest harvest index (46.78%) was found from chemical fertilizer (50%) + cowdung (25%) + compost (25%) and the lowest (44.06%) was from chemical fertilizer (50%) +

compost (50%).

Interaction effect of water regime and manural status significantly affected growth as well as yield and yield contributing characters except the number of unfilled grains panicle^{-1}. The tallest plant height was initially found in chemical fertilizer (50%) + cowdung (25%) + compost (25%) at waterlogged condition. At harvest, the tallest plant (80.27 cm) was obtained from chemical fertilizer (100%) at saturated condition. The highest number of tillers hill^{-1} (41.33) was obtained from compost (100%) at alternate wet and dry condition and the highest leaf area index was observed in the chemical fertilizer (100%) at waterlogged condition. At harvest, chemical fertilizer (100%) at saturated condition produced highest dry weight. Chemical fertilizer (50%) + cowdung (25%) + compost (25%) at alternate wet and dry condition required the highest duration for flowering, the lowest duration for flowering was observed in cowdung (100%) at waterlogged condition and for maturity compost (100%) at alternate wet and dry condition needed the highest duration. The lowest duration was found from chemical fertilizer (100%) at saturated condition. The maximum (96.667) number of weed population was obtained from chemical fertilizer (50%) + cowdung (50%) at alternate wet and dry condition and the minimum (12.00) number was obtained from chemical fertilizer (100%) at waterlogged condition. Highest dry weight of weed (1.353) was recorded from chemical fertilizer (100%) at saturated condition

The maximum number of effective tillers hill^{-1} (28.80) was obtained from chemical fertilizer (50%) + cowdung (25%) + compost (25%) at waterlogged condition however the lowest number of effective tillers hill^{-1} (20.53) was obtained from chemical fertilizer (50%) + compost (50%) at waterlogged condition. The longest panicle was obtained from the compost (100%) at waterlogged condition. The highest (115.60) number of grains panicle^{-1} was obtained from chemical fertilizer (100%) at waterlogged condition and the lowest (63.73) number grains panicle^{-1} was obtained from cowdung (100%) at alternate wet and dry condition. The highest number of filled grains panicle^{-1} (88.00) was obtained from the cowdung (100%) at waterlogged condition and the lowest number was obtained from chemical fertilizer (50%) + cow dung (50%) at alternate wet and dry condition. The highest weight of 1000-grains (22.87 g) was obtained from compost (100%) at saturated condition. The lowest weight of 1000-grains (21.70 g) was obtained from chemical fertilizer (100%) at alternate wet and dry condition. The highest grain yield was observed in chemical fertilizer (50%) + cowdung (25%) + compost (25%) at saturated condition (6.80 t ha^{-1}) and the lowest yield (3.42 t ha^{-1}) was observed in cowdung (100%) at alternate wet and dry condition. The highest straw yield (7.71t ha^{-1}) was recorded in chemical fertilizer (50%) + cowdung (25%) + compost (25%) at saturated condition and the lowest (4.20 t ha^{-1}) was found in cowdung (100%) of alternate wet and dry condition. The highest biological yield (14.53 t ha^{-1}) was recorded in chemical fertilizer (50%) + cowdung (25%) + compost (25%) at saturated condition and the lowest (7.63 t ha^{-1}) was found in cowdung (100%) at alternate wet and dry condition. The highest flag leaf length (24.50 cm) was recorded in chemical fertilizer (50%) + compost (50%) at waterlogged condition and the lowest flag leaf length (19.97 cm) was found in cowdung (100%) at alternate wet and dry condition. The highest harvest index (48.71%) was recorded in chemical fertilizer (50%) + cowdung (50%) at waterlogged condition and the lowest (44.60%) was found in compost (100%) at alternate wet and dry condition. The maximum (8.13) number of rachis branch $panicle^{-1}$ was obtained from chemical fertilizer (100%) at alternate wet and dry condition and the minimum (6.53) number was obtained from cowdung (100%) under alternate wet and dry condition.

Based on the results of the present study, the following conclusions may be drawn-

- The highest yield was observed in water logged condition that was statistically similar with saturated condition.
- Chemical fertilizer (50%) + cow dung (25%) + compost (25%) showed the higher yield that similar to chemical fertilizer (100%).
- The highest grain yield and most of the yield contributing characters were observed in chemical fertilizer (50%) + cow dung (25%) + compost (25%) at saturated condition.

However, to reach a specific conclusion and recommendation the same experiment need to be repeated and more research work should be done over different Agro-ecological zones.

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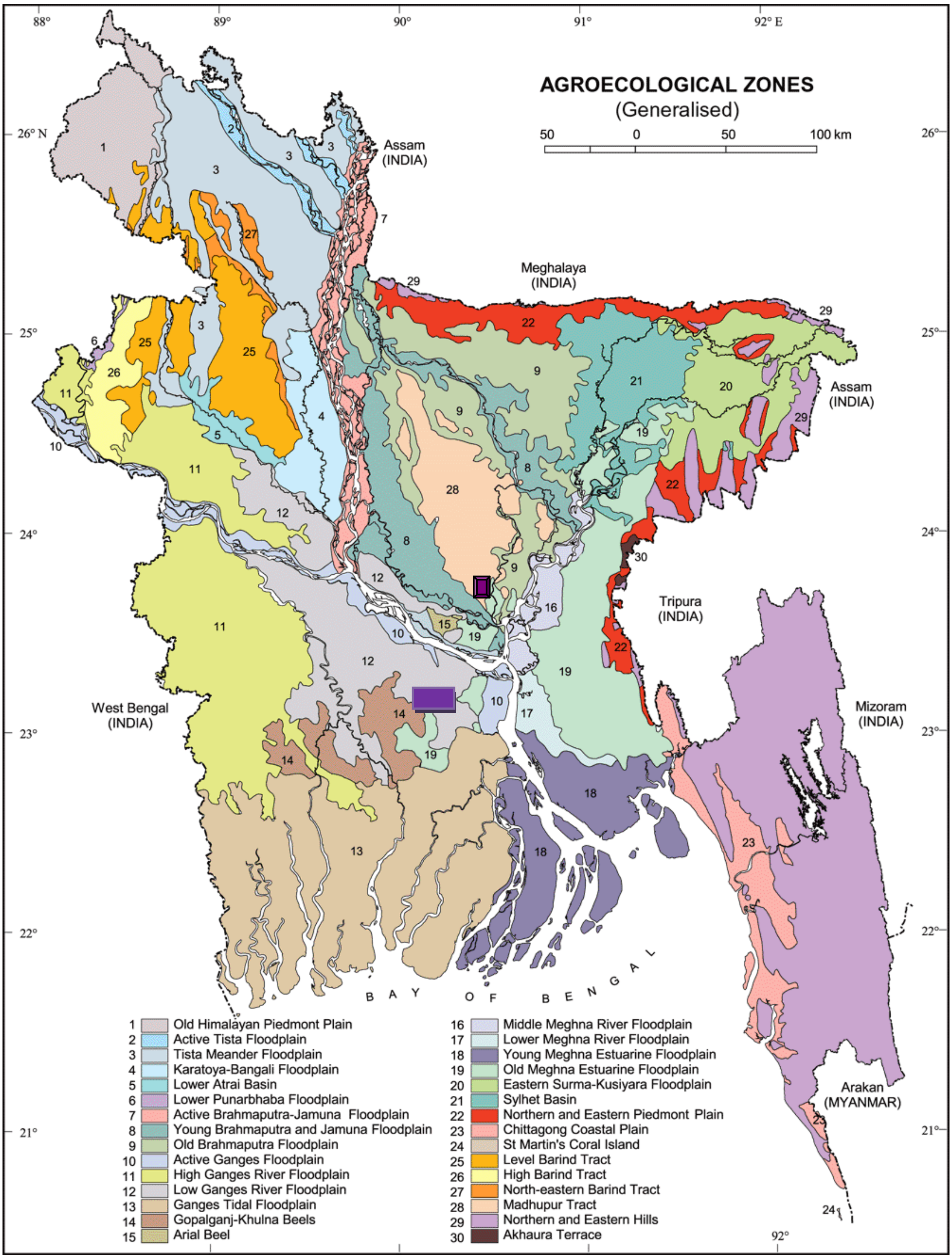
Appendices

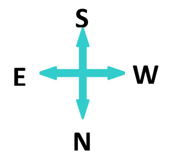
APPENDICES

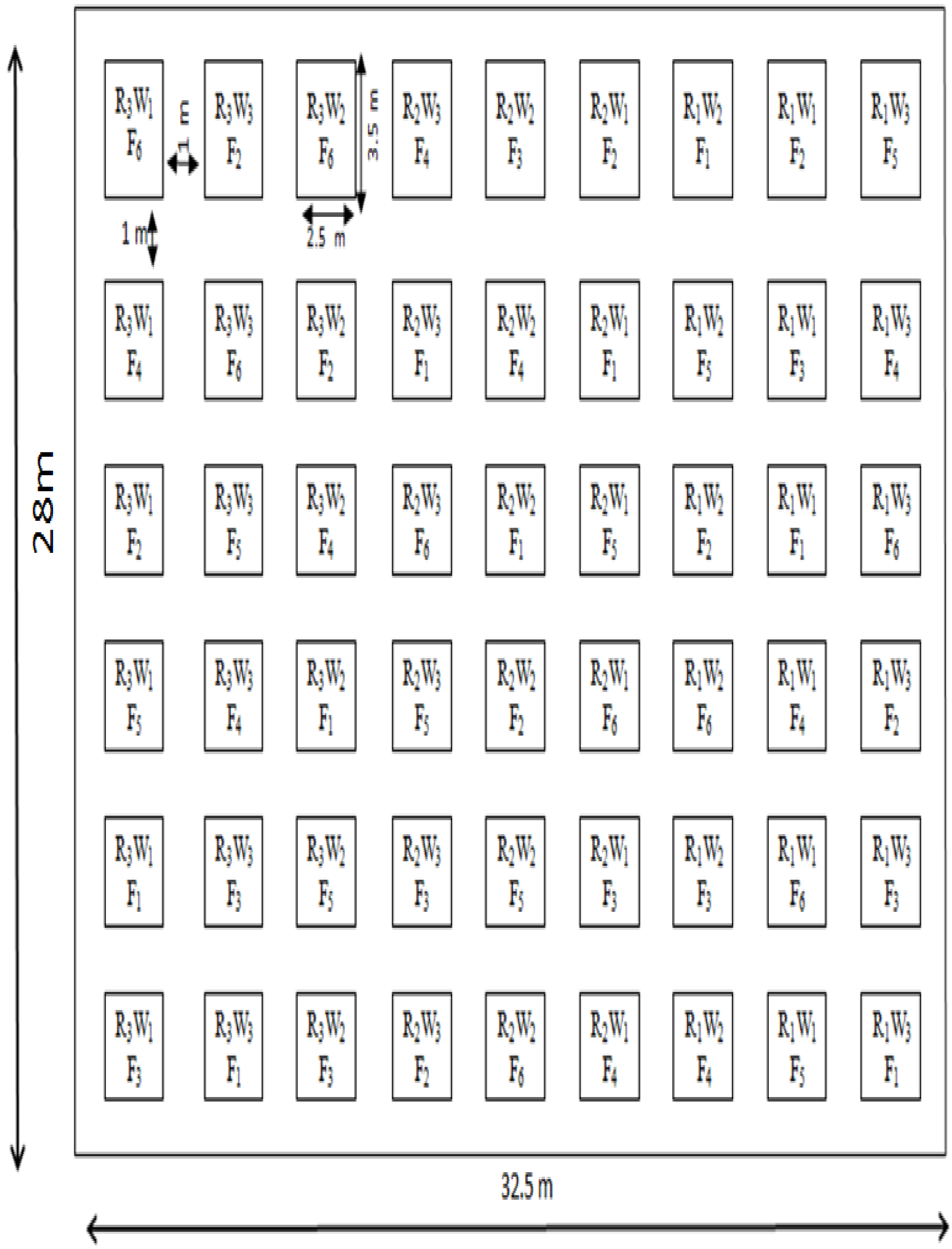
Appendix I. Map showing the experimental site under study



Experimental site

Appendix II. Layout of the experimental site





Appendix III. Monthly average of air temperature, relative humidity and total rainfall of the experimental site during the period from December 2011 to May 2012

Months	Maximum temperature (c^o)	Minimum temperature (c^o)	Relative humidity at 12 pm (%)	Rainfall (mm)
December (2011)	28	16	64	2
January (2012)	26	14	69	0
February (2012)	33	19	51	0
March(2012)	35	22	48	0
April (2012)	36	23	61	184
May (2012)	26	24	62	180

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

Appendix IV. Mean square values for plant height of *Boro* rice (BRRI dhan45) at different days after transplanting

Sources of variation	Degrees of freedom	Plant height of *boro* rice at			
		35 DAT	60 DAT	85 DAT	At harvest
Replication	2	3.081	63.851	101.879	123.383
Water regime	2	57.603**	181.061**	717.667**	155.476**
Error (a)	4	1.572	9.940	36.596	9.666
Manural status	5	3.592*	66.430**	138.332**	62.104**
Interaction	10	1.880*	15.044*	35.364*	5.491*
Error (b)	30	2.005	7.055	10.312	10.692

* Significant at 5% level
** Significant at 1% level

Appendix V. Mean square values for tillers hill^{-1} of *Boro* rice (BRRI dhan45) at different days after transplanting

Sources of variation	Degrees of freedom	Tillers hill^{-1} of *boro* rice at			
		35 DAT	60 DAT	85 DAT	At harvest
Replication	2	0.201	22.981	2.155	37.756
Water regime	2	2.503**	577.587**	72.517**	23.161
Error (a)	4	0.130	15.704	6.658	28.497
Manural status	5	0.270	106.020**	35.816**	119.512**
Interaction	10	0.320*	17.426*	22.834**	23.830
Error (b)	30	0.266	11.344	5.776	20.457

* Significant at 5% level
** Significant at 1% level

Appendix VI. Mean square values for leaf area index of *Boro* rice (BRRI dhan45) at different days after transplanting

Sources of variation	Degrees of freedom	Leaf area index of *boro* rice at			
		35 DAT	60 DAT	85 DAT	At harvest
Replication	2	0.000002	0.002	0.089	0.018
Water regime	2	0.001168**	2.565**	6.759**	3.197**
Error (a)	4	0.000004	0.017	0.262	0.317
Manural status	5	0.000032**	0.701**	5.404**	1.666**
Interaction	10	0.000066**	0.354**	0.421**	0.133*
Error (b)	30	0.000007	0.008	0.061	0.086

* Significant at 5% level
** Significant at 1% level

Appendix VII. Mean square values for plant dry weight m^{-2} of *boro* rice (BRRI dhan45) at different days after transplanting

Sources of variation	Degrees of freedom	Plant dry weight m^{-2} of *boro* rice at			
		35 DAT	65 DAT	95 DAT	At harvest
Replication	2	0.025	401.341	7775.120	12864.000
Water regime	2	39.853**	53599.300**	331846.000**	689871.000**
Error (a)	4	0.055	302.503	5870.070	8044.940
Manural status	5	14.504**	6204.840**	84515.600**	233844.000**
Interaction	10	5.018**	2366.350**	31541.100**	27144.000**
Error (b)	30	0.016	138.997	8284.070	1915.050

* Significant at 5% level
** Significant at 1% level

Appendix VIII. Mean square values for flowering and maturity duration of *boro* rice (BRRI dhan45)

Sources of variation	Degrees of freedom	Days to flowering	Days to maturity
Replication	2	0.722	0.519
Water regime	2	126.722**	52.241**
Error (a)	4	0.028	1.352
Manural status	5	4.389*	14.819**
Interaction	10	2.144*	4.752**
Error (b)	30	1.548	1.141

* Significant at 5% level
** Significant at 1% level

Appendix IX. Mean square values for number of weed population and total weeds dry weight of *boro* rice (BRRI dhan45) at different days after transplanting

Sources of variation	Degrees of freedom	Total weed population m^{-2} at		Total weeds dry weight m^{-2} at	
		25 DAT	55DAT	25 DAT	55 DAT
Replication	2	1589.850	354.056	0.065	0.291
Water regime	2	800.463	5995.500**	0.315**	21.237**
Error (a)	4	396.074	249.472	0.008	0.430
Manural status	5	114.063	1132.880**	0.372**	6.234**
Interaction	10	115.819*	709.944**	0.173**	3.419**
Error (b)	30	181.422	124.822	0.019	0.307

* Significant at 5% level
** Significant at 1% level

Appendix X. Mean square values for different yield attributing characters of *boro* rice (BRRI dhan45)

Sources of variation	Degrees of freedom	Effective tillers ($hill^{-1}$)	Ineffective tillers ($hill^{-1}$)
Replication	2	16.072	4.658
Water regime	2	59.170	18.102**
Error (a)	4	22.119	2.702
Manural status	5	99.733**	1.932*
Interaction	10	21.222*	2.721*
Error (b)	30	13.698	1.546

* Significant at 5% level
** Significant at 1% level

Appendix XI. Mean square values for different yield attributing characters of *boro* rice (BRRI dhan45)

Sources of variation	Degrees of freedom	Panicle length	Total grain panicle^{-1}	Filled grains panicle^{-1}	Unfilled grains panicle^{-1}	Weight of 1000 grains
Replication	2	2.469	114.201	509.927	8.359	0.275
Water regime	2	12.446**	1081.910**	73.096	5.836	1.112
Error (a)	4	0.934	133.853	21.366	6.642	1.447
Manural status	5	2.729**	801.083**	492.885*	16.511	0.305
Interaction	10	0.917*	274.423*	97.125*	6.667	0.120*
Error (b)	30	0.619	95.186	142.418	16.995	0.467

* Significant at 5% level
** Significant at 1% level

Appendix XII. Mean square values for different yield attributing characters of *boro* rice (BRRI dhan45)

Sources of variation	Degrees of freedom	Grain yield ha^{-1}	Straw yield ha^{-1}	Biological yield ha^{-1}	Harvest index
Replication	2	0.023	0.089	0.172	0.849
Water regime	2	11.067**	13.018**	47.508**	1.840
Error (a)	4	0.017	0.245	0.783	0.880
Manural status	5	2.104**	3.517**	10.582**	8.204*
Interaction	10	0.673**	0.666*	2.034**	10.926*
Error (b)	30	0.136	0.232	0.360	7.278

* Significant at 5% level
** Significant at 1% level

Appendix XIII. Mean square values for different yield attributing characters of *boro* rice (BRRI dhan45)

Sources of variation	Degrees of freedom	Flag leaf length	No. of rachis branch per panicle
Replication	2	3.607	0.229
Water regime	2	10.978	0.329
Error (a)	4	3.048	0.194
Manural status	5	6.904**	1.922**
Interaction	10	0.994*	0.277*
Error (b)	30	1.407	0.147

* Significant at 5% level
** Significant at 1% level

PLATES

Plate 1. Cowdung and compost is only the selected plots

Plate 2. Twelve (12) days old rice seedlings in nursery tray

Plate 3. Twelve days old rice seedlings

Plate 4. Transplantation of rice seedlings

Plate 5. Waterlogged plots at 25 DAT

Plate 6. Saturated condition plots at 25 DAT

Plate 7. Alternate wet and dry condition plots at 25 DAT

Plate 8. At a glance alternate wet and dry (left side) condition, waterlogged condition (middle) and saturated condition (right side) plots

Plate 9. Sixty seven (67) tillers in waterlogged condition with 50% chemical fertilizer + 25% compost + 25% cowdung

Plate 10. Fifty eight (58) tillers in saturated condition with 50% chemical fertilizer + 25% compost + 25% cowdung