INFLUENCE OF AGRONOMIC MANAGEMENTS ON GROWTH AND YIELD OF BORO RICE

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INFLUENCE OF AGRONOMIC MANAGEMENTS ON GROWTH AND YIELD OF BORO RICE

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CERTIFICATE

This is to certify that the thesis entitled "INFLUENCE OF AGRONOMIC MANAGEMENTS ON GROWTH AND YIELD OF BORO RICE" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE (MS) in AGRONOMY, embodies the results of a piece of bona fide research work carried out by JIBAN CHANDRA ROY, Registration. No. 18-09101 under my supervision and guidance. No part of this 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:
Dhaka, Bangladesh

(Prof. Dr. Parimal Kanti Biswas)
Supervisor

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INFLUENCE OF AGRONOMIC MANAGEMENTS ON GROWTH AND YIELD OF BORO RICE

ABSTRACT

The experiment was conducted at the experimental field of Sher-e-Bangla Agricultural University, Dhaka during the period from December, 2018 to April 2019 to study the influence of agronomic managements on growth and yield of *Boro* rice. The experiment comprised of two factors having two varieties viz. BRRI dhan84 (V_1), and BRRI hybriddhan5 (V_2) in the main plots and seven agronomic managements viz. no management (M_0), no weeding but all other managements (M_1), no fertilizer application but all other managements (M_2), no irrigation in reproductive and ripening stage but all other managements (M_3), no insecticides but all other managements (M_4), no fungicides/ bactericides but all other managements (M_5) and complete managements (M_6) in the sub-plots with three replications. Significant variation was recorded for weed severity, different yield contributing characters and yield of *Boro* rice. The lowest weed population (13.83 m^{-2}) was recorded in M_4 and weight of weed biomass (2.81 g m^{-2}) was recorded in M_6, whereas the highest weed population (144.83 m^{-2}) was found in M_0 (no management) but the highest weight (77.17 g m^{-2}) was found in the M_1 treatment. The tallest plant of 24.81 cm, 51.56 cm, 86.71 cm and 119.21 cm were recorded at 20, 45, 70 DAT and at harvest, respectively. Higher grain yield (5.36 t ha^{-1}) and lower straw yield (4.97 t ha^{-1}) were recorded from V_2 compared to that of V_1. Irrespective of agronomic managements, the higher plant height was given by BRRI dhan84 except no management. The highest grain yield (6.70 t ha^{-1}) was observed from M_6 and the highest straw yield (6.55 t ha^{-1}) from M_4. In respect of interaction, the highest grain yield (7.35 t ha^{-1}) were observed from V_2M_6 where V_2M_5 statistically identical and V_1M_4, V_1M_5, V_1M_6, V_2M_3, V_2M_4 statistically similar and highest straw yield (7.37 t ha^{-1}) were observed from V_1M_4 where V_1M_3, V_1M_6, V_2M_3, V_2M_6 statistically similar, while the lowest grain yield (1.00 t ha^{-1}) from V_1M_0 and straw yield (2.07 t ha^{-1}) from V_2M_0. Irrespective of variety, the highest yield reduction in BRRI dhan84 was 84% in no management that followed by 80% in no fertilizer treatments whereas the rate was 71% for BRRI hybriddhan5 of *Boro* rice.

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CHAPTER I
INTRODUCION

Bangladesh is an agro-based country and thus most of our economic activities are related to agriculture. More than 80% of the population is directly dependent on agriculture. In Bangladesh rice dominates over all other crops and covers 75% of the total cropped area and 92% peasants grow rice (Rekabder, 2004). About 84.67% of cropped area of Bangladesh is used for rice production, with annual production of 36.39 million tons from 11.42 million hectare of land (BBS, 2018). Nearly 48% of rural employment is provided by rice in the country. Rice is grown on about 11.4 million hectares. This growth trend has remained almost stable over the past three decades. About 75% of the total cropped area and over 80% of the total irrigated area is planted to rice (BRKB, 2017).

The climatic condition of Bangladesh is favorable for rice cultivation. More than 80% of the total cultivable land is used for rice cultivation. Rice is a particularly important food for a larger population of the world. It is cultivated in the countries of all continents (Except Antarctica) from 53°N to 40°S latitude (Lu and Chang. 1980).

The average yield of rice in Bangladesh is about 3.07 t ha^{-1} (BBS, 2018). However, the national average of rice yield in Bangladesh is very low compared to other rice growing countries, like China (6.30 t ha^{-1}), Japan (6.60 t ha^{-1}) and Korea (6.30 t ha^{-1}) (FAO, 2009).

Among the plant nutrients, nitrogen is the key element which can augment the production *of* rice to a great extent. Urea has been found to be effective nitrogenous fertilizer that gives good yield (BRRI, 1998). The low nitrogen use efficiency has always seen a problem due to a substantial loss of the applied fertilizer. Phosphorus is the second major nutrient for plant growth and plays a critical role in the life cycle of plants. Although phosphorus is widely deficient in Bangladesh soils, the farmers are not fully aware of using phosphatic fertilizers. As a result, phosphate supplies in most of the Bangladesh soils are generally in adequate for good crop yield. Potassium is one of the primary and third so called major food elements for plant growth. Its function appears to be catalytic in nature and its deficiencies may greatly reduce crop yield. Potassium is found in soils in varying amounts but the reaction of total potassium in the plant availability is very small. Sulphur is increasingly being recognized as the fourth major element for plant growth and plays a unique role in plant metabolism. In Bangladesh, sulphur deficiency in rice was first detected at BRRI farm, Joydebpur. Gazipur (Islam, 1978). Zn increases the metabolic functions of plants. It is essential information of chlorophyll and carbohydrate by plants. Efficient fertilizer management gives higher yields of the crops and reduces fertilizer cost (Hossain and Islam, 1986). Fertilizing can change rates of plant growth, maturity time, size of plant parts, phyto-chemical content of plants and seed capabilities (Mevi Schütz *et al.,* 2003). Aerobic rice yields were lower by an average of 28 per cent in the dry season and 20 per cent lower in wet season (Ambrocio *et al.,* 2004).

At 5 cm submergence of soil was the best for rice yield in rabi season, and Marimithu and Kulandaivelu (1987) got the similar type of result in the summer season. (Krishnamurty *et al.,* 1980) The higher water use efficiency was observed when saturation was maintained at flowering stage during boro season. (Maity and Sarkar, 1990).

Water deficit during vegetative, flowering and grain filling stages reduced mean grain yield by 21, 50 and 21% on average in comparison to control respectively (Patel, 2000).

He showed that comparatively heavier (19.86 g) 1000 grains weight was found under saturated condition which was similar with that of submerge condition. (Dhar, 2006)

Weeds are the greatest yield-limiting pest to rice production (Ahmed and Chauhan, 2014). Global yield losses due to pests have been estimated approximately 40% where weeds caused the highest loss which is around 32% (Rao *et al.,* 2007). Weed infestation in rice crop may reduce the grain yield by 68-100% for direct seeded *Au*s rice, 14-48% for *Aman* Rice and 22.36% for *Boro* Rice (IRRI, 1998).

Appropriate agronomic management practices have a great influence to the growth and yield of rice. Yield loss is occurred due to improper weeds management, nutrient management and irrigation schedule. So, these managements is a complete package for satisfactory any crop production specially rice production in Bangladesh. Management of fertilizer application, appropriate amount of water and control of weeds are essential for obtaining optimum rice yield. Farmers in Bangladesh spend more time and energy to control of weeds; do not give proper dose of fertilizer and optimum amount of water for rice cultivation. Thus, the appropriate agronomic management practices need to be adopted by the farmers for maximizing rice yield. Keeping in view the importance of rice and role of agronomic managements, the present research work has been undertaken in *Boro* season with the following objectives:

i. To compare the yield of two *Boro* rice varieties.
ii. To find out individual role of agronomic managements on growth and yield of *Boro rice*.
iii. To study the interaction effect of variety and agronomic managements on the performance of *Boro* rice.

CHAPTER II

REVIEW OF LITERATURE

Rice is the staple food crop of the people of Bangladesh. Research on this crop is going on various aspects including agronomic management practices to increase its potential yield. An attempt is made to review the available literature those are related to the effect of agronomic management on the yield and yield attributes of rice as below under the followings-

2.1 Effect of irrigation on yield attributes and yields of rice

An experiment was carried out by Karim *et al.* (2014) at Bangladesh Agricultural Research Institute (BARI) farm during 2010-11 to evaluate yield and resource use efficiency of transplanted *Boro* rice under two tillage and three irrigation methods. Two tillage methods viz., conventional tillage with puddle transplanted rice and reduced tillage unpuddled transplanted rice and three irrigation methods viz., sprinkler irrigation, alternate wetting and drying (AWD) and flood irrigation were used as treatment variables. Grain yield was 7.62% higher in sprinkler and 4.72% higher in AWD irrigation method over flood irrigation method. Irrespective of tillage methods, reduced tillage method holds 4.62% higher yield production over conventional tillage method. Water use efficiency was found highest in sprinkler irrigation method (0.83 kg/m^3) and in reduced tillage method (0.773 kg/m^3). Labour required for land preparation was 15 md/ha in reduced tillage, whereas it was 38 md/ha in conventional tillage method. Seedling uprooting and transplanting required higher labour in reduced tillage method over conventional tillage. Fuel consumptions (49.78 l/ha) and electricity (3475.11 Kwhr/ha) was also less in reduced tillage method. Reduced tillage had less land preparation and fuel cost over conventional tillage method. But seedling uprooting and transplanting cost was higher in reduced tillage. Irrigation and total cost of production was 7753 Tk. ha^{-1} and 69972 Tk. ha^{-1} in Sprinkler × RT method. Benefit cost ratio was also higher in sprinkler irrigation (1.81) and reduced tillage method (1.82).

Bhuiyan (1999) showed that rice plant did not suffer from water deficiency if soil was saturated and there was no standing water but this result was disagreed with Khare *et al.* (1970) who reported that the panicle length was highest at 5 cm flooding than that's of continuous saturation.

Bhatia and Dastane (1971) conducted an experiment over a two year period with three rice varieties grown on soil submergence under 4 or 4-8 cm of water or irrigated at 0.4 atm. The yields of rice, number of productive tillers and filled grains panicle^{-1} and 1000-grain weight were higher with a water depth of 4cm than with a depth of 4-8 cm or with irrigation to 0.4 atm tension.

Zubaer *et al.* (2007) showed the interaction effect of soil moisture levels and rice genotypes on the number of unfilled grains per panicle, was significant. In all the rice genotypes, number of unfilled grains was increased with reduced soil moisture levels but the degree of increment was different in different genotypes. Increased unfilled grains per panicle under lower soil moisture level might be due to inactive pollen grain for dryness, incomplete development of pollen tube; insufficient assimilates production and its distribution to grains.

Patel (2000) observed no significant difference of 1000 grains weight under saturated and submerged condition. Dhar (2006) studied on the growth and yield of boro rice as influence by water level and seedling number hill^{-1} plant height of boro rice. He represented that weight of 1000 grains was found statistically unaffected by the variation of water levels. He showed that comparatively heavier (19.86 g) 1000 grains weight was found under saturated condition which was similar with that of submerge condition.

Sarvestani *et al.* (2008) conducted a field experiment during 2001-2003 to evaluate the effect of water deficiency on the yield and yield components of four rice cultivars commonly grown in Mazandaran province, Iran. Local and improved cultivars used were Tarom, Khazar, Fajr and Nemat. He used water deficiency during vegetative, flowering and grain filling stages and well watered was the control. He showed that water deficiency at flowering stage had a greater grain yield reduction than water deficiency at other times and the reduction of grain yield largely resulted from the reduction in fertile panicle and filled grain percentage. He also showed that water deficit during vegetative, flowering and grain filling stages reduced mean grain yield by 21, 50 and 21% on average in comparison to control respectively. Total biomass, harvest index, plant height, filled grain, unfilled grain and 1000 grains weight were reduced under water deficiency in all cultivars and water deficiency at vegetative stage effectively reduced total biomass due to decrease of photosynthesis rate and dry matter accumulation.

Dhar (2006) studied on the growth and yield of boro rice as influence by water level and seedling number hill^{-1} plant height of boro rice. He represented that grain yield of boro rice was not significantly influenced by water levels. The highest grain yield (6.44 t ha^{-1}) was obtained with continuous submerged condition that followed by continuous saturated condition. IRRI (1995) showed that maintaining a saturated soil throughout the growing season could save up to 40% of water in clay loam soil, without yield reduction.

Bali and Uppal (2006) laid out a field trial at Ludhiana, India in the year of 2000 and 2001 in rainy seasons. Rice cv. Basmati 370 was irrigated 2 or 4 days after infiltration of previously ponded water and irrigation was withdrawn at 7, 14 or 21 days after 50% flowering. Irrigation at 2 and 4 days after infiltration of ponded water produced grain yields of 2.45 and 2.07 t ha^{-1}, total water use of 141 and 123 cm, and water use efficiency of 17.4 and 16.8 kg ha^{-1} per cm, respectively. Mean yield was 1.85, 2.38 and 2.57 t ha^{-1} when irrigation was withdrawn at 7, 14 and 21 days after flowering with water consumption of 126, 131 and 139 cm.

Torres and Valle (2006) established a demonstration plot in southern Campeche, Mexico using supplementary irrigation from deep tube-wells with the aim to increase productivity during two consecutive spring-summer cycles on 60 and 100 hectors using Campeche A-80 (non-irrigated) and Philippine Miracle (irrigated) varieties. Results of both cycles appeared the superiority in yield with irrigation; 5.89 and 5.63 t ha^{-1} were harvested in the 1989 and 1990 cycles, respectively. In 1989, no yield was obtained in the non-irrigated plot due to drought while in 1990. 3.10 t ha^{-1} was recorded.

ZouGui *et al.* (2006) carried out field study in Shanghai, China. The results illustrated that irrigation treatments significantly affected the growth, photosynthesis and grain yield of the 2 rice cultivars compared to those under rainfed conditions, the decrease in grain yield of Zhonghan 3 was 68.42%.

Water productivity (WP) of irrigated lowland rice was determined by Murali and Thabonithy (1997) during the 1994 dry (January to May) and wet (August to December) seasons on a heavy clay acid sulphate soil in Thailand. Treatments consisted of three cultivation methods: transplanted rice, pregerminated seeds broadcasted on puddled soil (wet seeding) and dry seeds broadcasted on unpuddled soil (dry seeding). Total highest water requirement for rice production was 755 mm in wet season and 1154 mm in dry season in transplanted plots. Total percolation was 62 mm in wet season and 94 mm in dry season in transplanting method. Water productivity (the ratio between grain yield and total amount of water used in production) was 3.5-4.1 kg ha^{-1} per mm in transplanted rice.

Sattar and Bhuiyan (1994) revealed that yield from all the treatments of direct – seeded rice was significantly higher (0.6 t/ha) than transplanted one using 20% less amount of water. Under continuous saturated condition, 30% water was saved during normal irrigation period over the amount used in farmers' water management practices (continuous 5-7 cm standing water) with the direct-seeded methods without any significant yield reduction. In transplanted rice 1,238 mm water used for farmers normal management practice whereas continuous saturated soil condition had the most water-saving regime requiring 917 mm (26% less) water for the whole growing season.

Hoque *et al.* (1994) found that consumptive use of *Boro* rice was 461.02 mm and net irrigation requirement of *Boro* rice was 410.01 mm.

Karim and Akhand (1982) observed that the consumptive use of *Boro* rice for the entire growing season was 469.2 mm.

Zhang *et al.* (2004) carried out an experiment to identify water saving technology for paddy rice irrigation in a demonstration region of the city of Yancheng, China. Test results showed that dry-foot paddy irrigation saved 48.5% of water, and increased from 8.9 to 12.9% of yield, increasing 1302 Yaun of benefit per hectare, compared to traditional flooding irrigation. The technology has the advantages of clear index, notable effectiveness of water saving, reduction of soil loss and high production; besides, the rice was of good quality and the investment was economical. So, it is easy to be popularized in large areas.

Sharma (1987) studied water management practices in rice for higher yield and higher water use efficiency. The consumptive use was highest under saturation by water use efficiency and irrigation efficiency increased with each increase in the period of soil moisture stress.

Islam (1992) observed that maximum grain yield of 5.19 t ha^{-1} was obtained in plots maintaining 5 to 7 cm standing water. The lowest yield (3.85) was noted in plot where water level was maintained from 1 cm to saturation.

Maity and Sarkar (1990) revealed that there was no significant difference in yield between any two water management practices during two *Aman* seasons (1972-73) and one *Boro* season (1973-74). The maximum and minimum yields were obtained in two *Boro* season (1971-72 and 1972-73), respectively under continuous soil submergence of 2-4 cm and continuous saturation due to prevailing high atmospheric evaporative demand. The total evapo-transpiration under continuous submergence was 14.85 and 26.00 percent higher over that under continuous saturation during *Aman* and *Boro* seasons, respectively. The higher water use efficiency was observed when saturation was maintained at flowering stage during *Boro* season.

Chowdhury (1988) carried out an experiment at Bangladesh Rice Research Institute farm, Joydebpur during the *Boro* season of 1986 and 1987 to find out the optimum water regime for boro season. He revealed that continuous flooding and soil moisture below saturation reduced tillering but the effective tillers were only reduced by soil moisture below saturation. Both total dry matter and grain yield in particular was affected by water regimes. Continuous flooding and alternate drying and flooding produced similar grain yield and as moisture regime dropped below saturation the yield declined significantly. Straw yield was not affected by the water regimes tested in 1986 while in 1987 straw yield significantly decreased whenever soil moisture dropped below saturation.

Krishnamurty *et al.* (1980) stated that 5 cm submergence of soil was the best for rice yield in rabi season, and Marimithu and Kulandaivelu (1987) got the similar type of result in the summer season.

Cruj *et al.* (1975) supported that continuous flooding gave greater plant height, higher grain and straw ratio, a lower proportion of sterile florets and a lower number of days to anthesis.

2.2 Effect of weed management on yield attributes and yields of rice

Weed management plays an important role on the performance of rice crop. Thus, the best weed management needs to be resorted to reduce weed infestation and maximum rice yield.

Singh *et al*. (1999) studied the effect of various weed management practices on the weed growth and yield and nitrogen uptake in transplanted rice and weeds and reported that weed control until maturity removed significantly higher amount of nitrogen through weeds (12.97 kg ha^{-1}) and reduced the grain yield of rice by 49% compared to that of weed free crop up to 60 DAT.

Sushmita *et al.* (2017) established an experiment during dry seasons of 2013 and 2014 to develop a robust strategy for effective weed management in aerobic rice system for tropical rice belts. The efficacy of post-emergent herbicides bispyribac-sodium, azimsulfuron and flucetosulfuron were evaluated under different rice establishment methods (row sowing, spot seeding and broadcasting). Grass weed species constituted 58–68% of the total weed density across the establishment methods in the weedy check treatment. The total weed density and weed biomass were lowest in spot seeding with azimsulfuron (35 g active ingredient (a.i.) ha^{-1}) 30 and 60 days after sowing. Among herbicides, use of azimsulfuron caused the highest grain yield (5.2 t ha^{-1}), realizing 72% increase in grain yield over the weedy check. Yields in row sowing and spot seeding were similar and the same was verified when comparing yields in plots treated with bispyribac-sodium and azimsulfuron. Based on our findings and considering both weed presence and grain yield, azimsulfuron in spot seeding can be recommended in aerobic rice.

Field investigations carried out at Tamil Nadu Rice Research Institute, Aduthurai during wet seasons of 2011-12 and 2012-13 to study the effect of integrated weed control on growth and yield of transplanted rice and its residual effect on succeeding black gram. Experiments were tested in randomized block design replicated thrice. Treatments consisted of application of herbicides viz., clomazone 500 g ha^{-1}, clomazone + 2, 4-DEE 500 g ha^{-1}, butachlor 1250 g ha^{-1}, pretilachlor 500 g ha^{-1} and bispyribac sodium 25 g ha^{-1} followed by (fb) hand weeding (HW) on 45 days after transplanting (DAT). Pre plant incorporation of glyphosate 2.5 L ha^{-1} fb pre emergence application of bensulfuron methyl plus pretilachlor 660 g ha^{-1} was also tested with two hand weedings and unweeded control. The highest grain yield (5831 and 8783 kg ha^{-1}) were recorded under two hand weedings during both years as a result of reduced weed dry weight and increased growth attributes. This was at par with application of bispyribac sodium 25 g ha^{-1} fb one HW (5613 and 8653 kg ha^{-1}). The results indicated that herbicides applied in rice did not find their residual effects on succeeding black gram. Even though the results of two hand weedings were better, it cannot be recommended at larger scale as it is time consuming and laborious. Hence, post emergence application of bispyribac sodium 25 g ha^{-1} fb one HW on 45 DAT can be recommended for better weed control and productivity in transplanted rice (Parthipan *et al.*, 2013).

Sanioy *et al*. (1999) observed that control of weeds played a key role in improving the yield of rice because of panicle m^{-2} increased 18% due to weed control over its lower level, number of filled grains $panicle^{-1}$ increased 32% due to weed control over its lower level and significant yield increase was observed (43%) with weed control.

Weed control efficiency was higher in two hand weeding (90.67%) than dose of Oxadiazon and Cinosulfuron treatments (Alam *et al*., 1996).

Ahmed *et al*. (1997) reported that higher weed control efficiency (90.35%) was observed in herbicides with one hand weeding treatment than sole herbicides or conventional weed control methods.

Thomas *et al*. (1997) reported that rice weed competition for moisture was heavy during initial stages and yield losses from uncontrolled weeds might be as high as 74%.

Madhu *et al*. (1996) at Bangalore, to evaluate the effectiveness of four herbicides, pendimethylin, Anilofos, Butachlor and oxyfluorfen at 2 application rates during dry and wet seasons in paddled seeded rice field and the results showed that grain and straw yields were higher in the plots treated with Butachlor @ 1.5 kg ha^{-1}.

Bhattacharya *et al*. (1996) reported that although the hand weeding treatment gave the highest grain yield, the results indicated that this was laborious, time consuming and costly and hand weeding, could be replaced by application of Butachlor at 1 kg a.i. ha^{-1}.

Putnam and DeFrank (1983) showed reductions in germination and growth of several problem agronomic weeds including barnyardgrass (*Echinochloa crusgalli* L.), common lambsquarters (*Chenopodium album* L.), common ragweed (*Ambrosia artemisiifolia* L.), green foxtail [*Setaria viridis* (L.) Beauv.] and redroot pigweed (*Amaranthus retroflexus* L.)

Zaman *et al*. (2013) organized an experiment to evaluate the best option of weed control for the farmers. They observed that herbicide Sirius 10WP and one hand weeding at 20 DAS gave the highest grain yield whereas no weeding condition gave the lowest yield contributing characters, grain yield and straw yield.

Pasha *et al*. (2012) laid out trail to study the effects of several weed control methods on yield and yield components of rice in Northern part of Iran. They worked with seven treatments including hand weeding twice (T_1), powered weeding twice (T_2), powered weeding + hand weeding once (3), cono-weeder weeding twice (T_4), herbicide application + hand weeding once (T_5), control treatment (T_6) and herbicide application once (T_7). Among treatments, herbicide application + hand weeding once (T_5) gave the highest grain yield (4584 kg ha^{-1}), while control treatment (T_6) because of the high unfilled grain per panicle and less panicle number per square meter gave the lowest grain yield (2505 kg ha^{-1}).

Ismail *et al*. (2011) performed the upland rice experiment field at the National Cereals Research Institute (NCRI), Badeggi, Nigeria in 2008 and 2009 to evaluate the efficacy of different method of weed control and their profitability in inter-specific and intra-specific upland rice varieties. Two varieties of rice and seven weed control treatments were used in the experiment. Results displayed that three hoe weedings at 25, 45 and 65 DAS, twice at 25 and 45 DAS and at 25 followed by orizoplus at 45 DAS gave better weed control than other treatments. However, hoe weeding at 25, 45 and 65 DAS gave significantly higher grain yield of 3.1 t ha^{-1} than that of other treatments.

Chauhan *et al*. (2011) mentioned that yield losses due to weeds (with one weeding at 28 days after sowing) in aerobic rice were about 50% relative to weed-free rice. They stated that critical periods for weed control, to obtain 95% of a weed free yield were estimated at between 17 to 56 days after sowing of the DSR crops at 15 cm row spacing.

Prasad (2011) revealed that cultivars played an important role in crop-weed competition because of their diverse morphological traits, canopy structure and relative growth rate. A quick growing and early canopy cover enables a cultivar to compete better against weeds. Research evidences have opined that traditional tall cultivars like Nerica rice exert effective smothering effect on weeds.

2.3 Effect of nutrient management on yield attributes and yields of rice

Thakur (1991) obtained the highest plant height when 40%, 30% and 30% N were applied as basal dose, at maximum tillering and panicle initiation stages, respectively. Plant height increased with increasing rates of N application (Talukder, 1973).

Lin and Lin (1983) raised two rice cultivars treated with 80, 120 and 160 kg N ha^{-1}. They found that high N levels resulted in the higher tiller number unit $area^{-1}$.

Mondal *et al.* (1987) observed that increasing rates of N from 40 to 160 kg ha^{-1} increased the 1000-grain weight.

Wagh and Throat (1988) reported that 50+30+10+10 kg N ha^{-1} applied at 8 days after transplanting, maximum tillering, primordial initiation and flowering gave the highest yield. Number of splitting of urea-N may have effect on grain yield. Milam *et al*. (1986) observed that 3 split applications of urea yielded higher than pre-plant incorporation.

Prakash and Bhadoria (2002) reported that the treatments with vermicompost recorded highest grain yield of rice and imparted maximum tolerance to pathogen than any other nutrient sources.

Ji-ming *et al.* (2011) conducted a field experiment to study the effects of manure application on rice yield and soil nutrients in paddy soil. The results show that the long-term applications of green manure combined with chemical fertilizers (N, P. K. S) are in favour of stable and high yields of rice.

Singh *et al.* (2001) reported that the application of FYM @ 10 t ha^{-1} produced 4.64% higher yield than the control.

Bayan and Kandasarny (2002) noticed that the application of recommended doses of N in four splits at 10 days after sowing, active tillering and panicle initiation and at heading stages recorded significantly lower dry weight of weeds and increased crop growth viz., effective tillers/rn2. Number of effective tillers hill^{-1} increased with top dressing of N (Islam *at al.*, 1996). Effective tillers hill^{-1} was significantly affected by the level of N. The highest number of productive tillers hill^{-1} was obtained from the highest level (120 kg ha^{-1}) of nitrogen (BINA, 1996).

Ehsanullah *at al.* (2001) reported that the application of different levels (75 kg, 100 kg and 125 kg ha^{-1}) of N fertilizers in rice field, resulted the significantly increased 1000 grain weight and straw yield of 125 kg ha^{-1} N application

lqbal (2004) carried out an experiment on interactions of N, P and water application and their combined effects on biomass and yield of rice. It was concluded that the yield of rice increased by 50-60% in response to the application of N and P interaction with 1120.

Sharma and Prasad (2003) studied the effect of rock phosphate (RP) and TSP in three cycle of rice-wheat cropping systems. Application of TSP had significant effect on grain and straw yields and P uptake by rice and wheat. They found that the efficiency of R9+TSP was better than that of RP alone in rice wheat cropping system.

Sahrawat *et al.* (2001) reported that phosphorus deficiency has been identified as a major constant to crop production on highly weathered; tow activity clay soils in the humid and sub humid zones of sub Saharan Africa. The main problem concerning is its fixation with soil complex with a very short period of application of inorganic P and relative increase in grain and straw yields.

Chitdeshwari and Savithri (2000) reported that the combined use of organic and inorganic phosphate fertilizer on yield and P status of rice. They obtained highest yield applying 100% of recommended P (SSP) and green manure @ 6.25 t ha^{-1}.

BRRI (1994) reported that applying K rate up to 120 kg ha^{-1} that, it failed to increase the straw and grain yield significantly over 30 kg ha^{-1}.

Purohit *et al.* (1986) conducted two years trails with three varieties of rice and four levels of K_20 (0, 40. 60 and 80 kg ha^{-1}) and observed that grain yield and net profit were the highest with 80 kg K_20 ha^{-1}.

Raju and Reddy (2001) conducted field investigations at Agricultural Research Station, Maruteru, Andhra Prades, India to study the response of both hybrid and conventional rice to sulphur (at 20 kg ha^{-1}) and Zn (at 10 kg ha^{-1}) applications. Significant improved in grain yield was observed due to sulphur application.

Haque and Jahiruddin (1994) studied effects of single and multiple applications of S and Zn in a continuous rice cropping system and noted that crop yields were increased by S (20 kg ha^{-1} as gypsum.) and not generally by Zn. They also observed that although added gypsum had residual effect up to 3 crops application in every crop produced comparatively higher grain yield of rice.

Kumar and Reddy (2010) conducted an experiment during three consecutive kharif seasons of 2000, 2001 and 2002 at Agricultural Research Station, Neliore in the southern Agro-climatic Zone of Andhra Pradesh to study the effect of organic and inorganic sources of nitrogen on soil fertility, productivity and profitability of lowland rice. Farmyard manure, poultry manure and neem-cake were tried as organic sources of nitrogen substituting 25% and 50% of inorganic nitrogen in comparison to 100% inorganic nitrogen. The experiment was laid out in randomized block design, replicated thrice. The combination of 50% N through urea and 50% N through any of the organic sources viz., farmyard manure, poultry manure and neem- cake produced significantly higher grain and straw yield, net returns and benefit cost ratio. Integrated supply of N at 50% each through fertilizer and organics recorded higher N uptake than all other combinations. Post-harvest soil fertility status *viz.*, organic carbon, available nitrogen, phosphorus and potassium was highest by substituting 50% N fertilizer with any of the organic source compared to recommended dose of N entirely through inorganic source. Lowest soil organic carbon and available nitrogen was registered with control while, lowest available phosphorus and potassium was with 100% N through urea.

Nyalemeghe *et al.* (2010) studied at the Agricultural Research Centre, Kpong, of the University of Ghana, to find solution to the problem of low rice yields on the Vertisols of the Acera Plains. Rice yields from continuously cropped fields have been observed to decline with time, even with the application of recommended levels of inorganic fertilizers. The decline in yield has been attributed to low inherent soil fertility, which was partly the result of low levels of soil organic matter (SOM). As part of the study, cow dung (CD) and poultry manure (PM) were separately applied to the soil at 20 t ha solely and also 5, 10 and 15 t ha^{-1} in combination with urea fertilizer at 90, 60 and 30 kg N ha^{-1}, respectively. Other treatments included a control and urea fertilizer at 30, 60, 90 and 120 kg N ha^{-1}. There was a basal application of phosphorus and potassium to all plots at 45 kg P_2O_5 ha^{-1} and 35 kg K_2O ha^{-1}, respectively, based on the recommended fertilizer rate of 90 kg N ha^{-1}, 45 kg P_2O_5 ha^{-1} and 35 kg K_2O ha^{-1}, on the Vertisols of the Accra Plains. Studies were also conducted on the redox potential of CD. PM and rice straw (RS). The application of 10 t ha^{-1} CD and urea fertilizer (at 45 kg N ha^{-1}) and 10 t ha^{-1} PM and rea (at 60 kg N ha^{-1}) both gave paddy yields of 4.7 t ha^{-1}, which did not differ significantly from the yield of 5.3 t ha^{-1}, obtained tinder the recommended inorganic nitrogen fertilizer application of 90 kg N ha^{-1}. This indicates a synergistic effect of OM and urea on soil fertility. The redox potential studies showed that RS had greater propensity to bring about reduced soil condition in paddy fields than CD and PM. while PM brought about greater reduction than CD.

Singh *et al.* (2004) conducted a field experiment in West Bengal, India during *Boro* and kharif seasons of 2001and 2002 respectively in a randomized block design with seven treatment combinations (T_1 = control, T_2= 100% recommended dose of N through straight fertilizer, T_3=100% N through IFFCO-NPK + urea, T_4=25% of N as FYM & 75%N as straight fertilizer, T_5= 25% N as FYM + 75% N as IFFCO NPK + urea. T_6= 50% of N as FYM + 50% N as straight fertilizer and T_7 = 50% as FYM + 50% N as IF'CO-NPK+ urea) to study the effect of organic and inorganic manuring on growth and yield of high yielding rice cv. lET 1786 (shatabdi) grown under rice crop sequence. 100% recommended dose of N through IFFCO-NPK and urea produced higher number of panicle m^{-2}, number of filled grains $panicle^{-1}$, 1000 grains weight and ultimately grain yield increased by 17.9, 4.6. 0.5 and 20.7% over the control treatment in *Boro* season. This was closely followed by 100% recommended doses of N through straight fertilizer or 25% N through FYM + 75% N through IFFCO-NPK, while in kharif season all the yield components responded well with either 25% N as FYM + 75% N as IFFCO-NPK + urea of 100% recommended dose of N through IFFCO-NPK + urea, tinder rice-rice cropping sequence maximum grain yield, total nutrient uptake, net return per rupee invested were recorded when the crop received 100% recommended doses of N through IFFCO-NPK + urea. Fertility status of soil declined in all the treatment combination as compared to initial status after harvesting of the first and second season rice crop.

Zhang and Peng (1996) showed that the content of soil organic matter and total N, P and K were raised, soil nutrients were activated, soil fertilizers were enhanced, nutrient absorption by rice was increased and rice yields were heightened by combined application of organic and inorganic fertilizers.

Singh *et al.* (1995) reported that cattle manure significantly improves rice yield but was less efficient than urea. The combination of cattle manure and urea showed no positive interaction effects. Total N uptake by rice was also significantly higher from urea than manure. P and K up take by rice increased in response to N application from urea and cattle manures.

Singh and Modgal (2005) noted that dry-matter accumulation (DMA) and concentration and uptake of nitrogen increased with increasing level of nitrogen at all the stages of crop growth. Split application of nitrogen with its heavier fractions (1 /3+1/3+ 1/3) at tillering and panicle initiation stages resulted in higher dry-matter accumulation, and higher nitrogen concentration of rice. They also noted that the rice plants accumulated nearly 15% of the total absorbed nitrogen, up to tillering, 50% up to panicle initiation and 85-90% up to heading.

Reddy *et al.* (1987) observed from an experiment that panicle length and total no. of spikelets panicle^{-1} increased with 120 kg N ha^{-1} in three split at tillering, panicle initiation and booting stages.

A site-specific nutrient management (SSNM) field trial carried out for irrigated rice using five fertilizer treatments: i) omission of N, ii) omission of P, iii) omission of K, iv) NPK and v) farmers' practice (FP). Substantial variation in the native N, P, and K supply was found among farmers' fields. The indigenous soil K produced 4.5 to 5.0 t ha^{-1} but native P and N gave only rice yield of 3.5 to 4.0 t ha^{-1}. The highest grain yield (6.0 to 7.5 t ha^{-1}) was recorded from balanced fertilization, followed by FP (4.0 to 5.0 t ha^{-1}).The optimal grain yield at Faridpur was recorded by using N, P and K at 135, 8 and 49 kg ha^{-1}; 139, 9 and 42 kg ha^{-1}; and 140, 10 and 43 kg ha^{-1} for high, medium and low land rice, respectively. However, for Gopalgonj district fertilizer doses of N, P and K were 140, 11 and 38 kg ha^{-1}; 142, 10 and 42 kg ha^{-1}; and 138, 10 and 49 kg ha^{-1}; and for Madaripur district, 126, 8 and 46 kg ha^{-1}; 120, 7 and 38 kg ha^{-1}; and 99, 6 and 27 kg ha^{-1} for high, medium and low land rice, respectively. These predicted fertilizer doses increase farmers' income and protect environment from pollution (Mamun *et al.*, 2017).

Experiments were conducted during dry seasons of 2010 and 2012 with three fertilizer packages and four weed control measures. The results differed that weed density and weed biomass were strongly influenced by weed control methods and fertilizer rates. Weed density was higher in unweeded plots with 140:36:43 kg NPK ha^{-1}. Three hand weeding controlled maximum weeds. Uses of herbicide for controlling weeds were above 80 and 70% effective. Herbicide with one hand weeding and BRRI weeder in combination with 160:46:53 kg NPK ha^{-1} produced about 81- 104% higher grain yield than no weeding. Weed free plot produced 112% higher yield with 160:46:53 kg NPK ha^{-1}. Besides, herbicide with one hand weeding and BRRI weeder treated plot produced similar yield irrespective of fertilizer doses. Direct seeded culture using herbicide with one hand weeding and 120:26:33 kg NPK ha^{-1} could be an option for reducing production cost in dry season along with satisfactory grain yield (Shultana *et al.*, 2016).

Bahmanyar and Mashaee (2010) stated that maximum grain yield (75.46 g pot^{-1}) was recorded @ 23 kg N ha^{-1} in *Aus* rice.

Patel *et al*. (2010) plotted a field experiment to study the performance of rice and a subsequent wheat crop along with changes in properties of a sodic soil treated with gypsum, press mud and pyrite under draining and non-draining conditions in a greenhouse experiment. The highest rice yield was recorded with press mud applied at a rate of 50 and 75% gypsum requirement.

Wan *et al*. (2010) laid out an experiment to see the effects of application of fertilizer, pig manure (PM), and rice straw (RS) on rice yield, uptake, and usage efficiency of potassium, soil K pools, and the non-exchangeable K release under the double rice cropping system. The field treatments included control (no fertilizer applied), NP, NK, NPK, and NK + PM, NP + RS, NPK + RS. The application of K fertilizer (NPK) increased grain yield by 56.7 kg ha^{-1} double rice cropping system. The field treatments included control (no fertilizer applied), NP, NK, NPK, and NK + PM, NP + RS, NPK + RS. The application of K fertilizer (NPK) increased grain yield by 56.7 kg ha^{-1} double rice cropping system. The field treatments included control (no fertilizer applied), NP, NK, NPK, and NK + PM, NP + RS, NPK + RS. The application of K fertilizer (NPK) increased grain yield by 56.7 kg ha^{-1}.

Mostofa *et al*. (2009) conducted a pot experiment in the net house at the Department of Soil Science, Bangladesh agricultural University, Mymensingh. Four levels of potassium (0, 100, 200, and 300 kg ha^{-1}) were applied. They observed that the yield contributing characters like plant height, tiller number, and dry matter yield were the highest in 100 kg ha^{-1} of K.

Salahuddin *et al*. (2009) conducted an experiment to study the effect of nitrogen levels and plant spacing on the yield and yield contributing characters of T. *Aman* rice (var. BRRI dhan31) and found that panicle length increased with the increase of nitrogen rate up to 150 kg N ha^{-1} and thereafter declined. They reported that the longest panicle (24.50 cm) was observed when 150 kg N ha^{-1} was applied. The highest number of grains panicle^{-1} (109.79) was obtained at 150 kg N ha^{-1}, which was significantly different from other N levels. Nitrogen helped in proper filling of seeds which resulted higher produced plump seeds and thus the higher number of grains panicle^{-1}. The lowest number of grains panicle^{-1} (99.41) was obtained from 0 kg N ha^{-1}.

Dunn and Stevens (2008) organized a field experiment to evaluate the effect of polymer coating of phosphate fertilizer on rice yield. Three rates of phosphate fertilizer, including polymer coated and non-coated, were compared to an untreated check. Net return was calculated based on crop price and input costs. At the rate of 25 lb/acre P_2O_5 rate the polymer coated treatments gave greater yields than equivalent non coated treatments. At higher P_2O_5 rates both polymers coated and non-coated treatments produced equivalent yields. The 25 lb P_2O_5 coated TSP treatment produced the greatest returns to producers.

Manivannan *et al.* (2008) conducted a field experiment in sulfur deficient soils to study the response of rice genotypes to sulfur fertilization. The treatments consisted of three levels of sulphur (0, 20 and 40 kg ha^{-1}) applied through gypsum and 10 rice genotypes (ADT 36, ADT 37, ADT 42, ADT 43, ADT 38, ADT 39, CO 43, CO 45, CO 47 and ASD 19). The results revealed that rice genotypes differed significantly among themselves to growth and yield on S addition. Rice genotypes CO 43 (5,090 kg ha^{-1}) and CO 47 (5,243 kg ha^{-1}) recorded the highest grain yield.

Muangsri *et al*. (2008) reported that the effect of rice straw and rice hull in combination with nitrogen, phosphorus and potassium fertilizer on yield of rice grown on Phimai soil series. The investigation carried out in pots. A completely randomized design with 3 replications was used. The treatments consisted of the control (without fertilizer) NPK fertilizer, rice straw at the rate of 0.75, 1.5 and 3.0 g kg^{-1} soil in combination with NPK fertilizer, and rice hull at the rate of 0.75, 1.5, 3.0 and 4.5 g kg^{-1} soil in combination with NPK fertilizer. The results showed that the growth, yield and nutrient uptake of rice plant grown on Phimai soil series without fertilizer were the lowest. Application of rice hull in combination with NPK fertilizer increased nutrient absorption and rice yield better than with NPK alone, especially at the rate of 1.5 g kg^{-1} soil. Yield of rice plant grown on the soil amended with rice straw in combination with NPK fertilizer tended to be higher than that of rice plant grown on the soil amended with only NPK fertilizer.

Bhuvaneswari *et al.* (2007) conducted a field experiment in Tamil Nadu, India during the 2001 kharif season to study the effect of sulphur at varying rates i.e. 0, 20, 40 and 60 kg ha^{-1} with different organic fertilizers i.e. green manure, farmyard manure, sulfitation press mud and lignite fly ash each applied at 12.5 t ha^{-1} on yield, S use efficiency and S optimization of rice cv. ADT 43. The results revealed that rice responded significantly to the application of S and organic compared to the control. The highest grain (5,065 kg ha^{-1}) and straw yield (7,525 kg ha^{-1}) was obtained with 40 kg S ha^{-1} application. Green manure addition caused 8.9% increase in grain yield and 10.6% increase in straw yield, closely followed by sulfitation press mud. Sulphur use efficiency was highest at 20 kg ha^{-1} and higher in the presence of organic fertilizers.

CHAPTER III
MATERIALS AND METHODS

The experiment was conducted during the period from December 2018 to April 2019 to study the growth and yield of *Boro* rice as affected by Agronomic Managements. The details of the materials and methods have been presented below:

3.1 Description of the experimental site

3.1.1 Location

The present piece of research work was conducted in the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka. The location of the site is 23 º74´N latitude and 90º35´E longitude with an elevation of 8.2 meter from sea level.

3.1.2 Soil

The soil belongs to “The Modhupur Tract”, AEZ- 28 (FAO, 1988). The texture of top soil was silty clay, olive-gray with common fine to medium distinct dark yellowish brown mottles. Soil pH was 5.6 and has organic carbon 0.45%. The experimental area was flat having available irrigation and drainage system and above flood level. The selected plot was medium high land. The details were presented in Appendix I.

3.1.3 Climate

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

3.2 Test crop and its characteristics

BRRI dhan84 and BRRI hybriddhan5 was used as the test crop in this experiment. These two varieties are recommended for *Boro* season. Average plant height of the BRRI dhan84 variety is 90-96 cm at the ripening stage. The grains are medium fine and white. It requires about 140-145 days completing its life cycle with an average grain yield of 6.0-6.5 t ha^{-1} (BRKB, 2017). BRRI dhan84 is grown in *Boro* season. The test crop BRRI dhan84 variety is recommended for cultivation in *Boro* season. BRRI dhan84 a long duration rice variety in Bangladesh. It is Zn rich variety. It contains 9.7 % protein, 25.9% amylase, 10.1 mg Fe and 27.6 mg Zn.

3.3 Experimental details

3.3.1 Treatments The experiment comprised as two factors.

Factor A: Variety

i. BRRI dhan84- V_1

ii. BRRI hybriddhan5- V_2

Factor B: Agronomic management

i. No managements-M_0

ii. No weeding, but all other managements –M_1

iii. No fertilizer application, but all other managements –M_2

iv. No Irrigation in reproductive and ripening stage, but all other managements -M_3

v. No Insecticides, but all other managements (M_4)

vi. No Fungicides/bactericides, but all other managements (M_5)

vii. Complete Managements (M_6)

As such there were 4 (2 × 7) treatment combinations viz. V_1M_0, V_1M_1, V_1M_2, V_1M_3, V_1M_4, V_1M_5, V_1M_6, V_2M_0, V_2M_1, V_2M_2, V_2M_3, V_2M_4, V_2M_5 and V_2M_6.

3.3.2 Experimental design and layout

The experiment was laid out in split-plot design with three replications. The layout of the experiment was prepared for distributing the combination of variety and agronomic management. There were 14 plots of size 5.0 m × 2.0 m in each of 3 replications. The treatments of the experiment were assigned at random into each replication following the experimental design where variety was in main plot and agronomic management in sub-plot.

3.4 Growing of crops

3.4.1 Seed collection

The seeds of the test crop i.e BRRI dhan84 (V_1) and BRRI hybriddhan5 (V_2) seed was collected from Bangladesh Rice Research Institute (BRRI), Gazipur.

3.4.1.2 Breaking of Seed dormancy

Collected seeds are dried 3 days in the sunlight to break the dormancy because seeds were stored in control temperature for long time viability. Dried seeds are packed in air tight bags.

3.4.2 Preparation of the main field

The plot selected for the experiment was opened in the first week of December 2018 with a power tiller, and was exposed to the sun for a week, after which the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain a good tilth. Weeds and stubble were removed, and finally obtained a desirable tilth of soil for direct seeding.

3.4.3 Fertilizers and manure application

The fertilizers N, P, K, S and B in the form of urea, TSP, MoP, Gypsum and Zinc sulphate, respectively were applied in all plots except no management and no fertilizer application. The entire amount of TSP, MoP, Gypsum and Zinc sulphate were applied during the final preparation of land. One third of Urea was applied after recovery period (7 DAT) and rest urea applied in two equal installments at 30 DAT and 45 DAT. The dose and method of application are shown in Table 1.

Table 1. Dose and method of application of fertilizers in rice field (Ref. FRG, 2018)

Fertilizer	Dose ha^{-1}	Dose Plot^{-1}	Application (%)		
			1st installment	2nd installment	3rd installment
Urea	200 kg N	309 g	33.33	33.33	33.33
TSP	80 kg P_2O_5	125 g	100	-	-
MoP	125 kg K_2O	150 g	100	-	-
Gypsum	20 kg S	85 g	100	-	-
Zinc Sulphate	10 kg Zn	15 g	100	-	-

3.4.4 Preparation of Nursery bed

Separated seed were sown in the nursery bed on 9 December 2018 after proper preparation of seedbed. Proper care and management were maintained to prepare healthy seedlings.

3.4.5 Preparation of land for transplanting the seedlings in the field

Land was prepared for seedling transplanting. Ten lines were made in each plot. Thirty five days old seedlings were transplanted maintaining distance of 20cm × 20 cm on January 02, 2019 with two seedlings per hill.

3.4.6 After-care

Intercultural operations were done maintaining standard procedure and as per treatment.

3.4.6.1 Irrigation and drainage

Flood irrigation was given to respective plots to maintain a constant level of moisture into the soil to develop tillering. The field was finally dried out at 15 days before harvesting. Proper drainage was developed to drain out the excess water from the field.

3.4.6.2 Thinning and Gap filling

At 15 days after transplanting (DAT) gap filling was done for all of the plots by planting same aged seedlings.

3.4.6.3 Weeding

Weeding was done all plots at 25, 35 and 50 DAT except no management and no weeding plot.

3.4.6.4 Top dressing

The urea fertilizer was top-dressed in 2 equal installments at 30 DAT and 45 DAT in all plots except no management and no fertilizer application.

3.4.6.5 Plant protection measures

Infestations of insect-pests were seen during the growing period of rice. The crop growth was normal plant protection measures were taken and controlled successfully.

3.5 Harvesting, threshing and cleaning

The rice plant was harvested depending upon the maturity of plant and harvesting was done manually from each plot. The BRRI dhan84 was harvested on 28th April, 2019 and BRRI hybriddhan5 on 3th June, 2019. The harvested crop of each plot was bundled separately, properly tagged and brought to threshing floor. Enough care was taken for harvesting, threshing and also cleaning of rice seed. Fresh weight of grain and straw were recorded plot wise. The grains were cleaned and finally the weight was adjusted to a moisture content of 14%. The straw was sun dried and the yields of grain and straw plot^{-1} were recorded and converted to t ha^{-1}.

3.6 Data recording

The following data were collected during the study period:

3.6.1 Data regarding weed

1. Weed population

2. Dry weight of weed biomass

3.6.2 Data regarded on growth, yield contributing characters and yield of rice

1. Plant height at 20, 45, 70 DAT and harvest
2. Number of tillers hill^{-1} at 20, 45, 70 DAT and harvest
3. Number of leaves hill^{-1} at 20, 45, 70 DAT and harvest
4. Dry matter hill^{-1}
5. Effective tillers hill^{-1}
6. Non-effective tillers hill^{-1}
7. Total tillers hill^{-1}
8. Length of panicle
9. Filled grains panicle^{-1}
10. Unfilled grains panicle^{-1}
11. Total grains panicle^{-1}
12. Weight of 1000 grains
13. Grain yield
14. Straw yield
15. Biological yield
16. Harvest index

3.6.1.1 Weed population

From the 1.0 m^2 area of every plot at 65 DAT, the total weeds were uprooted and counted.

3.6.1.2 Dry weight of weed biomass

The fresh weight of weeds from 1.0 m^2 area of each plot was weighed and oven dried at 80ºC for 24 hours. The sample was then transferred into desiccators and allowed to cool down to the room temperature and then final weight of the sample was taken.

3.6.2 Growth, yield contributing characters and yield of rice

3.6.2.1 Plant height

The height of plant was recorded in centimeter (cm) at the time of 20, 45 and 70 DAS (days after sowing) and at harvest. Data were recorded as the average of same 5 plants pre-selected at random from the inner rows of each plot. The height was measured from the ground level to the tip of the plant.

3.6.2.2 Number of tillers hill^{-1}

The number of tillers hill^{-1} was recorded at 20, 45 and 70 DAS by counting total tillers as the average of same 5 hills pre-selected at random from the inner rows of each plot.

3.6.2.3 Number of leaves hill^{-1}

The number of leaves hill^{-1} was recorded at 20, 45 and 70 DAS by counting total number of leaves as the average of same 5 hills pre-selected at random from the inner rows of each plot.

3.6.2.4 Dry matter hill^{-1}

Total dry matter hill^{-1} was recorded at the time of 20, 45 and 70 DAS and at harvest by drying plant sample. Data were recorded as the average of 5 sample hill plot^{-1} selected at random from the outer rows of each plot leaving the border line and expressed in gram.

3.6.2.5 Effective tillers hill^{-1}

The total number of effective tillers hill^{-1} was counted as the number of panicle bearing hill plant^{-1}. Data on effective tillers hill^{-1} were counted from 5 selected hills at harvest and average value was recorded.

3.6.2.6 Non-effective tillers hill^{-1}

The total number of non-effective tillers hill^{-1} was counted as the number of non-panicle bearing tillers plant^{-1}. Data on non-effective tiller hill^{-1} were counted from 5 selected hills at harvest and average value was recorded.

3.6.2.7 Total tillers hill^{-1}

The total tillers hill^{-1} was calculated by adding effective and non-effective tillers hill^{-1} and average value was recorded.

3.6.2.8 Length of panicle

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

3.6.2.9 Filled grains panicle^{-1}

The total number of filled grains was collected randomly from selected 5 plants of a plot and then average number of filled grains panicle^{-1} was recorded.

3.6.2.10 Unfilled grains panicle^{-1}

The total number of unfilled grains was collected randomly from selected 5 plants of a plot and then average number of unfilled grains panicle^{-1} was recorded.

3.6.2.11 Total grains panicle^{-1}

The total number of grains was calculated by adding filled and unfilled grains and then average number of grains panicle^{-1} was recorded.

3.6.2.12 Weight of 1000 grains

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

3.6.2.13 Grain yield

Grains obtained from each unit plot were sun-dried and weighed carefully. The central 5 lines from each plot were harvested, threshed, dried, weighed and finally converted to t ha^{-1} basis.

3.6.2.14 Straw yield

Straw obtained from each unit plot were sun-dried and weighed carefully. The dry weight of straw of central 5 lines were harvested, threshed, dried and weighed and finally converted to t ha^{-1} basis.

3.6.2.15 Biological yield

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

Biological yield = Grain yield + Straw yield.

3.6.2.16 Harvest index

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

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

3.7 Statistical Analysis

The data obtained for different characters were statistically analyzed to observe the significant difference among the treatments. The mean values of all the characters were calculated and analysis of variance was performed. The significance of the difference among the treatments means were estimated by the Duncan's Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to study the growth and yield of *Boro* rice, which were influenced by different agronomic managements. Data on different yield contributing characters, yield, weed population and dry weight of weed were recorded. Different data of yield contributing characters, yield, weed population and dry weight of weed were recorded. Different parameters of data are presented in Apendices III-XI. The results have been presented with the help of tables and graphs and possible interpretations under the following headings:

4.1 Weed growth and development

4.1.1 Weed population

Data on weed population were numerically different due to BRRI dhan84 and BRRI hybridedhan5 (Appendix III). Data on weed were recorded at 65 DAT, the maximum number of weeds (55.48 m^{-2}) was found in BRRI hybriddhan5 (Fig. 1), while the lower number (42.52 m^{-2}) was recorded in BRRI dhan84.

Weed population was statistically similar but numerically different, due to various agronomic managements (Appendix III). The lowest weed population (13.83 m^{-2}) was recorded in M_6 (all managements), while the highest weed population (144.83 m^{-2}) was found in M_0 (no management) plot (Fig. 2). Shultana *et al.* (2016) reported that weed density was higher in un-weeded plots with 140:36:43 kg NPK ha^{-1}.

There was a statistically significant effect on weed population by the interaction of variety and agronomic managements (Appendix III). The maximum weed population (177.00 m^{-2}) was observed in V_2M_0 (BRRI hybriddhan5 + no management) that was statistically similar (112.66 m^{-2}) to V_1M_1 (BRRI dhan84 with no weeding) and the lowest weed population (9.33 m^{-2}) was in V_1M_6 (BRRI dhan84 with recommended management) which was similar (12.00 m^{-2}) to V_1M_5 (BRRI dhan84 with no fungicide/bactericide application) (Table 2).

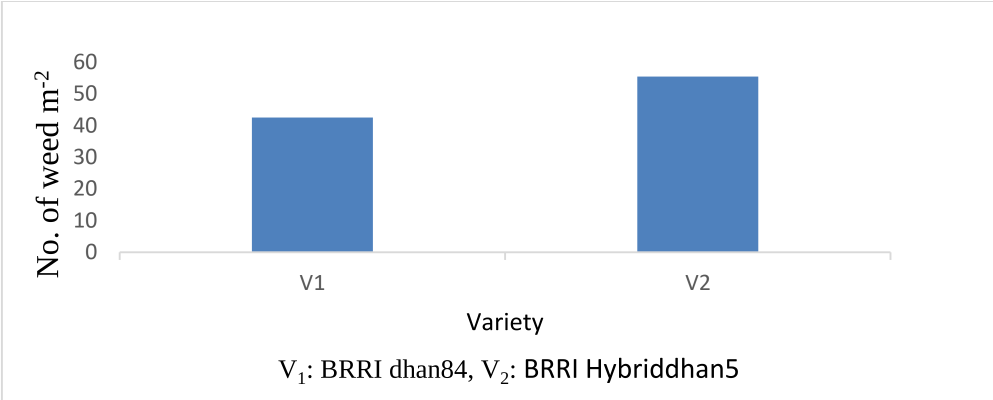
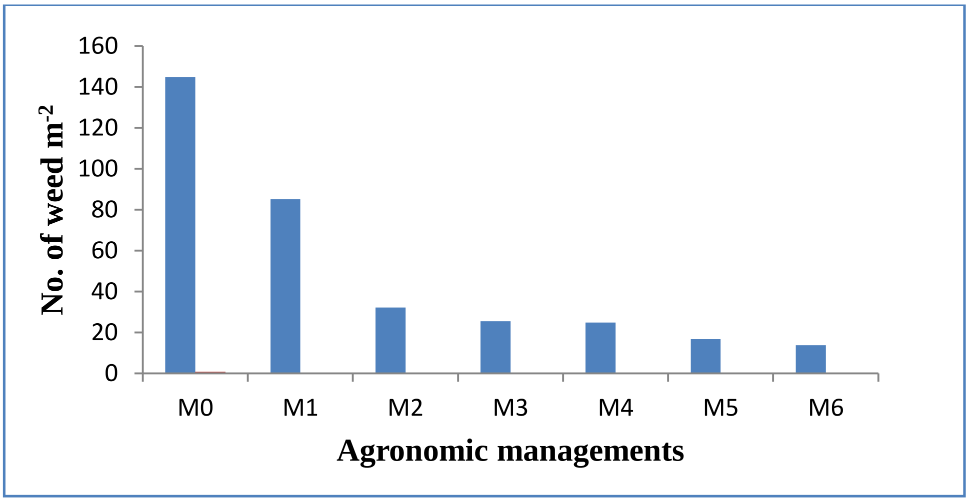


Figure 1. Effect of variety on weed population in *Boro* rice.



In a column mean values having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

V_1: BRRI dhan84, V_2: BRRI hybriddhan5
M_0: No management, M_1: No weeding, but all other managements, M_2: No fertilizer application, but all other managements, M_3: No Irrigation in reproductive and; ripening stage, but all other managements, M_4: No Insecticides, but all other managements, M_5: No Fungicides/bactericides, but all other managements, M_6: Complete Managements

Figure 2. Effect of agronomic managements on weed population in *Boro* rice (SE= 12.83).

4.1.2 Dry weight of weed biomass

Dry weight of weed biomass was not significant due to varieties (BRRI dhan84 and BRRI hybriddhan5) (Appendix III). It was found that the higher weed biomass (27.10 g m^{-2}) was found in the BRRI dhan84 cultivated plot (Fig. 3), while the lower weight (22.43 m^{-2}) was recorded in BRRI hybriddhan5.

Table 2. Interaction effect of variety and agronomic managements on population and dry weight of weeds in *Boro* rice

Treatments	Number of weeds m^{-2}	Dry weight (g) of weeds m^{-2}
V_1M_0	112.68 ab	33.57 bc
V_1M_1	79.00 bcd	110.61 a
V_1M_2	33.33 bc	5.04 c
V_1M_3	34.00 bc	9.16 bc
V_1M_4	17.33 bc	26.02 bc
V_1M_5	12.00 d	2.09 c
V_1M_6	9.33 d	3.24 c
V_2M_0	177.00 a	52.63 b
V_2M_1	91.33 bc	43.73 bc
V_2M_2	31.00 bc	3.92 c
V_2M_3	17.00 bc	11.38 bc
V_2M_4	32.33 bc	5.06 c
V_2M_5	21.33 bc	37.90 bc
V_2M_6	18.33 bc	2.38 c
SE	499.25	162.47s
CV (%)	94.59	106.74

In a column mean values having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

V_1: BRRI dhan84, V_2: BRRI hybriddhan5
M_0: No management, M_1: No weeding, but all other managements, M_2: No fertilizer application, but all other managements, M_3: No Irrigation in reproductive and; ripening stage, but all other managements, M_4: No Insecticides, but all other managements, M_5: No Fungicides/bactericides, but all other managements, M_6: Complete Managements

Dry weight of weed biomass varied significantly due to different agronomic managements (Appendix III and Fig. 4). The lowest weight of weed biomass (2.81 g m^{-2}) was recorded in M_6 (no fertilizer application) that was statistically similar to M_2 (4.48 g m^{-2}) and M_3 (10.27 g m^{-2}) M_4 (15.54 g m^{-2}) M_5 (19.99 g m^{-2}), while the highest dry weight (77.17 g m^{-2}) in M_1 (no weeding). Manish *et al.* (2006) recorded maximum weed dry weight recorded in no management treatment, while the minimum values were obtained with hand weeding at 15 and 30 DAT.

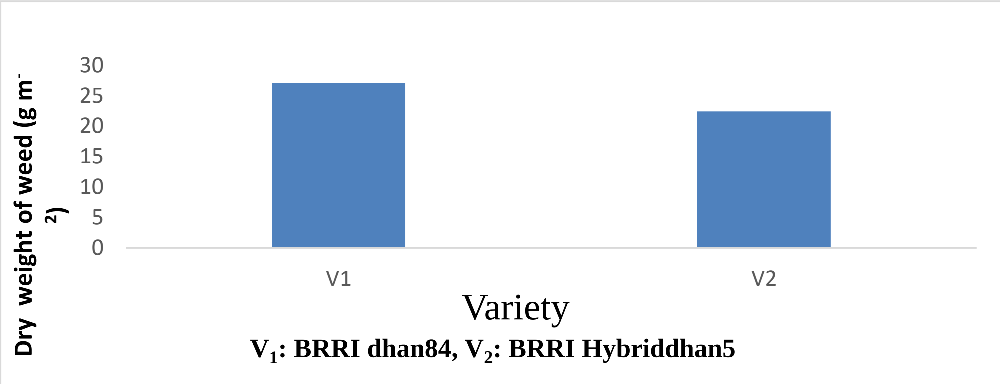
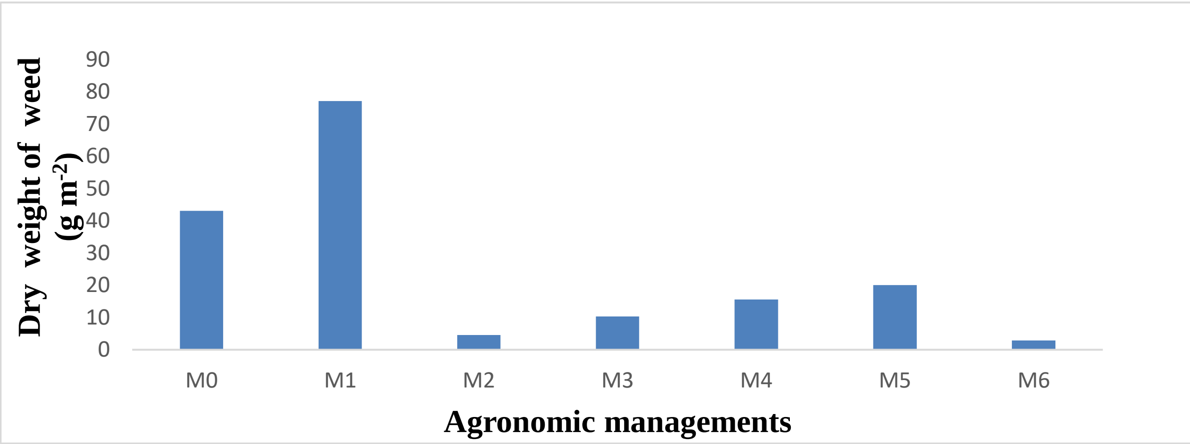


Figure 3. Effect of variety on dry weight of weed of *Boro* rice.



In a column mean values having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

V_1: BRRI dhan84, V_2: BRRI hybriddhan5; M_0: No management, M_1: No weeding, but all other managements, M_2: No fertilizer application, but all other managements, M_3: No Irrigation in reproductive and; ripening stage, but all other managements, M_4: No Insecticides, but all other managements, M_5: No Fungicides/bactericides, but all other managements, M_6: Complete Managements

Figure 4. Effect of agronomic managements on dry weight weed of *Boro* rice (SE= 12.83).

There was significant effect on weed biomass by the interaction effect of variety and agronomic managements (Appendix III). The highest weed biomass (110.61 g m^{-2}) was observed in V_1M_1 (BRRI dhan84 with no weeding) followed by (52.63 g m^{-2}) V_2M_0 (Table 2), while the lowest weed dry weight (2.09 g m^{-2}) in V_1M_5 (BRRI dhan84 with No Fungicides/bactericides, but all other managements) that was similar to V_1M_2, V_1M_6, V_2M_2, V_2M4 and V_2M_6 plots.

4.2 Yield and other crop characters of rice

4.2.1 Plant height

Plant height varied numerically at 20, 45 and 70 DAT and significantly at harvest of BRRI dhan84 and BRRI hybriddhan5 under the present trial (Appendix IV). At 45 and 70 DAT and at harvest the tallest plant (24.81 cm, 51.56 cm, 86.71cm and 119.21 cm, respectively) was recorded from V_1 (BRRI dhan84), whereas the shorter plant (25.28 cm, 49.53 cm, 79.61 cm and 104.08 cm) from V_1 (BRRI hybriddhan5) (Fig.5). Different varieties produced longest or smallest plant on the basis of their varietal characters.

Different agronomic managements showed variation numerically on plant height at 20, 45 and 70 DAT and significantly at harvest (Appendix IV). At 20, 45, 70 DAT and at harvest, the tallest plant (25.65 cm, 53.713 cm, 87.26 cm, 118.15 cm, respectively) was observed from M_6 (recommended management), which was closely followed by $M_{3,}$ $M_{4,}$ M_5, while the shortest plant (22.73 cm, 39.76 cm, 66.95 cm, 93.88 cm, respectively) from M_0 (no management) (Fig. 6).

Interaction effect of variety and agronomic managements showed significant differences on plant height at 20, 45, 70 DAT and harvest (Appendix IV). At 20, 45, 70 DAT and harvest, the tallest plant (25.89 cm, 55.6 cm, 89.32 cm and 127.4 cm respectively) was observed from V_1M_6 (BRRI dhan84 + recommended management), while the shortest (22.92 cm, 36.93 cm, 61.28 cm and 90.6 cm respectively) from V_1M_0 (BRRI hybriddhan5 + no management) (Table 3).

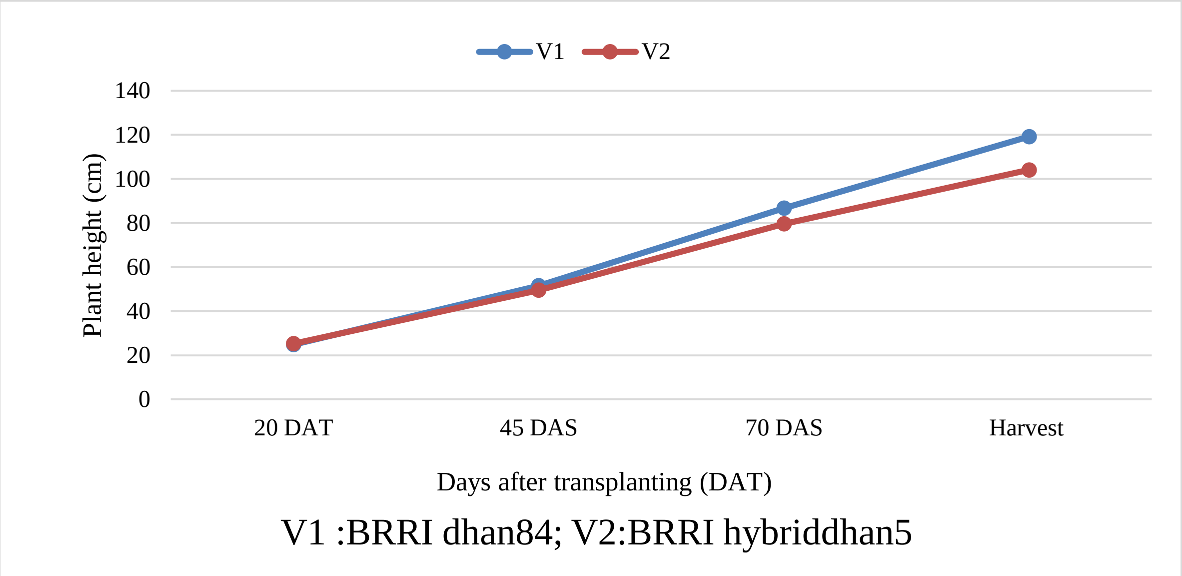
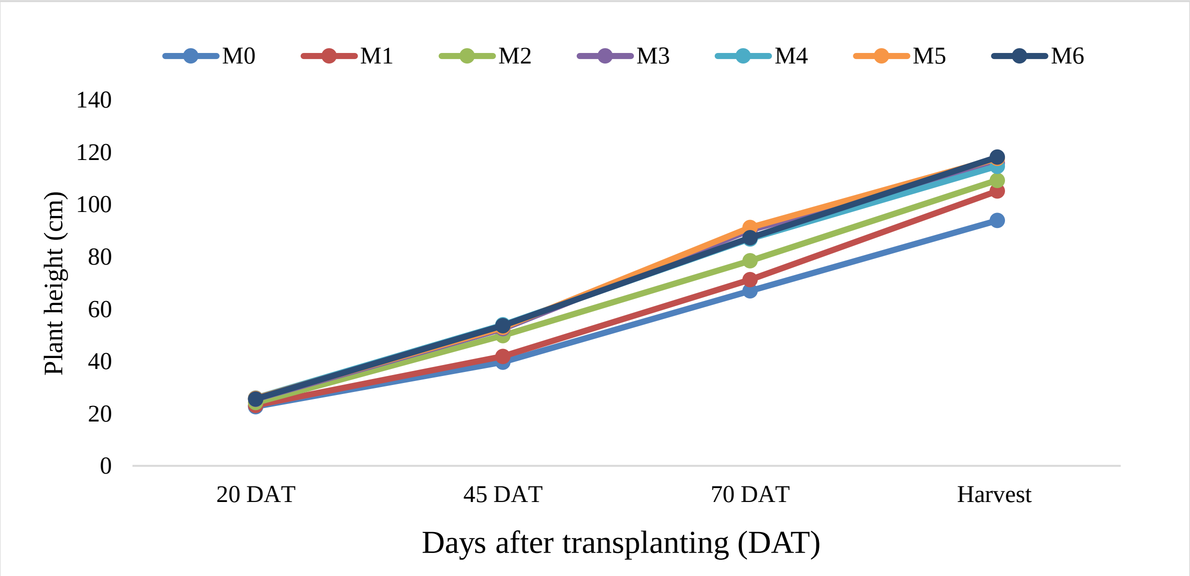


Figure 5. Effect of variety on plant height of *Boro* rice (SE=2.85 at harvest).



In a column mean values having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

V_1: BRRI dhan84, V_2: BRRI hybriddhan5
M_0: No management, M_1: No weeding, but all other managements, M_2: No fertilizer application, but all other managements, M_3: No Irrigation in reproductive and; ripening stage, but all other managements, M_4: No Insecticides, but all other managements, M_5: No Fungicides/bactericides, but all other managements, M_6: Complete Managements

Figure 6. Effect of agronomic managements on plant height of *Boro* rice (SE= 1.69 at harvest).

Table 3. Interaction effect of variety and agronomic managements on plant height of *Boro* rice at different days after transplanting (DAT)

Treatments	Plant height (cm) at			
	20 DAT	45 DAT	70 DAT	Harvest
V_1M_0	22.54 b	42.58 de	72.61 d	97.16 de
V_1M_1	22.87 b	38.94 ef	70.94 d	111.20 b
V_1M_2	26.50 ab	60.04 a	92.60 ab	125.90 a
V_1M_3	27.16 ab	53.92 bc	94.82 a	123.53 a
V_1M_4	24.94 ab	54.79 bc	91.46 ab	124.80 a
V_1M_5	23.75 ab	55.04 bc	95.22 a	124.53 a
V_1M_6	25.89 ab	55.60 abc	89.32 abc	127.40 a
V_2M_0	22.92 b	36.93 f	61.28 e	90.60 e
V_2M_1	23.56 ab	44.98 d	71.56 d	99.13 cde
V_2M_2	26.03 ab	57.70 ab	84.28 bc	106.63 bcd
V_2M_3	23.95 ab	51.11 c	85.53 bc	108.13 bc
V_2M_4	27.10 ab	53.16 bc	82.23 c	104.43 bcd
V_2M_5	28.01 a	51.04 c	87.16 abc	110.73 b
V_2M_6	25.42 ab	51.82 c	85.20 bc	108.90 bc
SE	1.13	1.09	1.99	2,39
CV (%)	11.48	5.49	6.12	5.46

In a column mean values having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

V_1: BRRI dhan84, V_2: BRRI hybriddhan5
M_0: No management, M_1: No weeding, but all other managements, M_2: No fertilizer application, but all other managements, M_3: No Irrigation in reproductive and; ripening stage, but all other managements, M_4: No Insecticides, but all other managements, M_5: No Fungicides/bactericides, but all other managements, M_6: Complete Managements

4.2.2 Number of tillers hill^{-1}

Number of tillers hill^{-1} varied numerically at 20 and 45 DAT and significant at 70

DAT of BRRI dhan84 and BRRI hybriddhan5 under the present trial (Appendix V). At 45 and 70 DAT the higher number of tillers hill^{-1} (11.85, and 13.82 respectively) was recorded from V_1 (BRRI dhan84), whereas the lower number (7.56, 9.76, respectively) from V_2 (BRRI hybriddhan5) (Table 4).

Table 4. Effect of variety and agronomic managements on number of tillers hill^{-1} of *Boro* rice at different days after transplanting (DAT)

Treatments	Number of tillers hill^{-1} at		
	20 DAT	45 DAT	70 DAT
Variety			
V_1	0.63	11.85 a	13.82 a
V_2	0.65	7.56 a	9.76 b
SE	NS	NS	0.70
CV (%)	12.29	39.43	19.20
Agronomic managements			
M_0	0.58	5.93 d	5.67 d
M_1	0.68	7.20 d	9.13 c
M_2	0.66	9.16 cd	9.57 c
M_3	0.61	11.33 ab	14.83 ab
M_4	0.63	10.30 bc	13.97 ab
M_5	0.70	11.30 ab	13.33 b
M_6	0.61	12.73 a	16.07 a
SE	0.05	0.48	0.53
CV (%)	26.94	17.7	16.26

In a column mean values having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

V_1: BRRI dhan84, V_2: BRRI hybriddhan5
M_0: No management, M_1: No weeding, but all other managements, M_2: No fertilizer application, but all other managements, M_3: No Irrigation in reproductive and; ripening stage, but all other managements, M_4: No Insecticides, but all other managements, M_5: No Fungicides/bactericides, but all other managements, M_6: Complete Managements

Different agronomic managements showed significant differences on number of tillers hill^{-1} at 20, 45 and 70 DAT (Appendix V). At 45 and 70 DAT, the highest number of tillers hill^{-1} (12.73, 16.06, respectively) was observed from M_6 (recommended management) followed (11.33, 14.83, respectively) by M_3 (no irrigation), while the lowest number (5.93, 5.67, respectively) from M_0 (no management) (Table 4).

Interaction effect of variety and agronomic managements showed significant differences on number of tillers hill^{-1} at 20, 45 and 70 DAT (Appendix V). At 45 and 70 DAT, the highest number of tillers hill^{-1} (17.2, 19.67, respectively) was observed from V_1M_6 (BRRI dhan84+ recommended management), while the lowest (3.67, 3.93, respectively) from V_2M_0 (BRRI hybriddhan5+ no management) (Table 5).

Table 5. Interaction effect of variety and agronomic managements on number of tillers hill^{-1} of *Boro* rice at different days

Treatments	Number of tillers hill^{-1} at			
	20 DAT	45 DAT	70 DAT	Harvest
V_1M_0	0.63	8.20 cd	7.40 h	7.80 ef
V_1M_1	0.80	7.33 d	9.80 efg	9.53 c-f
V_1M_2	0.60	10.93 bc	11.47 def	9.20 def
V_1M_3	0.53	13.53 ab	16.47 ab	12.53 abc
V_1M_4	0.57	12.40 ab	16.07 bc	14.07 a
V_1M_5	0.70	13.40 ab	15.93 bc	11.33 a-d
V_1M_6	0.60	17.20 a	19.67 a	13.13 ab
V_2M_0	0.53	3.67 e	3.93 i	3.73 g
V_2M_1	0.57	7.07 d	8.47 fgh	7.87 ef
V_2M_2	0.73	7.40 d	7.67 gh	6.33 fg
V_2M_3	0.70	9.13 cd	13.20 cd	10.00 bcde
V_2M_4	0.70	8.20 cd	11.87 de	8.80 def
V_2M_5	0.70	9.20 cd	10.73 defg	9.27 def
V_2M_6	0.63	8.27 cd	12.47 de	9.13 def
SE	0.07	0.67	0.75	0.76
CV (%)	26.94	17.7	16.26	20.44

In a column mean values having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

V_1: BRRI dhan84, V_2: BRRI hybriddhan5; M_0: No management, M_1: No weeding, but all other managements, M_2: No fertilizer application, but all other managements, M_3: No Irrigation in reproductive and; ripening stage, but all other managements, M_4: No Insecticides, but all other managements, M_5: No Fungicides/bactericides, but all other managements, M_6: Complete Managements

4.2.3 Leaf Area Index (LAI)

Leaf Area Index varied numerically at 20 and 45 and statistically at 70 DAT of BRRI dhan84 and BRRI hybriddhan5 (Appendix VI). At 20, 45 and 70 DAT, the higher leaf area index (0.09, 3.3, 6.9, respectively) was recorded from V_1 (BRRI dhan84), whereas the lower (0.1, 2.35, 6.44, respectively) from V_2 (BRRI hybriddhan5) (Table 6).

Different agronomic managements showed significant variation on leaf area index at 20, 45 and 70 DAT (Appendix VI). At 20, 45 and 70 DAT, the highest leaf area index (0.11, 3.43, 9.40, 9.00, respectively) was observed from M_6 (recommended management), while the lowest leaf area index (0.09, 1.30, 1.67, 2.08, respectively) was recorded from M_0 (no management) (Table 6).

Table 6. Effect of variety and agronomic managements on leaf area index of *Boro* rice at different days

Treatments	Leaf Area Index (LAI)			
	20 DAT	45 DAT	70 DAT	Harvest
Variety				
V_1	0.09 b	3.30 a	6.86 a	7.06 a
V_2	0.10 a	2.35 b	6.44 b	5.20 b
SE	0.01	0.2	0.18	1.52
CV (%)	33.41	22.85	8.78	80.43
Agronomic managements				
M_0	0.09 a	1.30 b	1.67 c	2.08 d
M_1	0.09 a	1.37 b	3.25 c	3.74 cd
M_2	0.12 a	3.81 a	5.91 b	4.67 bc
M_3	0.10 a	3.28 a	9.30 a	8.98 a
M_4	0.09 a	3.27 a	8.70 a	7.68 a
M_5	0.10 a	3.33 a	8.34 a	6.76 ab
M_6	0.11 a	3.43 a	9.40 a	9.00 a
SE	0.01	0.26	0.51	0.61
CV (%)	31.48	33.66	27.48	35.98

In a column mean values having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

V_1: BRRI dhan84, V_2: BRRI hybriddhan5
M_0: No management, M_1: No weeding, but all other managements, M_2: No fertilizer application, but all other managements, M_3: No Irrigation in reproductive and; ripening stage, but all other managements, M_4: No Insecticides, but all other managements, M_5: No Fungicides/bactericides, but all other managements, M_6: Complete Managements

Interaction effect of variety and agronomic managements showed significant differences on leaf area index at 20, 45, 70 DAT and harvest (Appendix VI). At 20, 45, 70 DAT and harvest the highest leaf area index (0.12, 4.15, 9.84, 10.98, respectively) was observed from V_1M_6 (BRRI dhan84 + recommended management), while the lowest (0.09, 0.87, 1.22, 1.21, respectively) from V_2M_0 (BRRI hybriddhan5 + no management) (Table 7).

Table 7. Interaction effect of variety and agronomic managements on Leaf Area Index (LAI) of *Boro* rice

Treatments	Leaf Area Index (LAI)			
	20 DAT	45 DAT	70 DAT	Harvest
V_1M_0	0.08 abc	1.72 cde	2.13ef	2.95 ef
V_1M_1	0.07 c	1.11 de	2.51ef	3.17 ef
V_1M_2	0.11 abc	4.83 a	6.68bcd	5.54 cde
V_1M_3	0.10 abc	3.61 ab	8.6ab	9.12 abc
V_1M_4	0.08 abc	3.71 ab	9.62ab	9.64 ab
V_1M_5	0.07 bc	3.95 ab	8.65ab	8.05 abc
V_1M_6	0.12 ab	4.15 ab	9.84a	10.98 a
V_2M_0	0.09 abc	0.87 e	1.22f	1.21 f
V_2M_1	0.11 abc	1.62 cde	3.99def	4.31 def
V_2M_2	0.12 ab	2.78 bc	5.14cde	3.80 def
V_2M_3	0.10 abc	2.94 bc	10a	8.85 abc
V_2M_4	0.08 abc	2.82 bc	7.77abc	5.72 cde
V_2M_5	0.13 a	2.72 bc	8.02abc	5.47 cde
V_2M_6	0.10 abc	2.71 bcd	8.96ab	7.02 bcd
SE	0.01	0.37	0.72	0.86
CV (%)	31.48	33.66	27.48	35.98

In a column mean values having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

V_1: BRRI dhan84, V_2: BRRI hybriddhan5
M_0: No management, M_1: No weeding, but all other managements, M_2: No fertilizer application, but all other managements, M_3: No Irrigation in reproductive and; ripening stage, but all other managements, M_4: No Insecticides, but all other managements, M_5: No Fungicides/bactericides, but all other managements, M_6: Complete Managements

4.2.4 Dry matter weight hill^{-1}

Dry matter weight hill^{-1} varied significantly at 20, 45, 70 DAT of BRRI dhan84 and BRRI hybriddhan5 (Appendix VII). At 20, 45, 70 DAT the higher dry matter content hill^{-1} (0.83 g, 9.22 g, 27.65 g, 28.02 g, respectively) was recorded from V_2 (BRRI hybriddhan5), whereas the lower (0.71 g, 7.87 g, 22.39 g, 30.47 g, respectively) from V_1 (BRRI dhan84) (Fig. 7). Amin *et al.* (2006) reported the variation of dry matter among different rice varieties.

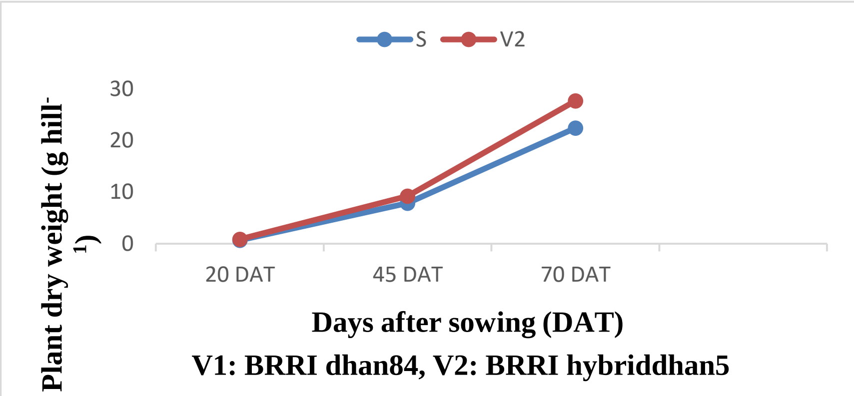
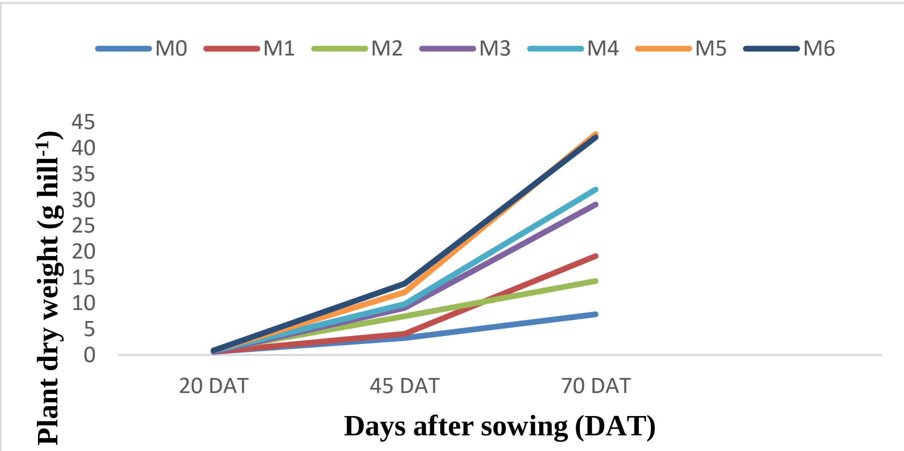


Figure 7. Effect of variety on plant dry weight hill^{-1} of *Boro* rice (SE=5.54 at harvest).



In a column mean values having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

V_1: BRRI dhan84, V_2: BRRI hybriddhan5; M_0: No management, M_1: No weeding, but all other managements, M_2: No fertilizer application, but all other managements, M_3: No Irrigation in reproductive and; ripening stage, but all other managements, M_4: No Insecticides, but all other managements, M_5: No Fungicides/bactericides, but all other managements, M_6: Complete Managements

Figure 8. Effect of agronomic managements on plant dry weight hill^{-1} of *Boro* rice (SE= 0.21, 1.2, 5.61 and 3.6 at 20, 45, 70 DAT respectively).

Different agronomic managements showed significant variation on dry matter content hill^{-1} at 20, 45, 70 DAT and harvest (Appendix VII). At 20, 45, 70 DAT and at harvest, the highest dry matter content hill^{-1} (0.87 g, 12.13 g, 42.69 g, 46.95

g, respectively) was observed from M_5 (No Fungicides/bactericides, but all other managements), which was closely followed (0.85 g, 13.81 g, 42.08 g, 44.87 g, respectively) by M_6 (recommended managements), while the lowest matter content hill^{-1} (0.14 g, 1.13 g, 3.04 g and 4.55 g, respectively) was recorded from M_0 (no management) (Fig. 8).

Table 8. Interaction effect of variety and agronomic managements on plant dry weight of *Boro* rice

Treatments	Plant dry weight (g hill^{-1}) at			
	20 DAT	45 DAT	70 DAT	Harvest
V_1M_0	0.6	2.76 e	7.66 d	13.11 m
V_1M_1	0.58	3.90 de	19.41 a-d	29.25 fg
V_1M_2	0.88	8.12 cd	11.89 cd	17.13 kl
V_1M_3	0.54	8.53 bcd	25.52 a-d	39.6 c
V_1M_4	0.59	7.72 cde	23.12 a-d	24.99 hi
V_1M_5	0.95	10.45 abc	42.99 a	58.87 a
V_1M_6	0.81	13.61 ab	26.15 a-d	37.29 cd
V_2M_0	0.68	3.86 de	8.09 a	8.99 n
V_2M_1	0.68	4.31 de	18.83 a-d	23.45 ij
V_2M_2	1.06	6.89 cde	16.76 cd	20.25 jk
V_2M_3	0.68	9.68 abc	32.64 abc	27.83 gh
V_2M_4	1.05	11.97 abc	40.84 ab	48.14 b
V_2M_5	0.79	13.81 a	42.38 a	35.03 de
V_2M_6	0.89	14.01 a	34.02 abc	32.44 ef
SE	0.125	1.186	5.62	3.595
CV (%)	41.18	35.43	57.31	39.85

In a column mean values having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

V_1: BRRI dhan84, V_2: BRRI hybriddhan5
M_0: No management, M_1: No weeding, but all other managements, M_2: No fertilizer application, but all other managements, M_3: No Irrigation in reproductive and; ripening stage, but all other managements, M_4: No Insecticides, but all other managements, M_5: No Fungicides/bactericides, but all other managements, M_6: Complete Managements

Interaction effect of variety and agronomic managements showed statistically differences on dry matter content hill^{-1} at 20, 45, 70 DAT and at harvest (Appendix VII). At 20, 45, 70 DAT and at harvest, the highest dry matter content hill^{-1} (0.95 g, 10.45 g, 42.99 g, 58.88 g, respectively) was observed from V_1M_5 (BRRI dhan84

+ No Fungicides/bactericides, but all other managements), while the lowest (0.60 g, 2.77 g 7.66 g, 13.11 g, respectively) from V_1M_0 (BRRI dhan84 + no management) (Table 8).

4.2.5 Number of effective tillers hill^{-1}

Number of effective tillers hill^{-1} at harvest varied numerically for BRRI dhan84 and BRRI hybriddhan5 under the present trial (Appendix VIII). The higher number of effective tillers hill^{-1} (10.83) was recorded from V_1 (BRRI dhan84), whereas the lower number (7.33) from V_2 (BRRI hybriddhan5) (Table 9).

Different agronomic managements showed significant differences on number of effective tillers hill^{-1} at harvest (Appendix VIII). The highest number of effective tillers hill^{-1} (10.90) was observed from M_4 (No Insecticides, but all other managements) followed by M_3, M_5, M_6 while the lowest number (5.60) was recorded from M_0 (no management) which was closely followed (7.27) by M_2 (no fertilizer) (Table 9).

Interaction effect of variety and agronomic managements showed significant differences on number of effective tillers hill^{-1} at harvest (Appendix VIII). The highest number of effective tillers hill^{-1} (14.00) was observed from V_1M_4 (BRRI dhan84 + No Insecticides, but all other managements), while the lowest (3.65) from V_2M_0 (BRRI hybriddhan5 + no management) followed (5.73) by V_2M_2 (BRRI hybriddhan5 + No fertilizer application, but all other managements) (Table 10).

4.2.6 Number of non-effective tillers hill^{-1}

Number of non-effective tillers hill^{-1} at harvest varied numerically for BRRI dhan84 and BRRI hybriddhan5 under the present trial (Appendix VIII). The higher number of non-effective tillers hill^{-1} (0.54) was recorded from V_2 (BRRI hybriddhan5), whereas the lower number (0.26) from V_1 (BRRI dhan84) (Table 9).

Table 9. Effect of variety and agronomic managements on number of total tillers, effective tillers and non-effective tillers hill^{-1} and panicle length of *Boro* rice

Treatments	Number of effective tillers hill^{-1}	Number of non-effective tillers hill^{-1}	Total tillers hill^{-1}	Panicle length (cm)
Variety				
V_1	10.83 a	0.26 b	11.09 a	25.91a
V_2	7.33 b	0.54 a	7.88 a	24.36a
SE	0.44	0.02	0.55	1.59
CV (%)	3.87	4.63	3.75	20.49
Agronomic managements				
M_0	5.60 d	0.17 a	5.77 d	22.43b
M_1	8.20 bc	0.50 a	8.70 bd	24.68b
M_2	7.27 cd	0.50 a	7.77 cd	24.04b
M_3	10.90 a	0.37 a	11.27 ab	24.77b
M_4	10.90 a	0.53 a	11.43 a	25.94ab
M_5	9.90 b	0.40 a	10.30 ab	28.65a
M_6	10.80 a	0.33 a	11.13 ab	25.44ab
SE	0.59	0.09	0.60	0.87
CV (%)	4.21	14.58	4.06	12.45

In a column mean values having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

V_1: BRRI dhan84, V_2: BRRI hybriddhan5; M_0: No management, M_1: No weeding, but all other managements, M_2: No fertilizer application, but all other managements, M_3: No Irrigation in reproductive and; ripening stage, but all other managements, M_4: No Insecticides, but all other managements, M_5: No Fungicides/bactericides, but all other managements, M_6: Complete Managements

Different agronomic managements showed numerically differences on number of non-effective tillers hill^{-1} at harvest (Appendix VIII). The highest number of non-effective tillers hill^{-1} (0.53) was observed from M_4 (No Insecticides, but all other managements), while the lowest number (0.17) was recorded from M_0 (no management) (Table 9).

Interaction effect of variety and agronomic managements showed significant differences on number of non-effective tillers hill^{-1} at harvest (Appendix VIII). The highest number of non-effective tillers hill^{-1} (1.00) was observed from V_2M_4 (BRRI dhan84 + No Insecticides, but all other managements), while the lowest (0.07) from V_2M_0 (BRRI hybriddhan5 + no management) that was similar to V_1M_4 (0.07), V_1M_5 (0.13) and V_1M_6 (0.13) (Table 10).

Table 10. Interaction effect of variety and agronomic managements on number of total tillers, effective tillers and non-effective hill^{-1}and panicle length of *Boro* rice

Treatments	Number of effective tillers hill^{-1}	Number of non-effective tillers hill^{-1}	Total tillers hill^{-1}	Panicle length (cm)
V_1M_0	7.53 de	0.02 cde	7.80 ef	22.86 b
V_1M_1	8.93 cd	0.60 bc	9.53 de	24.98 b
V_1M_2	8.80 cd	0.40 b-e	9.20 de	23.76 b
V_1M_3	12.33 ab	0.20 de	12.53 abc	25.02 b
V_1M_4	14.00 a	0.07 e	14.07 a	26.37 b
V_1M_5	11.20 bc	0.13 e	11.33 bcd	32.52 a
V_1M_6	13.00 ab	0.13 e	13.13 ab	25.86 b
V_2M_0	3.67 f	0.07 e	3.73 h	21.99 b
V_2M_1	7.47 de	0.40 b-e	7.87 ef	24.39 b
V_2M_2	5.73 ef	0.6 bc	6.33 fg	24.31 b
V_2M_3	9.47 cd	0.53 bcd	10.00 cde	24.52 b
V_2M_4	7.80 de	1.00 a	8.80 def	25.50 b
V_2M_5	8.60 d	0.67 ab	9.33 de	24.79 b
V_2M_6	8.60 d	0.53 bcd	9.13 de	25.02 b
SE	0.95	0.09	0.6	0.87
CV (%)	4.21	14.58	4.06	12.45

In a column mean values having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

V_1: BRRI dhan84, V_2: BRRI hybriddhan5
M_0: No management, M_1: No weeding, but all other managements, M_2: No fertilizer application, but all other managements, M_3: No Irrigation in reproductive and; ripening stage, but all other managements, M_4: No Insecticides, but all other managements, M_5: No Fungicides/bactericides, but all other managements, M_6: Complete Managements

4.2.7 Number of total tillers hill^{-1}

Number of total tillers hill^{-1} varied numerically for BRRI dhan84 and BRRI hybriddhan5 under the present trial (Appendix VIII). The higher number of total tillers hill^{-1} (11.09) was recorded from V_1 (BRRI dhan84), whereas the lower number (7.88) from V_2 (BRRI hybriddhan5) (Table 9). Hossain and Alam (1991) reported that growth characters like total tillers hill^{-1} differed significantly among BR3, BR11, Pajam and Jaguli varieties in *Boro* season.

Different agronomic managements showed significant differences on number of total tillers hill^{-1} (Appendix VIII). The highest number of total tillers hill^{-1} (11.43) was observed from M_4 (No Insecticides, but all other managements) followed by M_3, M_5 M_6, whereas the lowest number (5.77) was recorded from M_0 (no management) followed by M_1, M_2 (Table 9).

Interaction effect of variety and agronomic managements showed statistically differences on number of total tillers hill^{-1} (Appendix VIII). The highest number of total tillers hill^{-1} (14.07) was observed from V_1M_4 (BRRI dhan84 + No Insecticides, but all other managements), that was closely followed by V_1M_3, V_1M_6 while the lowest (7.80) from V_1M_0 (BRRI hybriddhan5 + no management) (Table 10).

4.2.8 Length of panicle

Length of panicle varied numerically for BRRI dhan84 and BRRI hybriddhan5 under the present trial (Appendix VIII). The longer panicle (25.91 cm) was recorded from V_1 (BRRI dhan84), whereas the shorter (24.36 cm) from V_2 (BRRI hybriddhan5) (Table 9). BINA (1993) evaluated the performance of four varieties Iratom 24, BR14, Binadhan13 and Binadhan19 and found that varieties differed significantly on panicle length.

Different agronomic managements showed significant differences on panicle length (Appendix VIII). The longest panicle (28.65 cm) was observed from M_5 (No Fungicides/bactericides, but all other managements), which was statistically similar (25.94 cm) to M_4 (no irrigation) followed (25.44 cm) by M_6 (Complete Managements), whereas the shortest (24.03 cm) was recorded from M_2 (No fertilizer application, but all other managements) (Table 9).

Interaction effect of variety and agronomic managements showed statistically differences on panicle length (Appendix VIII). The longest panicle (32.52 cm) was observed from V_1M_5 (BRRI dhan84 + No Fungicides/bactericides, but all other managements), while the shortest (21.99 cm) from V_2M_0 (BRRI hybriddhan5 + no management) (Table 10).

4.2.9 Number of filled grains panicle^{-1}

Number of filled grains panicle^{-1} varied numerically for BRRI dhan84 and BRRI hybriddhan5 under the present trial (Appendix IX). The higher number of filled grains panicle^{-1} (161.24) was recorded from V_2 (BRRI hybriddhan5), whereas the lower number (123.81) from V_1 (BRRI dhan84) (Table 11). Ahmed *et al.* (1997) found that percent filled grain was the highest in Nizersail followed by BR25 and the lowest in BR11 and BR23.

Different agronomic managements showed significant differences on number of filled grains panicle^{-1} (Appendix IX). The highest number of filled grains panicle^{-1} (165.17) was observed from M_4 (No Insecticides, but all other managements), which was statistically similar to (155.50) by M_5 (No Fungicides/bactericides, but all other managements) and (160.67) by M_6 (Complete Managements) while the lowest number (101.17) was recorded from M_0 (no management) (Table 11).

Interaction effect of variety and agronomic managements showed significant differences on number of filled grains panicle^{-1} (Appendix IX). The highest number of filled grains panicle^{-1} (74.67) was observed from V_2M_4 (BRRI hybriddhan5 + No Insecticides, but all other managements) that similar to V_2M_6 (BRRI dhan84 + complete management) and V_2M_6 (176.00), while the lowest (93.00) from V_1M_0 (BRRI dhan84 + no management) that similar to V_1M_2 (98.00), V_1M_3 (123.67) and V_2M_1 (109.33) (Table 12).

4.2.10 Number of unfilled grains panicle^{-1}

Number of unfilled grains panicle^{-1} varied numerically for BRRI dhan84 and BRRI hybriddhan5 under the present trial (Appendix IX). The higher number of unfilled grains panicle^{-1} was recorded (26.00) from V_1 (BRRI dhan84), whereas the lower number (16.29) from V_2 (BRRI hybriddhan5) (Table 11). BINA (1993) evaluated the performance of four varieties Iratom24, BR14, Binadhan13 and Binadhan19 and found that varieties differed significantly on sterile spikelets panicle^{-1}.

Different agronomic managements showed significant differences on number of unfilled grains panicle^{-1} (Appendix IX). The highest number of unfilled grains panicle^{-1} (28.17) was observed from M_5 (No Fungicides/bactericides, but all other managements), which was closely followed by M_4, M_6, while the lowest number (8.50) was recorded from M_0 (no management) followed (15.17) by M_1 (No weeding, but all other managements) (Table 11).

Table 11. Effect of variety and agronomic managements on number of grains panicle^{-1} and weight of 1000 grains of *Boro* rice

Treatments	Number of filled grains panicle^{-1}	Number of unfilled grains panicle^{-1}	Number of total grains panicle^{-1}	Weight of 1000 grains (g)
Variety				
V1	123.81	26.00	149.81	21.71b
V2	161.24	16.29	177.52	31.10a
$LSD_{(0.05)}$	51.86	14.64	44.59	1.41
SE	12.05	3.40	10.36	0.33
CV (%)	27.40	52.13	20.52	4.03
Agronomic Managements				
M0	101.17c	8.50d	61.67d	25.68b
M1	146.50ab	15.17cd	109.67c	25.70b
M2	125.50bc	20.50bc	146.00b	25.88b
M3	143.17ab	26.17ab	169.33ab	26.01ab
M4	165.17a	22.67ab	187.00a	26.14ab
M5	155.50a	28.17a	183.67a	26.57ab
M6	160.67a	26.83ab	187.83a	26.70a
SE	8.12	2.22	6.47	0.37
CV (%)	14.55	26.83	12.80	3.61

In a column mean values having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

V_1: BRRI dhan84, V_2: BRRI hybriddhan5
M_0: No management, M_1: No weeding, but all other managements, M_2: No fertilizer application, but all other managements, M_3: No Irrigation in reproductive and; ripening stage, but all other managements, M_4: No Insecticides, but all other managements, M_5: No Fungicides/bactericides, but all other managements, M_6: Complete Managements

Table 12. Interaction effect of variety and agronomic managements on number of filled, unfilled, total grains panicle^{-1} and weight of 1000 grains of *Boro* rice

Treatments	Number of filled grains panicle^{-1}	Number of unfilled grains panicle^{-1}	Number of total grains panicle^{-1}	Weight of 1000 grains (g)
V_1M_0	93.00f	7.67f	100.67e	20.17d
V_1M_1	134.67cde	15.67def	150.33d	23.55c
V_1M_2	98.00f	20.00cd	118.00e	21.60d
V_1M_3	123.67def	36.33ab	160.00d	21.65d
V_1M_4	143.00bcde	27.33bc	170.33cd	23.62c
V_1M_5	135.00cde	39.33a	174.33bcd	23.66c
V_1M_6	139.33cde	35.67ab	175.00bcd	23.75c
V_2M_0	109.33ef	9.33ef	118.67e	30.18b
V_2M_1	158.33abcd	14.67def	173.00bcd	30.60ab
V_2M_2	153.00abcd	21.00cd	174.00bcd	30.16b
V_2M_3	162.67abc	16.00def	178.67abc	31.45ab
V_2M_4	187.33a	18.00cde	200.00ab	31.88a
V_2M_5	176.00ab	17.00def	193.00abc	31.47ab
V_2M_6	182.00a	18.00cde	205.33a	31.97a
SE	8.12	2.22	6.47	0.37
CV (%)	14.55	26.83	12.80	3.61

In a column mean values having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

V_1: BRRI dhan84, V_2: BRRI hybriddhan5
M_0: No management, M_1: No weeding, but all other managements, M_2: No fertilizer application, but all other managements, M_3: No Irrigation in reproductive and; ripening stage, but all other managements, M_4: No Insecticides, but all other managements, M_5: No Fungicides/bactericides, but all other managements, M_6: Complete Managements

Interaction effect of variety and agronomic management showed significant differences on number of unfilled grains panicle^{-1} (Appendix IX). The highest number of unfilled grains panicle^{-1} (39.33) was observed from V_1M_5 (BRRI dhan84 + No Fungicides/bactericides, but all other managements) that similar to V_1M_6 (35.67), while the lowest number (7.65) from V_1M_0 (BRRI dhan84+ No managements) that similar to V_1M_1, V_2M_1, V_2M_3, V_2M_5 (Table 12).

4.2.11 Number of total grains panicle^{-1}

Number of total grains panicle^{-1} varied numerically for BRRI dhan84 and BRRI hybriddhan5 under the present trial (Appendix IX). The higher number of total grains panicle^{-1} (177.52) was recorded from V_2 (BRRI hybriddhan5), whereas the lower number (149.81) from V_1 (BRRI dhan84) (Table 11).

Different agronomic managements showed significant differences on number of total grains panicle^{-1} (Appendix IX). The highest number of total grains panicle^{-1} (187.83) was observed from M_6 (recommended management), which was similar to M_4 (187.00) and M_5 (183.67) (no irrigation), while the lowest number (61.67) was recorded from M_0 (no management) (Table 11).

Interaction effect of variety and agronomic managements showed significant differences on number of total grains panicle^{-1} (Appendix IX). The highest number of total grains panicle^{-1} (205.33) was observed from V_2M_6 (BRRI hybriddhan5 + recommended management) that similar to V_2M_4 (200.00) and V_2M_5 (193.00), while the lowest (100.67) from V_1M_0 (BRRI dhan84 + no management) that similar to V_1M_2 (118.00) and V_2M_0 (118.67) (Table 12).

4.2.12 Weight of 1000 grains

Weight of 1000 grains was not varied significantly for BRRI dhan84 and BRRI hybriddhan5 under the present trial (Appendix IX). The higher weight of 1000 grains (31.10 g) was recorded from V_2 (BRRI hybriddhan5), whereas the lower weight (21.71 g) from V_1 (BRRI dhan84) (Table 11).

Different agronomic managements showed significant differences on weight of 1000 grains (Appendix IX). The highest weight of 1000 grains (26.70 g) was observed from M_6 (recommended management), which was similar to M_5 (26.57 g), M_4 (26.14 g), M_3 (26.01 g) while the lowest weight (25.68 g) was recorded from M_0 (no management) (Table 11).

Interaction effect of variety and agronomic managements showed significant differences on weight of 1000 grains (Appendix IX). The highest weight of 1000 seeds (31.97 g) was observed from V_2M_6 (BRRI hybriddhan5 + recommended management) that similar to V_2M_4 (31.88 g), while the lowest weight (20.17 g) from V_1M_0 (BRRI dhan84 + no management) that similar to V_1M_2 (21.60 g), V_1M_3 (21.65 g) (Table 12).

4.2.13 Grain yield

Grain yield was not varied significantly for BRRI dhan84 and BRRI hybriddhan5 under the present trial but varied numerically (Appendix X). The higher grain yield (5.36 t ha^{-1}) was recorded from V_2 (BRRI hybriddhan5), whereas the lower yield (4.31 t ha^{-1}) from V_1 (BRRI dhan84) (Table 13). Molla (2001) reported that Pro-Agro6201 (hybrid) had a significant higher yield than IET4786 (HYV), due to more mature panicles m^{-2}, higher number of filled grains $panicle^{-1}$ and greater seed weight.

Different agronomic managements showed significant differences on grain yield (Appendix X). The highest grain yield (6.70 t ha^{-1}) was observed from M_6 (recommended management), which was similar to M_5 (6.69 t ha^{-1}), M_4 (6.02), M_3 (6.28), while the lowest grain yield (1.68 t ha^{-1}) was recorded from M_0 (no management) which was statistically similar to (1.85 t ha^{-1}) by M_1 (no weeding) and M_2 (No irrigation) (Table 13). No management reduced 74% grain yield of *Boro* rice that followed by 72% for no weeding and 70% for no fertilizer application. No irrigation reduced 6 % yield that might be due to the contribution of rainfall during the growing period. Baloch *et al*. (2006) obtained the maximum paddy yield in hand weeding, closely followed by Butachlor (Machete 60EC during both cropping seasons. Singh *et al*. (1999) reported that no weed management until maturity removed significantly higher amount of nitrogen through weeds (12.97 kg ha^{-1}) and reduced the grain yield of rice by 49% compared to that of weed free crop up to 60 DAT.

Interaction effect of variety and agronomic managements showed significant differences on grain yield (Appendix X). The highest grain yield (7.35 t ha^{-1}) was observed from V_2M_6 (BRRI hybriddhan5 + recommended management) which was similar to(7.33 t ha^{-1}) V_2M_5, V_2M_4, V_2M_3, V_1M_6, V_1M, and V_1M_4 while the lowest yield (1.00 t ha^{-1}) from V_1M_0 (BRRI dhan84 + no management) which similar to (1.51 t ha^{-1}) V_2M_0 (BRRI hybriddhan5 + no management), (1.85 t ha^{-1}) V_1M_2 (Table 14).

4.2.14 Straw yield

Straw yield varied numerically for BRRI dhan84 and BRRI hybriddhan5 under the present trial (Appendix X). The higher straw yield (5.22 t ha^{-1}) was recorded from V_1 (BRRI dhan84), whereas the lower yield (4.97 t ha^{-1}) from V_2 (BRRI hybriddhan5) (Table 13). Xu and Wang (2001) evaluated with ten restorer and ten maintainer lines and observed that the restorer lines showed more straw yield than maintainer lines.

Table 13. Effect of variety and agronomic managements on yields and harvest index of *Boro* rice

Treatments	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
Variety				
V1	4.31	5.22	9.85	45.41
V2	5.36	4.97	10.01	48.62
SE	0.37	0.22	0.63	5.08
CV (%)	24.69	9.31	20.64	34.99
Agronomic Managements				
M0	1.68b	2.22 c	3.90 c	43.02 b
M1	1.85b	4.02 bc	8.57 b	52.15 ab
M2	1.98b	4.31 bc	6.29 bc	29.52 c
M3	6.28a	6.50 a	12.78 a	49.20 ab
M4	6.02a	6.55 a	12.57 a	49.78 ab
M5	6.69a	5.47 ab	12.16 a	55.16 a
M6	6.70a	6.53 a	13.23 a	50.26 ab
SE	0.28	0.50	0.64	2.77
CV (%)	20.73	31.94	20.92	19.09

In a column mean values having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

V_1: BRRI dhan84, V_2: BRRI hybriddhan5
M_0: No management, M_1: No weeding, but all other managements, M_2: No fertilizer application, but all other managements, M_3: No Irrigation in reproductive and; ripening stage, but all other managements, M_4: No Insecticides, but all other managements, M_5: No Fungicides/bactericides, but all other managements, M_6: Complete Managements

Different agronomic managements showed significant differences on straw yield (Appendix X). The highest straw yield (6.55 t ha^{-1}) was observed from M_4 (No Insecticides, but all other management), which was similar to (6.53 t ha^{-1}) by M_6

(Complete Management) and (6.50 t ha^{-1}) by M_3 (No Irrigation in reproductive and ripening stage, but all other management), while the lowest straw yield (2.22 t ha^{-1}) was recorded from M_0 (no management) which was similar to (4.02 t ha^{-1}) M_1 (no weeding) (Table 13). Moorthy and DAT (1992) stated that the paddy wheel hoe use twice resulted in the greatest straw yields (3.54 t ha^{-1}) and the finger weeder used twice resulted in the greatest straw yields (3.54 t ha^{-1}) but the paddy wheel hoe used gave twice higher straw yield (4.68 t ha^{-1}).

Table 14. Interaction effect of variety and weed managements on grain, straw and biological yield and harvest index of *Boro* rice

Treatments	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
V_1M_0	1.00f	2.36 ef	4.35 ef	44.34 ab
V_1M_1	3.71cd	3.62 def	7.92 cd	53.84 a
V_1M_2	1.85ef	4.77 bcd	5.81 def	17.99 c
V_1M_3	5.53b	6.36 abc	12.52 a	49.13 ab
V_1M_4	5.67ab	7.37 a	13.24 a	47.41 ab
V_1M_5	6.05ab	5.21 bcd	11.62 ab	55.62 a
V_1M_6	6.34ab	6.87 ab	13.50 a	49.50 ab
V_2M_0	1.51ef	2.07 f	3.44 f	41.69 b
V_2M_1	3.39cd	4.43 cd	9.22 bc	50.46 ab
V_2M_2	2.97de	3.85 def	6.78 cde	41.04 b
V_2M_3	7.04ab	6.64 ab	13.04 a	49.26 ab
V_2M_4	6.36ab	5.74 bcd	11.90 ab	52.15 ab
V_2M_5	7.33a	5.73 bcd	12.70 a	54.69 a
V_2M_6	7.35a	6.34 abc	12.96 a	51.02 ab
SE	0.39	0.50	0.64	2.77
CV (%)	20.73	31.94	20.92	19.09

In a column mean values having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

V_1: BRRI dhan84, V_2: BRRI hybriddhan5; M_0: No management, M_1: No weeding, but all other managements, M_2: No fertilizer application, but all other managements, M_3: No Irrigation in reproductive and; ripening stage, but all other managements, M_4: No Insecticides, but all other managements, M_5: No Fungicides/bactericides, but all other managements, M_6: Complete Managements

Interaction effect of variety and agronomic managements showed significant differences on straw yield (Appendix X). The highest straw yield (7.37 t ha^{-1}) was observed from V_1M_4 (BRRI dhan84 + No Insecticides, but all other managements) that similar to (6.87 t ha^{-1}) V_1M_6 (BRRI dhan84+ complete management), while the lowest yield (2.07 t ha^{-1}) from V_2M_0 (BRRI hybriddhan5 + no management) that similar to (2.36 t ha^{-1}) V_1M_0 (BRRI dhan84 + no management) (Table 14).

4.2.15 Biological yield

Biological yield per hectare varied numerically for BRRI dhan84 and BRRI hybriddhan5 under the present trial (Appendix X). The higher biological yield (10.01 t ha^{-1}) was recorded from V_2 (BRRI hybriddhan5), whereas the lower yield (9.85 t ha^{-1}) from V_1 (BRRI dhan84) (Table 13).

Different agronomic managements showed significant differences on biological yield per hectare (Appendix X). The highest biological yield (13.23 t ha^{-1}) was observed from M_6 (recommended management), which was similar to (12.78) M_3 (No Irrigation in reproductive and ripening stage, but all other management) and (12.57) M_4 (No Insecticides, but all other management), while the lowest biological yield (3.90 t ha^{-1}) was recorded from M_0 (no management) which was similar to (6.29 t ha^{-1}) M_2 (no fertilizer application), respectively (Table 13).

Interaction effect of variety and agronomic managements showed significant differences on biological yield (Appendix X). The highest biological yield (13.24 t ha^{-1}) was observed from V_1M_4 (BRRI dhan84 + No Insecticides, but all other managements) which is similar to (13.52 t ha^{-1}) V_1M_3 , (13.50 t ha^{-1}) V_1M_6 , (13.04 t ha^{-1}) V_2M_3 , (12.70 t ha^{-1}) V_2M_5 , (12.96 t ha^{-1}) V_2M_6, while the lowest yield (3.44 t ha^{-1}) from V_2M_0 (BRRI hybriddhan5 + no management) (Table 14).

4.2.16 Harvest index

Harvest index varied significantly for BRRI dhan84 and BRRI hybriddhan5 under the present trial (Appendix X). The maximum harvest index (48.62%) was recorded from V_2 (BRRI hybriddhan5), whereas the minimum (45.91%) from V_1 (BRRI dhan84) (Table 13).

Different agronomic managements showed significant differences on harvest index (Appendix X). The maximum harvest index (55.16%) was observed from M_5 (No Fungicides/bactericides, but all other managements), which was statistically similar (50.26%) by M_6 (Complete Managements), while the minimum harvest index (29.52%) was recorded from M_2 (no fertilizer) (Table 13).

Interaction effect of variety and agronomic managements showed significant differences on harvest index (Appendix X). The maximum harvest index (55.62%) was observed from V_1M_5 (BRRI dhan84 + No Fungicides/bactericides, but all other managements) that similar to V_2M_5 (54.69%) and V_1M_1 (53.84%), while the minimum (17.99%) from V_1M_2 (BRRI dhan84 + No fertilizer application, but all other managements) (Table 14).

CHAPTER V
SUMMARY AND CONCLUSION

The experiment was conducted in the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from December 2018 to April 2019 to study the growth and yield of *Boro* rice as affected by agronomic managements. The experiment comprised as two factors. Factor A: Variety: 2 levels; BRRI dhan84-V_1; BRRI hybriddhan5-V_2; Factor B: Agronomic management: 7 levels; No management-M_0; No weeding, but all other managements -M_1; No fertilizer application, but all other managements-M_2; Irrigation in reproductive & ripening stage, but all other managements-M_3, No Insecticides, but all other managements-M_4, No Fungicides/bactericides, but all other managements-M_5, Complete Managements (recommended)-M_6. The experiment was laid out in Split plot design with three replications having variety in the main plot and agronomic managements in sub-plots. Significant variation was recorded for data on weed population, dry weight of weed, different yield contributing characters and yield of *Boro* rice.

Weed data were recorded at 65 DAT, it was found that the higher numbers of weeds (55.48 m^{-2}) were found in the BRRI hybriddhan5 cultivated plot whereas the lower number (42.52 m^{-2}) was found in BRRI dhan65. The maximum weight of weed biomass (27.10 g m^{-2}) was found in the BRRI dhan84 cultivated plots, whereas the lower weight (22.43 g m^{-2}) was found in BRRI hybriddhan5.

The lowest weed population (13.83 m^{-2}) was recorded in M_4, while the highest weed population (144.83 m^{-2}) was found in the M_0. The lowest weight of weed biomass (2.81 g m^{-2}) was recorded in M6, while the highest weight (77.17 g m^{-2}) was found in the M_1 plot.

The maximum (177.00 m^{-2}) weed population was observed in V_2M_0 and the lowest (9.33 m^{-2}) population observed in V_1M_6. The maximum (110.61 g m^{-2}) weed biomass was observed in V_1M_1 and lowest weight (2.09 g m^{-2}) observed in V_1M_5.

At 20, 45, 70 DAT and harvest the taller plant (24.81 cm, 51.56 cm, 86.71 cm and 119.21 cm, respectively) was recorded from V_2, whereas the shorter plant (25.28

cm, 49.53 cm, 79.61 cm and 104.08 cm) from V_1.

At 45 and 70 DAT the higher number of tillers hill^{-1} (11.85, and 13.82, respectively) was recorded from V_1, whereas the lower number (7.56, 9.76, respectively) from V_2. At 20, 45 and 70 DAT, the higher leaf area index (0.09, 3.3, 6.9, respectively) was recorded from V_1, whereas the lower (0.1, 2.35, 6.44, respectively) from V_2. At 20, 45, 70 DAT and harvest the higher dry matter weight hill^{-1} (00.83 g, 9.22 g, 27.65 g, 28.02 g, respectively) was recorded from V_2, whereas the lower (0.71 g, 7.87 g, 22.39 g, 30.47 g respectively) from V_1. The higher number of effective tillers hill^{-1} (10.83) was recorded from V_1, whereas the lower number (7.33) from V_2. The higher number of non-effective tillers hill^{-1} (0.54) was recorded from V_2, whereas the lower number (0.26) from V_1. The higher number of total tillers hill^{-1} (10.09) was recorded from V_1, whereas the lower number (7.88) from V_2. The longer panicle (25.91cm) was recorded from V_1, whereas the shorter (24.36 cm) from V_2. The higher number of filled grains panicle^{-1} (161.24) was recorded from V_2, whereas the lower number (123.81) from V_1. The lower number of unfilled grains panicle^{-1} was recorded (26.00) from V_1, whereas the higher number (16.29) from V_2. The higher number of total grains panicle^{-1} (177.52) was recorded from V_2, whereas the lower number (149.81) from V_1. The higher weight of 1000 grains (31.10g) was recorded from V_2, whereas the lower weight (21.71g) from V_1. The higher grain yield (5.36 t ha^{-1}) was recorded from V_2, whereas the lower yield (4.31 t ha^{-1}) from V_1. The higher straw yield (5.22 t ha^{-1}) was recorded from V_1, whereas the lower yield (4.97 t ha^{-1}) from V_2. The higher biological yield (10.01 t ha^{-1}) was recorded from V_2, whereas the lower yield (9.85 t ha^{-1}) from V_1. The maximum harvest index (48.62%) was recorded from V_2, whereas the minimum (45.41%) from V_1.

At 20, 45, 70 DAT and at harvest, the tallest plant (25.65 cm, 53.713 cm, 87.26 cm, 118.15 cm, respectively) was observed from M_6, while the shortest plant (22.73 cm, 39.76 cm, 66.95 cm, 93.88 cm, respectively) from M_0. At 45, 70 DAT, the highest number of tillers hill^{-1} (12.73, 16.06 respectively) was observed from M_6, while the lowest number (11.33, 14.83, respectively) from M_0. At 20, 45, 70 DAT, the highest leaf area index (0.11, 3.43, 9.40, 9.00, respectively) was observed from M_6, while the lowest leaf area index (0.09, 1.30, 1.67, 2.08, respectively) was recorded from M_0. At 20, 45, 70 DAT and at harvest, the highest dry matter weight hill^{-1} (0.87 g, 12.13 g, 42.69 g, 46.95 g, respectively) was observed from M_5, while the lowest matter weight hill^{-1} (0.14 g, 1.13 g, 3.04 g and 4.55 g, respectively) was recorded from M_0. The highest number of effective tillers hill^{-1} (10.90) was observed from $M_{4,}$ which, while the lowest number (5.60) was recorded from M_0. The highest number of non-effective tillers hill^{-1} (0.53) was observed from M_4, while the lowest number (0.17) was recorded from M_0. The highest number of total tillers hill^{-1} (11.43) was observed from M_4, whereas the lowest number (5.77) was recorded from M_0. The longest panicle (28.65 cm) was observed from M_5, whereas the shortest (22.43 cm) was recorded from M_0. The highest number of filled grains panicle^{-1} (165.17) was observed from M_4, while the lowest number (101.17) was recorded from M_0. The highest number of unfilled grains panicle^{-1} (28.17) was observed from M_5, while the highest number (8.50) was recorded from M_0. The highest number of total grains panicle^{-1} (187.83) was observed from M_6, while the lowest number (61.67) was recorded from M_0. The highest weight of 1000 grains (26.70 g) was observed from M_6, while the lowest weight (25.68 g) was recorded from M_0. The highest grain yield (6.70 t ha^{-1}) was observed from M_6, while the lowest grain yield (1.68 t ha^{-1}) was recorded from M_0. No management reduced 74% yield of *Boro* rice whereas the reduction was 72, 70 and 6% for no weeding, no fertilizer and no irrigation, respectively. The highest straw yield (6.55 t ha^{-1}) was observed from M_4, while the lowest straw yield (2.22 t ha^{-1}) was recorded from M_0. The highest biological yield (13.23 t ha^{-1}) was observed from M_6, while the lowest biological yield (3.90 t ha^{-1}) was recorded from M_0. The maximum harvest index (55.16%) was observed from M_5, while the minimum harvest index (29.52%) was recorded from M_2.

At 20, 45, 70 DAT and at harvest the tallest plant (25.89 cm, 55.6cm, 89.32 cm and 127.4 cm, respectively) was observed from V_1M_6, while the shortest (22.92 cm, 36.93 cm, 61.28 cm and 90.6 cm, respectively) from V_1M_0. At 45, 70 DAT, the highest number of tillers hill^{-1} (17.2, 19.67, respectively) was observed from V_1M_6, while the lowest (3.67, 3.93, respectively) from V_2M_0. At 20, 45, 70 DAT and at harvest the highest leaf area index (0.12, 4.15, 9.84, 10.98, respectively) was observed from V_1M_6, while the lowest (0.09, 0.87, 1.22, 1.21, respectively) from V_2M_0. At 20, 45, 70 DAT and at harvest, the highest dry matter content hill^{-1} (0.95 g, 10.45 g, 42.99 g, 58.88 g, respectively) was observed from V_1M_5, while the lowest (0.60 g, 2.77 g, 7.66 g, 13.11 g, respectively) from V_1M_0. The highest number of effective tillers hill^{-1} (14.00) was observed from V_1M_4, while the lowest (3.67) from V_2M_0. The highest number of non-effective tillers hill^{-1} (1.00) was observed from V_2M_4, while the lowest (0.07) from V_2M_0. The highest number of total tillers hill^{-1} (14.07) was observed from V_1M_4, while the lowest (3.73) V_2M_0. The longest panicle (32.52 cm) was observed from V_1M_5, while the shortest (21.99 cm) from V_2M_0. The highest number of filled grains panicle^{-1} (187.33) was observed from V_2M_4, while the lowest (93.00) from V_1M_0. The highest number of unfilled grains panicle^{-1} (39.33) was observed from V_1M_5, while the lowest number (7.67) from V_1M_0. The highest number of total grains panicle^{-1} (205.33) was observed from V_2M_6, while the lowest (100.67) from V_1M_0. The highest weight of 1000 grains (31.97 g) was observed from V_2M_6, while the lowest weight (20.17 g) from V_1M_0. The highest grain yield (7.35 t ha^{-1}) was observed from V_2M_6, while the lowest yield (1.00 t ha^{-1}) from V_1M_0.

The highest reduction in BRRI dhan84 was 84% in no management that followed by 80% no fertilizer treatments whereas the rate was 71% for the other variety BRRI hybriddhan5.

The highest straw yield (7.37 t ha^{-1}) was observed from V_1M_4, while the lowest yield (2.07 t ha^{-1}) from V_2M_0. The highest biological yield (13.50 t ha^{-1}) was observed from V_1M_6, while the lowest yield (3.44 t ha^{-1}) from V_2M_0. The maximum harvest index (55.62%) was observed from V_1M_5 while the minimum (17.99%) from V_1M_2.

Considering the facts of the present experiment, further studies in the following areas may be suggested:

1. Such study is needed to conduct in different agro-ecological zones (AEZ) of Bangladesh for regional compliance and other performance.

2. More experiments may be carried out with different variety and agronomic managements.

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APPENDICES

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

A. Morphological characteristics of the experimental field

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

B. Physical and chemical properties of the initial soil

Characteristics	Value
% Sand	27
% Silt	43
% clay	30
Textural class	Silty-clay
pH	5.6
Organic carbon (%)	0.44
Organic matter (%)	0.76
Total N (%)	0.03
Available P (ppm)	20.04
Exchangeable K (me/100 g soil)	0.11
Available S (ppm)	43

Source: SRDI

Appendix II. Monthly record of air temperature, rainfall, relative humidity and Sunshine of the experimental site during the period from March to June 2018

Month (Year 2018)	*Air temperature (°C)		*Relative humidity (%)	*Rain fall (mm) (total)	*Sunshine (hr)
	Maximum	Minimum			
March	31.4	19.6	54	11	8.2
April	33.6	23.6	69	163	6.4
May	32.4	27.2	71	134	7.1
June	35.00	25.00	79	175	10.25

* Monthly average,

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

Appendix III. Analysis of variance of the data on weeds number and dry matter production of *Boro* rice as influenced by variety, agronomic managements at 65 DAS

Source of variation	Degrees of freedom	Mean square	
		Number of weeds in 1.00 m^2 area	Dry matter in 1.00 m^2 area
Replication	**2**	6108.50	397.111
Variety (A)	1	1761.52	229.507
Error (a)	2	1453.02	274.437
Agronomic managements (B)	4	14193.8	4294.10
Interaction (A×B)	4	951.024	1602.92
Error (b)	16	2148.26	699.111

**: Significant at 0.01 level of probability: ^{NS}: Non significant

Appendix IV. Analysis of variance of the data on plant height of *Boro* rice as influenced by variety, agronomic managements and their interaction at different DAS

Source of variation	Degrees of freedom	Mean square			
		Plant height at			
		20 DAT	45DAT	70 DAT	Harvest
Replication	2	16.7515	37.9133	116.011	165.615
Variety (A)	1	2.39048^{NS}	43.0464^{*}	529.731^{**}	2406.20^{**}
Error (a)	2	18.1242	67.7939	55.6406	85.1002
Agronomic managements (B)	4	12.4588^{NS}	291.296^{**}	576.643^{**}	483.353^{**}
Interaction (A×B)	4	8.16177^{NS}	21.4822^{*}	24.4978^{NS}	35.1119^{NS}
Error (b)	16	8.27643	7.71175	25.9392	37.1176

**: Significant at 0.01 level of probability: ^{NS}: Non significant

Appendix V. Analysis of variance of the data on number of tillers hill^{-1} of *Boro* rice as influenced by variety, agronomic managements and their interaction

Source of variation	Degrees of freedom	Mean square			
		Number of tillers hill^{-1} at			
		20 DAT	45DAT	70 DAT	Harvest
Replication	2	0.0038	10.5267	7.57809	0.749524
Variety (A)	1	0.0062^{NS}	193.715**	173.647**	108.161**
Error (a)	2	0.006	14.6581	5.12667	3.20667
Agronomic managements (B)	4	0.01^{NS}	35.5105**	84.1676**	27.7464**
Interaction (A×B)	4	0.032^{NS}	9.60191*	4.91556^{NS}	2.46317^{NS}
Error (b)	16	0.03	2.95238	3.67683	3.75476

**: Significant at 0.01 level of probability: *: Significant at 0.05 level of probability: ^{NS}: Non significant

Appendix VI. Analysis of variance of the data on leaf area index of *Boro* rice as influenced by variety, agronomic managements and their interaction

Source of variation	Degrees of freedom	Mean square			
		leaf area index			
		20 DAS	45DAS	70 DAS	Harvest
Replication	2	0.00111	0.211069	2.48654	9.19915
Variety (A)	1	0.00172^{NS}	9.42252**	1.83687^{NS}	36.5546*
Error (a)	2	0.00106	0.416861	0.341347	24.3069
Agronomic managements (B)	4	0.00106^{NS}	6.45533**	58.5345**	43.4538**
Interaction (A×B)	4	0.00105^{NS}	0.936213^{NS}	2.66776^{NS}	5.19025^{NS}
Error (b)	16	0.00094	0.904493	3.34218	4.86398

**: Significant at 0.01 level of probability: *: Significant at 0.05 level of probability: ^{NS}: Non significant

Appendix VII. Analysis of variance of the data on Stem dry matter hill $^{-1}$ of *Boro* rice as influenced by variety, agronomic managements and their interaction

Source of variation	Degrees of freedom	Mean square			
		Stem dry matter hill^{-1} at			
		20 DAS	45DAS	70 DAS	Harvest
Replication	2	0.0722935	26.3270	76.6104	62.9528
Variety (A)	1	0.168467^{NS}	19.0149^{NS}	290.615^{NS}	8.09821^{NS}
Error (a)	2	0.224172	0.0803375	65.0652	322.974
Agronomic managements (B)	4	0.119700^{NS}	90.7154**	845.870**	901.716**
Interaction (A×B)	4	0.0496958^{NS}	5.24514^{NS}	64.3941^{NS}	313.175^{NS}
Error (b)	16	0.101747	9.17270	205.657	135.836

**: Significant at 0.01 level of probability: ^{NS}: Non significant

Appendix VIII. Analysis of variance of the data on effective, non-effective & total tillers hill^{-1} and length of panicle of *Boro* rice as influenced by variety and agronomic managements and their interaction

Source of variation	Degrees of freedom	Mean square			
		Effective tiller hill^{-1}	Non-effective tiller hill^{-1}	Total tiller hill^{-1}	Length of panicle
Replication	2	2.30	0.18571	3.74762	18.1223
Variety (A)	1	614.24**	4.28572**	540.804**	25.1953^{NS}
Error (a)	2	15.45	0.0428572	16.03334	26.5335
Agronomic managements (B)	4	132.14**	0.488888^{NS}	138.7318**	21.9974^{NS}
Interaction (A×B)	4	17.21^{NS}	1.219048*	12.31588^{NS}	11.5009^{NS}
Error (b)	16	18.26	0.425396	18.7738	9.79984

**: Significant at 0.01 level of probability: *: Significant at 0.05 level of probability:
NS: Not Significant

Appendix IX. Analysis of variance of the data on filled, unfilled & total grains and weight of 1000 grains of *Boro* rice as influenced by variety, agronomic managements and their interaction

Source of variation	Degrees of freedom	Mean square			
		Number of filled grains panicle^{-1}	Number of unfilled grains panicle^{-1}	Number of total grains panicle^{-1}	Weight of 1000 grains
Replication	2	370.167	81.9286	123.024	0.777693
Variety (A)	1	14709.4**	990.857**	8064.86**	926.559**
Error (a)	2	1524.93	121.500	1127.64	1.12988
Agronomic managements (B)	4	3026.69**	305.246**	4816.28**	1.60421^{NS}
Interaction (A×B)	4	258.373^{NS}	163.913**	286.024^{NS}	2.45878*
Error (b)	16	429.770	32.1865	439.056	0.910392

**: Significant at 0.01 level of probability: *: Significant at 0.05 level of probability: ^{NS}: Non significant

Appendix X. Analysis of variance of the data on grain, straw & biological yield and harvest index of *Boro* rice as influenced by variety, agronomic managements and their interaction

Source of variation	Degrees of freedom	Mean square			
		Grain yield	Straw yield	Biological yield	Harvest index
Replication	2	0.763516	2.55647	6.20247	12.3674
Variety (A)	1	11.6499**	0.658753^{NS}	0.246867^{NS}	108.193^{NS}
Error (a)	2	1.42453	0.224867	4.20212	270.518
Agronomic managements (B)	4	28.3265**	16.5540**	82.4291**	437.837**
Interaction (A×B)	4	0.946672^{NS}	1.10770^{NS}	1.70618^{NS}	125.754^{NS}
Error (b)	16	1.00411	2.65032	4.31534	80.5604

**: Significant at 0.01 level of probability: *: Significant at 0.05 level of probability: ^{NS}: Non significant