GROWTH AND YIELD OF *AUS* RICE AS AFFECTED BY AGRONOMIC MANAGEMENTS

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CERTIFICATE

This is to certify that the thesis entitled "GROWTH AND YIELD OF AUS RICE AS AFFECTED BY AGRONOMIC MANAGEMENTS" 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 MD. HASAN MAHMUD, Registration. No. 17-08251 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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The author

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ABSTRACT

The experiment was conducted at the experimental field of Sher-e-Bangla Agricultural University, Dhaka during the period from March to June, 2018 to study the effects of agronomic managements on growth and yield of *Aus* rice. The experiment comprised as two factors having two varieties in the main plots and five agronomic managements in the sub-plots under split-plot design with three replications. Significant variation was recorded for weed severity, different yield contributing characters and yield of *Aus* rice. The lowest weed population (26.67 m^{-2}) and weed dry weight (1.96 g m^{-2}) was recorded in M_4 (recommended management) and M_2 (no fertilizer application), respectively, whereas the highest weed population (520.70 m^{-2}) was found in the M_0 (no management) but the highest dry weight (329.90 g m^{-2}) in M_1 (no weeding) treatment. At 30, 50, 70 DAS and harvest the taller plant (24.61 cm, 41.27 cm, 60.23 cm and 80.28 cm, respectively), grain yield (0.96 t ha^{-1}) and straw yield (2.75 t ha^{-1}) were recorded from V_2 compared to that of V_1. Similarly the tallest plant (27.11 cm, 49.66 cm, 71.49 cm and 91.07 cm at 30, 50, 70 DAS and harvest, respectively), grain yield (2.34 t ha^{-1}) and straw yield (5.30 t ha^{-1}) were observed from M_4. In respect of interaction, the highest grain yield (2.43 t ha^{-1}) and straw yield (5.31 t ha^{-1}) were observed from V_1M_4 (BRRI dhan65 with recommended management), while the lowest grain yield (0.12 t ha^{-1}) from V_1M_0 (BRRI dhan65 with no management) and straw yield (0.85 t ha^{-1}) from V_2M_0 (Nerica with no management). Irrespective of variety, no management reduced 94-95% grain yield of *Aus* rice that was 84-89% for no weeding and no fertilizer application.

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LIST OF ACRONYMS

AEZ	=	Agro-Ecological Zone
AIS	=	Agriculture Information Service
BARC	=	Bangladesh Agricultural Research Council
BINA	=	Bangladesh Institute of Nuclear Agriculture
BRRI	=	Bangladesh Rice Research Institute
CV %	=	Percentage of Coefficient of Variance
cv.	=	Cultivar
DAT	=	Days after transplanting
DAS	=	Days after sowing
DASP	=	Days after spraying
DMRT	=	Duncan's Multiple Range Test
^{o}C	=	Degree Centigrade
cm	=	Centimeter
df	=	Degree of freedom
EC	=	Emulsifiable Concentrate
et al.	=	and others
g	=	Gram
HI	=	Harvest Index
HYV	=	High yielding variety
hr	=	hour
IRRI	=	International Rice Research Institute
kg	=	kilogram
LV	=	Local variety
m	=	Meter
m^2	=	meter squares
ml	=	milliliter
mm	=	Millimeter
MV	=	Modern variety
NS	=	Non significant
%	=	Percent
SAU	=	Sher-e-Bangla Agricultural University
t ha^{-1}	=	Tons per hectare
viz.	=	namely

CHAPTER I
INTRODUCION

Rice (*Oryza sativa* L.) is the most important food in tropical and subtropical regions (Singh *et al*., 2012). It is the staple food of more than three billion people in the world, most of who live in Asia (IRRI, 2009). It is the staple food of not only Bangladesh but also for South Asia (Hien *et al.*, 2006). Rice production and consumption is concentrated in Asia, where more than 90% of all rice is consumed (FAO, 2006). In respect of area and production it ranks fourth among the rice producing countries of the world following China, India and Indonesia (FAO, 2009). 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). In Bangladesh, the geographical, climatic and edaphic conditions are favorable for year round rice cultivation. The slogan "Rice is life" is most appropriate for Bangladesh as this crop plays a vital role in our food security and is a means of livelihood for millions of rural peoples. About 84.67% of cropped area of Bangladesh is used for rice production, with annual production of 30.42 million tons from 10.4 million hectare of land (BBS, 2013). Agriculture in Bangladesh is dominated by intensive rice cultivation covering 80% of arable land. The population of Bangladesh is increasing at an alarming rate and the cultivable land is reducing due to urbanization and industrialization resulting in more shortage of food. As it is not possible to have horizontal expansion of rice area so, rice yield unit^{-1} area should be increased to meet this ever-increasing demand of food. Rice and rice based cropping system have important role in the Eastern Indo Gangetic Plain to increase food production for a rapidly growing population. Rice yields are either decelerating/stagnating/declining in post green revolution era mainly due to imbalance in fertilizer use, soil degradation, irrigation and weeding schedule, type of cropping system practiced lack of suitable rice genotypes/variety for low moisture adaptability and disease resistance (Prakash, 2010). 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).

The production efficiency of rice depends on the favorable climatic conditions particularly temperature, soil moisture level and sunshine hours. The yield and quality of *Aus* rice can possibly be increased by the growers through improved agronomic practices. 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).

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).

Water management has the great impact on the growth and yield of the crop. Water plays a vital role in growth, yield and nutrient uptake of rice plant. Insufficient water vigorously affects the germination of seed, cell division, tillering and nutrient uptake of the plants. Optimum supply of water is one of the most important factors in rice production. Rice plants need adequate moisture throughout of its life cycle. In tropical Asia on average a total of 1245 mm of water required for the complete growth cycle of rice. This total can be split into 40 mm for seedling nursery, 200 mm for land preparation and 1000 mm for satisfying the need during the whole growing period (Sattar, 2004).

Appropriate agronomic management practices greatly influences the growth and yield of rice. Yield loss is occured due to improper weeds, nutrient management and irrigation schedule. Therefore, these managements is a complete package for satisfactory any crop production specially rice production in Bangladesh. Weed free condition during the critical period of competition, recommendation doses of fertilizer application and appropriate amount of water are essential for obtaining optimum rice yield. Subsistence farmers in Bangladesh spend more time and energy on 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 *Aus* season with the following objectives:

i. To determine the yield of *Aus* rice varieties as affected by agronomic management.
ii. To find out individual role of agronomic managements on growth and yield of *Aus* rice.
iii. To study the interaction effect of variety and agronomic managements on performance of *Aus* 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 following headings-

2.1 Effect of irrigation on yield attributes and yield of rice

Parveen *et al.* (2015) conducted field experiment in silty clay soil to evaluate the water productivity and profitability of different rice based cropping sequences during 2006-07 to 2008-09 at the BRRI farm, Gazipur. Three cropping sequences viz T. *Aman*-*Boro*-Fallow, T. *Aman*-Wheat-Mungbean and T. *Aman*-Potato-Mungbean and three water regimes assigned differently for each component crop were evaluated in a split-plot design. Among the cropping sequences, T. *Aman*-Potato-Mungbean with one irrigation at vegetative and two in reproductive stages for T. *Aman* rice, three irrigation each at 20, 40 and 60 DAS for potato and two irrigations for mungbean gave significantly higher rice equivalent yield of 33.40, 22.59 and 28.44 t ha^{-1} in 2006-07, 2007-08 and 2008-09 respectively. The variation in yield equivalence was mostly governed by potato crop grown in *Rabi* season. The maximum water productivity of 23.41, 18.57 and 23.62 kg ha^{-1} mm was recorded in rainfed for T. *Aman* and mungbean and one irrigation for potato in 2006-07, 2007-08 and 2008-09 respectively.

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 and 69972 Tk./ha in Sprinkler × RT method. Benefit cost ratio was also higher in sprinkler irrigation (1.81) and reduced tillage method (1.82).

Kabir (2011) plotted field laboratory experiment at the Department of Soil Science, Bangladesh Agricultural University (BAU), Mymensingh during *aman* season to find out the yield performance of T. *aman* rice variety BINA Dhan7 under two conditions rainfed and supplemental irrigation. BINA Dhan7 result the minimum result grain yield 3.92 ha^{-1} under rainfed condition while the highest was obtained when irrigated four times (5.86 t ha^{-1}).

A field experiment carried out of the Department of Soil Science, Bangladesh Agricultural University (BAU), Mymensingh during *aman* season to study the yield performance of T. *aman* rice varieties viz. V_1: BR11, V_2: BRRI dhan41, V_3: BRRI dhan31, V_4: BRRI dhan40 and V_5: BRRI dhan30 under two conditions rainfed and supplemental irrigation. The sequence of varitals performance was $V_2>V_4>V_3>V_5>V_1$. The highest plant height (125.29 cm), grain yield (5.06 t ha^{-1}) and biological yield (11.67 t ha^{-1}) were result in BRRI dhan41 and harvest index (44.76%) in BRRI dhan31. The rate of increase occurred in each yield contributing components and yields especially panicle length by 5.86% < grain yield 7.67%, straw yield 1.14%, biological yield 3.77% and The harvest index 3.76% in supplemental irrigated plots over rainfed conditioned plots (Shamsuzzaman, 2007).

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 tubewells 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%.

Chen *et al.* (2005) designed three levels of soil water content during grain filling stage in an irrigated field in China to study their effects on the translocation and allocation of carbohydrates in rice inter-sub specific hybrids Xieyou 9308 and Liangyoupeijiu. The results showed that in conventional flooding or non-flooding cultivation, the exported rates of stored carbohydrate from stern and photosynthate from the leaves were 60 and 90%, respectively. The exported rate of carbohydrate was decreased significantly ($P<0.01$) in the non-flooding cultivation. Grains received nearly 50% of stored carbohydrate from leaf sheath and 80% of photosynthate from leaves. At the non-flooding conditions, the absorbing capacity of grains significantly decreased by 10 and 20% from leaf sheath and from leaf photosynthate, respectively. Dry stress caused a large decrease in the absorbing capacity for inferior grains, which might be one of the main reasons for the low seed-setting rate in non-flooding cultivation.

An experiment plotted out with aerobic rice varieties 1-11/502 and HD297 and lowland rice variety JD305 were conducted under aerobic and flooded conditions. Under flooded conditions JD305 yielded up to 8.8 t ha^{-1}, 11D502 up to 6.8 t ha^{-1} and 11D297 up to 5.4 t ha^{-1} compared to the flooded conditions (Yang *et al*., 2005).

Boling *et al.* (2004) led a field experiment in six crop seasons at Jakenan Experiment Station. Experimental treatment consists of two water supply levels (well-watered and rainfed). In one out of six seasons, yields under rainfed condition were 20-23% lower than under well-watered condition.

Spanu *et al*. (2004) studied a comparison of the performance of 24 rice cultivars to non-continuous irrigation in Sardinia on land cultivated with rice for 25 years. It was indicated that yields were satisfactory both in quantity and quality.

The effects of soil water content on the physiology of the rice root system in an irrigated paddy field were evaluated in China at grain filling, ripening and root senescence. There were 45 days from initial heading to harvesting and one-time irrigation was given during this period to saturate the soil. The treatment significantly improved root respiration and exudation, with little effect on gelatin content of the exudates. Thus, one-time irrigation during the filling stage could delay senescence of the root system, reduce non-effective tillers $hill^{-1}$ and unfilled grains $panicle^{-1}$ (TaoLong *et al.*, 2004).

Ganesh (2003) stated that the effects of irrigation on the yield of rice cv. Jaya were studied in Davangere, Karnataka, India. It was observed that Plant height did not significantly vary with irrigation treatment during both season.

A field experiment performed in Parbhani, Maharashtra, India to determine the effect of irrigation and nitrogenous fertilizer on the yield and quality of rice cv. Basmati-370. The treatments comprised irrigation at critical growth stages (I_1), 0.8 (I_2), 1.2 (I_3), and 1.6 (I_4) 14 showed the highest grain yield (2.26 t ha^{-1}), kernel length (6.76 and 6.66 mm in 1998 and 1999, respectively), kernel breadth (1.79 and 1.76 mm), and cooked kernel length (13.34 and 12.92 mm). The highest amylose content (23.90 and 23.82%) was obtained with I_2 and I_1 in 1998 and 1999, respectively while the highest head rice recovery (34.99 and 37.61%) was obtained with I_1 in 1998 and 1999, respectively (Jadhav *et al.*, 2003).

Pandey *et al.* (2003) investigated yield potential of rice cv. IR36 under rainfed and irrigated conditions in Madhya Pradesh, India. They stated that grain and straw yield were higher under irrigated condition over rainfed.

An experiment was carried out in Giridih, Jharkhand, India to evaluate the drought tolerance of upland rice cultivars Brown Gora, RR-167-982, Kalinga-3, RR-151-3, RR-511, RR-50-5, RR-2-6 and Birsa^{-1}01 under rainfed condition. Among the 8 short duration cultivars, 6 were drought-tolerant with sustainable yield potentials of 10.90, 8.51, 10.90, 14.70, 10.10 and 10.80 q ha^{-1}, respectively during the stress/drought year while the respective mean yield during the normal years were 12.75, 10.71, 15.90, 20.54, 14.46 and 17.26 q ha^{-1}, respectively (Sujit and Sarker, 2003).

Zeng *et al.* (2003) observed the physiological characteristics of the root and flag leaf of rice hybrids Honglianyou 6 and Liangyou 1193 after flowering under different irrigation conditions. The root densities and activities were higher under controlled damp irrigation compared to submerged irrigation. The flag leaf chlorophyll contents under controlled damp irrigation were not different at flowering stage but were significantly higher at maturity stage compared to submerged irrigation at reproductive stage. The hybrid rice combinations had high community and relative growth rate including grain yield under controlled damp irrigation.

Stanley (2002) examined a mathematical model for calculating the probabilities of the occurrence of non-rainy days of different duration during the period of crop cultivation was developed. The model was used to determine correct irrigation application durations under conditions of water scarcity for major paddy irrigation schemes in Srilanka. Water balance study revealed that a soil moisture deficit existed even during the months of rainy season (ranging from 20 to 30 mm).

2.2 Effect of weed management on yield attributes and yield 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.

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 can not 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).

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 evalute 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 weeding at 25, 45 and 65 DAS, twice at 25 and 45 DAS and at 25 followed by orizo plus at 45 DAS gave better weed control than other treatments. However, hoe weeding at 25, 45 and 65 DAS gave significantly greater grain yield of 3.1 t ha^{-1} than 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.

A field experiment led on loamy sand soils of Department of Agronomy, Punjab Agricultural University, Ludhiana during Kharif season of 2006 and sandy loam soil of the seed farms of Ladhowal and Kapurthala during 2007 to study the optimum seed rate and weed management practices in irrigated direct dry-seeded rice. A seed rate of 37.5 to 45 kg ha^{-1} depending upon varieties was found optimum for successful cultivation of direct-seeded rice (DSR). Weeds in DSR can be controlled effectively with integration of post-emergence (25-30 DAS) application of bispyribac 25 g ha^{-1} or azimsulfuron 20 g ha^{-1} with pre-emergence application of pendimethalin 0.75 kg ha^{-1}. Application of pendimethalin alone was found inadequate for controlling complex weed flora of DSR. Integration of pre-emergence application of pendimethalin 0.75 kg ha^{-1} with post-emergence application of bispyribac 25 g ha^{-1} or azimsulfuron 20 g ha^{-1} produced 61.7 and 42.1% higher yield, respectively, than alone application of pendimethalin 0.75 kg ha^{-1}(Walia *et al*., 2011).

Bari (2010) conducted an experiment with eight herbicides in transplanted wetland rice during *Aman* growing season to study the effect of weed control and rice yield. The highest grain yield of 4.08 t ha^{-1} was obtained from butachlor, while the lowest (2.83 t ha^{-1}) grain production was harvested in the plots receiving MCPA @ 125% of the recommended rate.

Pandey (2009) worked with eight weed treatments and two rice variety in SRI system and reported that among weed control treatments, three soil-aerating weeding at 14, 28 and 42 DAT was best for controlling weeds which contributed to the highest plant height and also higher number of tillers per plant and moderately higher leaf area index, higher number of effective tillers per square meter (282.67), panicle weight (3.92 gm), number of grains per panicle (184.54), lower sterility (7.36%), and higher grain yield (6.53 t ha^{-1}).

Singh *et al*. (2009) reported that weeds competed for moisture, nutrients, light and space and as a consequence, weeds infestation in Dry Seeded Rice resulted in yield losses in the range to 30 to 90%, reduced grain quality and enhanced the cost of production.

Mahajan *et al*. (2009) reported that sequential spray of pre-emergence application of pendimethalin (1 kg ha^{-1}) followed by bispyribac sodium (30 g ha^{-1}) at 15 days after sowing was found best for the control of weeds.

Bhagat *et al*. (2008) conducted an experiment at college of Agriculture, Kaul (Haryana) to evaluate methods of sowing and weed management in rice during 2005 and 2006. Planting method in rice did not influence the dry weight of total weeds. Pendimethalin 1.5 kg ha^{-1} (pre-emergence) followed by one hand weeding 30 DAS and Sesbania aculeate 2,4-D resulted in significantly lower dry weight of weight of weeds consequently resulting in superior yield and yield attributes.

Singh (2008) mentioned that the effective period of weed-crop competition in DSR occurs in two phases; i.e. between 15-30 days, and 45-60 days after seeding. The competition beyond 15 days after seeding may cause significant reduction in the grain yield. However, competition for the first 15 days only may not have much adverse effect on crop.

Aktaruzzaman (2007) revealed that weeding regimes exerted significance influence on all the crop characters performed except panicle length and highest grain yield was obtained from weed free treatment and the lowest value was obtained from no weeding treatment.

Mukherjee and Malty (2007) performed an experiment on the transplanted rice, with Butachlor 1 kg ha^{-1} at three days after transplanting + almix 20 WP 4 g ha^{-1} at 20 days after transplanting registered higher weed control efficiency and grain yield (3.17 and 3.5 t ha^{-1}) comparable with season long weed control weed-free condition.

An economic study was conducted in the different levels of herbicide used and hand weeding method in controlling weeds in transplanted *Aman* rice. The highest grain yield (5.35 t ha^{-1}) was obtained with the application of Rifit 500 EC at 1 litre ha^{-1}, which was similar to hand weeding (5.16 t ha^{-1}). The application of Rifit 500EC at 1.1 litre ha^{-1} maximized the profit and its benefit-cost ratio was the highest (1.55) among the treatments (Rahman *et al*., 2007).

Rao *et al*. (2007) stated that herbicides that are observed effective in DSR are pyrazosulfuron and oxadiragyl as pre-emergence and azimsulfuron, penoxsulam, cyhalopfop-butyl, and ethoxysulfuron as post-emergence.

Khan and Ashraf (2006) laid out an experiment to evaluate the effects of herbicides on weed control and paddy yield in rice. The treatment were Ronstar @ 2.0 t ha^{-1}; Machete @ 1.5 t ha^{-1} and Saturn @ 3.2 t ha^{-1}. They observed that Ronstar gives the highest grain yield (5.56 t ha^{-1}) than weedy plot (3.67 t ha^{-1}).

Mahadi *et al*. (2006) led an experiment in Nigeria to examine the performance of weeding and some herbicides. The treatments were two hand weeding and Butachlor @ 21 a.i ha^{-1} cinosulfuron @ 0.06 kg a.i ha^{-1}. All the treatments increase plant vigor, plant height, plant dry matter and rice grain yield.

Subramanian *et al*. (2006) plotted an experiment in Tamil Nadu during the winter season to observe the effect of integrated weed management practices on weed control and yield of wet seeded rice. The combination of pre-emergence herbicides + one hand weeding at 125 DAT will decrease weed density, dry weight and higher weed control efficiency, resulting in higher grain yield (58.73 t ha^{-1}) .

Singh *et al*. (2005) reported that the application of herbicides as pre-emergence supplemented with two weeding at 30 and 60 days after sowing under all rice, the highest weed dry matter reduction was achieved. The highest yield (4.23 t ha^{-1}) was obtained with the application of butachlor @ 1.5 kg ha^{-1} supplemented with two hand weeding in rice.

Amarjit *et al*. (2005) presented that hand weeding recorded the lowest weed count and weed dry weight and the highest values of panicle m^{-2}, panicle weight and grains $panicle^{-1}$ and grain yield. Maximum yield and its attributes were found with the application of anilophos + ethoxysulfuron (0.312 + 0.015 kg ha^{-1}) at 10 DAT, thereby realized an increase of 67.3% yield over weedy check but was at per with hand weeding treatment.

Mitra *et al*. (2005) delineated that among the treatments of weed control for transplanted *Aman* rice the highest grain yield (5.07 t ha^{-1}) was recorded from weed-free control while the lowest (2.46 t ha^{-1}) was recorded from the weedy control.

The effect of five weeding regimes viz. no weeding, one hand weeding, two hand weeding and three hand weeding and always weed free were evaluated on yield of rice. The highest grain yield and effective tillers hill^{-1} were recorded under always weed free condition, which was statistical similar to that recorded that of three times weeding (Islam, 2003).

Hossain and Haque (2002) laid out an experiment to examine the performance of *aus* rice under different weed management and weeding regimes and showed that the highest grain yield (2.92 t ha^{-1}) was observed from four tillage and two hand weeding at 15 and 30 days after sowing.

Gul-Hasan *et al*. (2002) showed that grain yields were highest in hand weeding and Basagran EC (post emergence) treated plots (2560 and 3256 kg ha^{-1}), respectively.

Jayadeva and Bhairappanavar (2002) stated that pendimethalin, thiobencarb, and anilofos have been performed more effective and safer for direct seeded rice. Pendimethalin at 1.0 kg ha^{-1} as preemergence has been quite effective and economical for dry-seeded rice.

Bhowmick *et al*. (2002) observed that two hand weeding at 26 and 40 DAT in transplanted rice generated the highest weed control efficiency and proved at par with the herbicide combination of Ethoxysulfuron + Anilophos.

Nair *et al*. (2002) investigated that application of Butachlor @ 1.25 kg ha^{-1} along with one hand weeding at 40 DAT recorded higher panicle m^{-2}, panicle length, grains panicle^{-1} and 1000 grain weight and which ultimately increased the grain yield of rice.

An experiment conducted at Agricultural Research Station of Bangladesh Agricultural Research Institute (BARI), Pabna during April to August 2001 to study the effect of weed control methods on the growth and yield of rainfed *aus* rice (CV. BR16). Plant height, effective tillers plant^{-1}, length of panicle, filled grains panicle $^{-1}$, unfilled grains panicle^{-1}, 1000-grain weight and grain yield were significantly influenced due to different treatments.

The maximum number of effective tillers plant^{-1} (3.60), filled grains panicle^{-1} (50.54) and grain yield (3.02 t ha^{-1}) were recorded from T_5 treatment (Ronstar @ 2.0 L ha^{-1}), which was closely followed by T_2 treatment (two hand weeding). The minimum number of effective tillers plant^{-1} (2.30), filled grains panicle^{-1} (41.32) and grain yield (2.27 t ha^{-1}) were recorded in control treatment (Alam *et al.,* 2002).

Chandra and Pandy (2001) showed that hand weeding was most effective in mitigating the dry matter accumulation and N depletion and also stated that higher grain and straw yields was found from hand weeding with 120 kg N ha^{-1}.

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

Bilkis *et al.* (2017) studied in the *Boro*-fallow-T. *Aman* cropping pattern over two years at Bangladesh Agricultural University (BAU) farm, Mymensingh under the AEZ 9 (Old Brahmaputra Floodplain). The field trial consisted of eight treatments and control (no fertilizer or manure), 100% chemical fertilizers (CF), and IPNS based six treatments with six types of manure. Cowdung (CD), CD slurry, Trichocompost (TC) and vermicompost (VC) were added to soil at 5 t ha^{-1} and poultry manure (PM) and PM slurry applied at 3 t ha^{-1}. For all IPNS treatments, nutrient supply from manure was adjusted with that from chemical fertilizers. In each crop cycle, manure was applied to the first crop (*Boro* rice) and the residual effect was examined on the succeeding crop (T. *Aman* rice). The IPNS based treatments significantly increased the grain and straw yields of Boro rice and it had also positive residual effect on T. *Aman* rice. Trichocompost and vermicompost, among the six IPNS treatments, demonstrated higher crop yield and that was followed by poultry manure slurry and cowdung slurry. Integrated use of manure with fertilizers gave on an average 8.3-33.8% and 2.9-18.3% higher grain yield in *Boro* and T. *Aman* rice, respectively over sole fertilizers treatment. Higher nutrient uptake by crops (N, P, K & S) was also found in IPNS treated plots. The IPNS treatments improved soil fertility in terms of increasing organic matter, N, P and S contents of soil after two crop cycles.

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).

Naher and Paul (2017) led an experiment at Sher-e-Bangla Agricultural University (SAU) Farm during July to November 2011 to study the effect of integrated nutrient management (INM) on T. *Aman* rice (cv. BRRI dhan40). They observed that the integrated use of chemical fertilizer and organic manure can help increase grain yield of rice without deteriorating soil fertility.

An experiment conducted by Kamrunnahar *et al.* (2016) at the Bangladesh Rice Research Institute (BRRI) farm, Gazipur in a permanent layout in wet season of 2014 to evaluate the effects of NPKS on grain yield, plant nutrition, requirement of NPKS to yield one ton grain and to estimate the indigenous nutrient supply of the soil. BRRI dhan49 was tested with NPKS (complete), PKS (-N), NKS (-P), NPS (-K) and NPK (-S) fertilizer packages. The NPKS were applied @ 100-7-80-3 kg ha^{-1}. Omission of each nutrient from the complete treatments significantly reduced grain and straw yields of BRRI dhan49. The highest yield reduction was recorded because of N omission followed by K. Nutrient concentration in grain and straw as well as nutrient uptakes were significantly affected by major plant nutrients. Nutrient uptake was directly related to the biomass production. About 87% of total K uptake remained in straw and thus a good K source for rice cultivation. Nitrogen, P, K, S and Zn required to produce one ton rice were 20.88, 5.04, 18.77, 2.08 and 0.07 kg, respectively. The indigenous N, P, K and S supply capacity of this soil was 37, 13, 41 and 6 kg ha^{-1}, respectively.

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).

Kashedul *et al.* (2015) plotted an experiment to assess the effect of integrated nutrient management on the growth and yield of NERICA 10 during *Aus* season (Mid March-July), 2012. Eleven treatments coded from T_1 to T_{11} were used in the experiment. The highest panicle length and effective tillers/hill was found in T_{10} (40 kg N from urea + 80 kg N from cowdung), maximum filled grains/panicle and 1000-grains weight was found in T_{11} (100% N from equal portion of cowdung and vermicompost). The maximum grain yield (4.4 t ha^{-1}) and straw yield (5.4 t ha^{-1}) was found from T_3 i.e., 100 kg N form urea and 20 kg N substituted by vermicompost, while the minimum was recorded from T_1 (1.5 t ha^{-1} and 2.10 t ha^{-1}, respectively). T_3 increased of 190% grain yield and 154.8% straw yield over control which was the maximum than other treatments. The effect of vermicompost along with nitrogenous fertilizer was the most pronounced than that of cowdung or nitrogenous fertilizer alone. Application of 100 kg N from urea with 20 kg N from vermicompost was best for higher rice.

Atera *et al*. (2011) conducted an experiment on field evaluation of selected NERICA rice cultivars in Western Kenya and reported that the highest plant height (103.8 cm) was obtained from 100 kg N ha^{-1}.

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

Kamara *et al*. (2011) conducted an experiment on the influence of nitrogen fertilization (0, 30 and 100 kg N ha^{-1}) on yield and yield components of rain-fed low land NERICA rice and reported that nitrogen application influenced number of spikelets $panicle^{-1}$ significantly by 19 to 22% over the control. In both years, number of spikelets increased with increasing nitrogen rates.

A field experiment was conducted on winter wheat (*Triticum aestivum* L.)-rice (*Oryza sativa* L.) crop rotations in Southwest China to investigate phosphorus (P) fertilizer utilization efficiency, including the partial factor productivity (PFP), agronomic efficiency (AE), internal efficiency (IE), partial P balance (PPB), recovery efficiency (RE) and the mass (input–output) balance. This study suggests that, in order to achieve higher crop yields, the P fertilizer utilization efficiency should be considered when making P fertilizer recommendations in wheat-rice cropping systems (Tang *et al*., 2011).

Wang *et al*. (2011) carried out a field experiment to evaluated the effects of N, P and K fertilizer application on grain yield, grain quality as well as nutrient uptake and utilization of rice to elucidate the interactive effects among N, P and K in a field experiment with four levels of nitrogen (N), phosphorus (P) and potassium (K) fertilizers. The results displayed that the application of N, P and K fertilizer significantly increased grain yield, and the highest yield was found under the combined application of N, P and K fertilizer.

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 nondraining 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.

Li *et al.* (2007) conducted an experiment to evaluate the contributions of rice root morphology and phosphorus uptake kinetics to P uptake by rice from iron phosphates. The Fe-P treatment significantly ($P<0.05$) decreased plant dry weight, P uptake per plant, and P concentration in plant dry matter of all cultivars in comparison with the control plants. In Fe-P treated plants, significant ($P<0.05$) genotype variation was shown in root morphology including root length, surface area, volume and number of lateral roots. The P uptake per plant from Fe-P by rice was significantly ($P<0.05$) correlated with root surface area and root volume as well as with the number of lateral roots suggesting that the ability of rice to absorb P from Fe-P was closely related to root morphology.

Field experiments were conducted by Ravi *et al.* (2007) at Annamalai University Experimental Farm (Tamil Nadu, India) during Navarai and Kuruvai season to study the effect of foliar spray of phytohormones and nutrients on the yield and nutrient uptake of transplanted rice cv. ADT 36. The results revealed that foliar application of miraculan @1000 ppm recorded an added beneficial effect over other treatments. Alam *et al.* (2006) reported that straw yield increased with increasing N levels in rice.

Krishnappa *et al.* (2006) mentioned that increasing K rates increased paddy yields. Potassium applied in split dressings were more effective than when applied at transplanting time. Application of potassium fertilizer with organic manure increased soil K availability, K content and the number of grains panicle^{-1}.

Surekha *et al*. (2006) delineated that the weight of 1000-grain was not affected significantly by crop management practices. Nitrogen application significantly increased 1000-grain weight and plant height. Singh *et al.* (2006) observed that the nitrogen application increased significantly plant height.

Mazumder *et al*. (2005) reported that different levels of nitrogen influenced grain, straw and biological yields with the application of 100% recommended dose (RD) of N (99.82 kg N ha^{-1}) which was statistically followed by other treatments in descending order. The highest grain yield (4.86 t ha^{-1}) was recorded with 100% RD of N and the lowest (3.80 t ha^{-1}) from no application of nitrogen.

Moula (2005) plotted an experiment on T. *aman* rice with different phosphorus rates. He found that when four treatments (P_0, 60 kg ha^{-1} phosphate rock, 60 kg ha^{-1} TSP and 210 kg ha^{-1} phosphate rock) were applied, 210 kg phosphate rock (PR) found better performance on yield contributing characters and nutrient content as well as nutrient uptake by rice over other treatments.

Natarajan *et al*. (2005) led an experiment during 2002-2003 with two rice hybrids, KRH2 and DRRHI in main plots and three levels of potassium (0, 40, and 80 kg ha^{-1}) in subplots to study the performance of rice hybrids with different K levels. The results clearly indicated that hybrid KRH2 performed superior with different levels of K.

Singh *et al. (*2005) carried out a field experiment during the kharif season on an Inceptisol in Varanasi, Uttar Pradesh, India to study the effect of S and Mn fertilizer application on the content and quality of bran oil of different rice cultivars viz. Pant-12 (short duration), Swarna (long duration) and Malviya-36 (medium duration). The treatments comprised S and Mn applied at 0, 25, 50 and 0, 10, 20 kg ha^{-1} through gypsum and $MnC1_2$, respectively and their combinations. A uniform application of recommended doses of N, P and K was given in all the experimental plots. Application of both S and Mn significantly enhanced the bran content and yield of rice over the control. The highest dose of Mn and S on an average caused an increase of 15.2 and 45.0% in bran oil yield over the control, respectively. Increasing levels of S brought about noticeable increment in the percentage of unsaturated fatty acids, including PUFA indicating improvement in the quality of bran oil.

Azmi *et al.* (2004) studies on long-term influence of four fertility levels and management practices under rice-wheat-sorghum and rice-mustard-mungbean rotations on soil fertility build-up and the yield of crops are being carried out in a Calciorthent of Pusa, Bihar, India. Increasing fertility levels significantly increased the crop yield and S uptake under both rotations. Depth-wise distribution of available S was also studied from the same experiment and the results revealed that high fertility level increased the available S at all the soil depths investigated. However, at medium and high fertility, available S was almost equal beyond 30-45 cm depth under rice-wheat-sorghum rotation. Higher fertility reduced leaching losses to some extent. Accumulation of available S under rice-wheat-sorghum rotation was higher at all the depths as compared to rice-mustard-mungbean rotation due to higher amount of S added under the former rotation. However, S movement down the depth was more in case of rice-wheat-sorghum rotation. Rice-mustard-mungbean rotation removed more S from surface soil but at the same time it restricted the downward movement up to only 45 cm.

Hu H *et al*. (2004) conducted a field experiment in Zhejiang, China, to investigate the K uptake, distribution and use efficiency of hybrid and conventional rice under different low-K stress conditions. The grain yield and total K uptake by rice increased, while the K use efficiency of rice decreased significantly. The interaction effect between cropping history and K application was also significant. The phase from panicle initiation to flowering was critical for K uptake by rice and more than half of the total plant K was accumulated during this phase.

Chandel *et al.* (2003) conducted a study to see the effect of sulphur nutrient on growth and sulphur content in rice and mustard grown in sequence. The experiment was laid out in split plot design with four sulphur levels (0, 15, 30 and 45 kg S ha^{-1}) applied to rice as main plot treatments during rainy season and each plot further divided into three subplots (0, 20 and 40 kg S ha^{-1}) applied to mustard during winter season. They found that increasing sulphur levels in rice significantly improved leaf area index, tiller number, dry matter production, harvest index and sulphur content in rice up to 45 kg S ha^{-1}.

Shen *et al*. (2003) studied the effects of N and K fertilizer on the yield and quality of rice. Potassium fertilizer significantly improved all quality parameters and yield at 150 kg N ha^{-1} and equal amounts of K fertilizer applied to rice fields are optimum to obtain high yield.

Singh and Singh (2002) carried out a field experiment to see the effect of different S levels (0, 20 and 40 kg ha^{-1}) on rice cv. Swarna and PR 108 in Varanasi, Uttar Pradesh, India. They reported that plant height, tillers m^{-2}, dry matter production, panicle length and grains $panicle^{-1}$ was significantly increased with increasing levels of S up to 40 kg ha^{-1}.

Sarfaraz *et al.* (2002) conducted a field experiment to determine the effect of different S fertilizers at 20 kg ha^{-1} on crop yield and composition of rice cv. Shaheen Basmati in Pakistan. They found that the number of tillers m^{-2}, 1000-grain weight, grain and straw yields were significantly increased with the application of NPK and S fertilizers compared to the control. They also found that NPK concentrations and their uptake in grain and straw significantly increased with the application of NPK + S fertilizers compared to the control. They also found that NPK concentrations and their uptake in grain and straw significantly increased with the application of NPK + S fertilizers compared to the control.

From the above review of literature, it is noticed that irrigation and weed management option exerted significant influenced on growth, yield and yield contributing characters of rice. Majority of the authors reported that rice response differently to different irrigation schedule and weed management option.

CHAPTER III
MATERIALS AND METHODS

The experiment was conducted during the period from March to June, 2018 to study the growth and yield of *Aus* 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). Top soil was silty clay in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. Soil pH was 5.6 and has organic carbon 0.45%. The experimental area was flat having available irrigation and drainage system 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 dhan65 and Nerica was used as the test crop in this experiment. These two varieties are recommended for *aus* season. Average plant height of the BRRI dhan65 variety is 90-95 cm at the ripening stage. The grains are medium fine and white. It requires about 80-100 days completing its life cycle with an average grain yield of 3.5-4.0 t ha^{-1} (BRKB, 2018). Nerica is grown in *Aus & Aman* season. The test crop Nerica variety is recommended for cultivation in *Aus* season. Nerica a short duration rice variety first introduced in Bangladesh in 2009 from Africa was used as a test crop. It is not only a drought tolerant but also drought avoidance variety and fast recovery with rains after drought.

3.3 Experimental details

3.3.1 Treatments The experiment comprised as two factors.

Factor A: Variety

i. BRRI dhan65- V_1

ii. Nerica-V_2

Factor B: Agronomic management

i. No management-M_0

ii. No weeding, but all other managements –M_1

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

iv. No irrigation application, but all other managements -M_3

v. Recommended management-M_4

As such there were 10 (2 × 5) treatment combinations viz. V_1M_0, V_1M_1, V_1M_2, V_1M_3, V_1M_4, V_2M_0, V_2M_1, V_2M_2, V_2M_3, V_2M_3 and V_2M_4.

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 10 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. Nerica seed was collected from Bangladesh Agricultural Development Corporation (BADC), Thakurgaon and BRRI dhan65 from Bangladesh Rice Research Institute (BRRI), Gazipur.

3.4.1.2 Breaking of Seed dormancy

Collected seeds are dried in the sunlight 3 days 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 March 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. Half of Urea was applied during final land preparation and rest half applied two equal installments at 30 DAS and 45 DAS. The dose and method of application are shown in Table 1.

Table 1. Dose and method of application of fertilizers in rice field

Fertilizer	Dose/ha	Dose/Plot	Application (%)		
			Basal	1st installment	2nd installment
Urea	120 kg N	264 g	50	25	25
TSP	100 kg P_2O_5	220 g	100	-	-
MOP	80 kg K_2O	134 g	100	-	-
Gypsum	60 kg S	334 g	100	-	-
Zinc Sulphate	10 kg Zn	28 g	100	-	-

3.4.4 Preparation of land for sowing the seeds in the field

Land was prepared for sowing of seeds. Ten lines were made each having a line to line distance of 20 cm. Seeds were sown directly in the lines.

3.4.5 Sowing of seeds

Seeds were sown in the line after made wet by application of water and covered by the soil. The seeds were sown in the block 29 on March 16, 2018.

3.4.6 After care

Before germination of seedlings from each plot, watering was done.

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 enhance tillering. The field was finally dried out at 15 days before harvesting. Proper drainage channels were made to drainout the excess water from the field.

3.4.6.2 Thinning and Gap filling

Though direct seeding, uneven germination of seedlings, excess seedlings were upto rooted and made plant to plant distance 15 cm. Gap filling was done for all of the plots at 25 days after sowing (DAS) by planting same aged seedlings.

3.4.6.3 Weeding

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

3.4.6.4 Top dressing

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

3.4.6.5 Plant protection measures

Infestations of insect-pests were seen during the growing period of rice. Plant protection measures were taken and controlled successfully that's why the crop growth was normal.

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 dhan65 was harvested on 25th June, 2018 and Nerica on 28th June, 2018. 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 regarding growth, yield contributing characters and yield of rice

1. Plant height
2. Number of tillers hill^{-1}
3. Number of leaves hill^{-1}
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 DAS, 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 30, 50, 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 30, 50 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 30, 50 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 30, 50, 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 boarder 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 *Aus* rice as affected by agronomic managements. Data on different yield contributing characters, yield, weed population and dry weight of weed were recorded. The analyses of variance (ANOVA) of the data on different parameters are presented in Appendix III-X. The results have been presented with the help of Tables and Graphs and possible interpretations given under the following headings:

4.1 Weed growth & development

4.1.1 Weed population

Weed population was varied numerically due to BRRI dhan65 and Nerica (Appendix III). Weed data were recorded at 65 DAS, the maximum number of weeds (277.73 m^{-2}) were found in the Nerica cultivated plot (Fig. 1), while the lower number (174.93 m^{-2}) was recorded in BRRI dhan65.

Weed population was varied significantly due to different agronomic managements (Appendix III). The lowest weed population (26.67 m^{-2}) was recorded in M_4 (recommended management), while the highest weed population (520.70 m^{-2}) was found in M_0 (no management) plot which was statistically similar to (510.70m^{-2}) M_1 (no weeding) plot (Fig. 2). Shultana *et al.* (2016) reported that weed density was higher in unweeded plots with 140:36:43 kg NPK ha^{-1}.

There was statistically significant effect on weed population by the interaction effect of variety and agronomic managements (Appendix III). The maximum weed population (732.00 m^{-2}) was observed in V_2M_0 (Nerica + no management) that statistically similar to (550.70 m^{-2}) V_2M_1 (Nerica with no weeding) and (470.70 m^{-2}) V_1M_1 (BRRI dhan65 with no weeding) and the lowest weed population (24.00 m^{-2}) was in V_2M_4 (Nerica with recommended management) which was similar to (29.33 m^{-2}) V_1M_4 (BRRI dhan65 with recommended management) (Table 2).

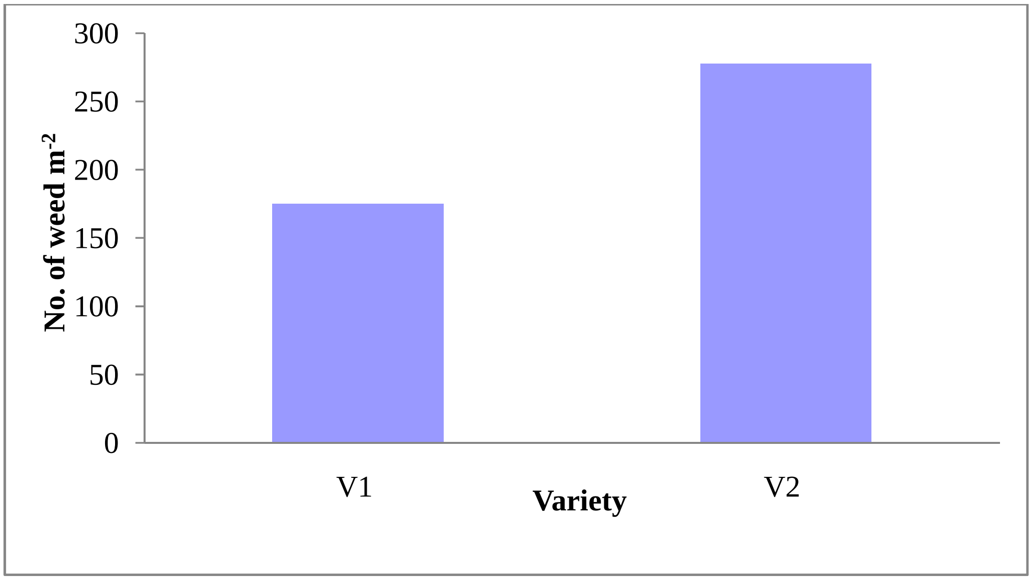
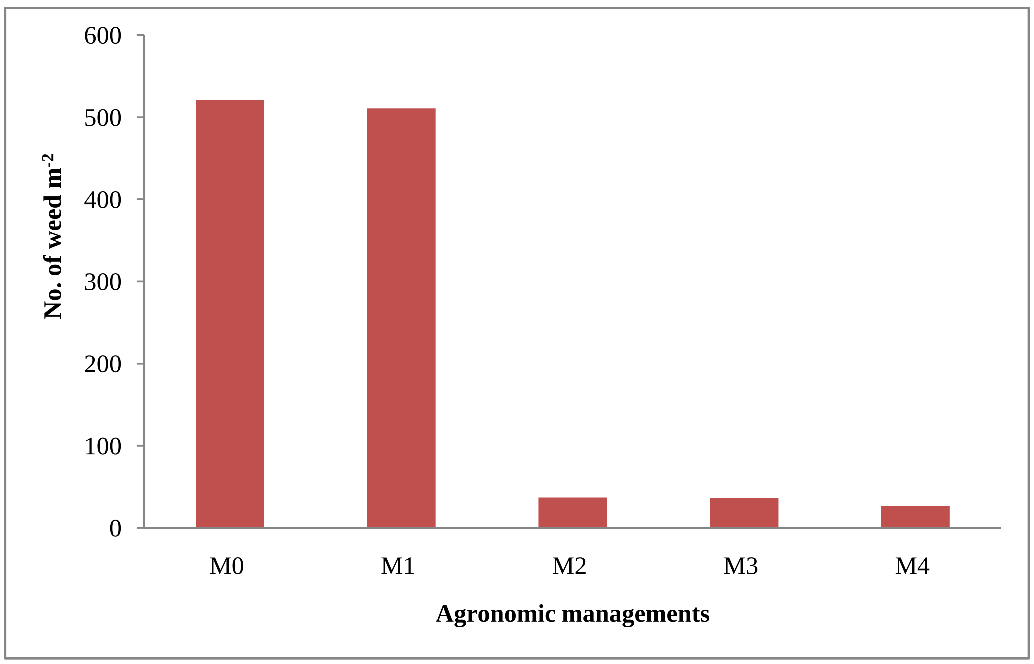


Figure 1. Effect of variety on weed population of *Aus* rice.



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 but all other managements, M_4: Recommended management

Figure 2. Effect of agronomic managements on weed population of *Aus* rice (SE= 57.39)

4.1.2 Dry weight of weed biomass

Dry weight of weed biomass was not significant due to varieties (BRRI dhan65 and Nerica) (Appendix III). It was found that the higher weed biomass (94.91 g m^{-2}) was found in the Nerica cultivated plot (Fig. 3), while the lower weight (83.72 g m^{-2}) was recorded in BRRI dhan65.

Table 2. Interaction effect of variety and agronomic managements on number of weed population and dry weight production of *Aus* rice

Treatments	Number of weeds m^{-2}	Dry weight (g) of weeds m^{-2}
V_1M_0	309.30b	119.30c
V_1M_1	470.70ab	292.60b
V_1M_2	33.33c	2.24d
V_1M_3	32.00c	2.45d
V_1M_4	29.33c	2.08d
V_2M_0	732.00a	101.00c
V_2M_1	550.70ab	367.10a
V_2M_2	40.67c	1.680d
V_2M_3	41.33c	2.243d
V_2M_4	24.00c	2.5070d
SE	57.39	37.58
CV(%)	30.45	22.88

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 dhan65, V_2: Nerica, 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 but all other managements, M_4: Recommended management

Dry weight of weed biomass varied significantly due to different agronomic managements (Appendix III). The lowest weight of weed biomass (1.96 g m^{-2}) was recorded in M_2 (no fertilizer application) that was statistically similar to M_4 (2.29 g m^{-2}) and M_3 (2.35 g m^{-2}), while the highest weight (329.86 g m^{-2}) in M_1 (no weeding) that was followed by (110.13 g m^{-2}) in M_0 (no management) plot (Fig. 4). Manish *et al.* (2006) recorded maximum weed dry weight were recorded in no management treatment, while the minimum values were obtained with hand weeding at 15 and 30 DAT.

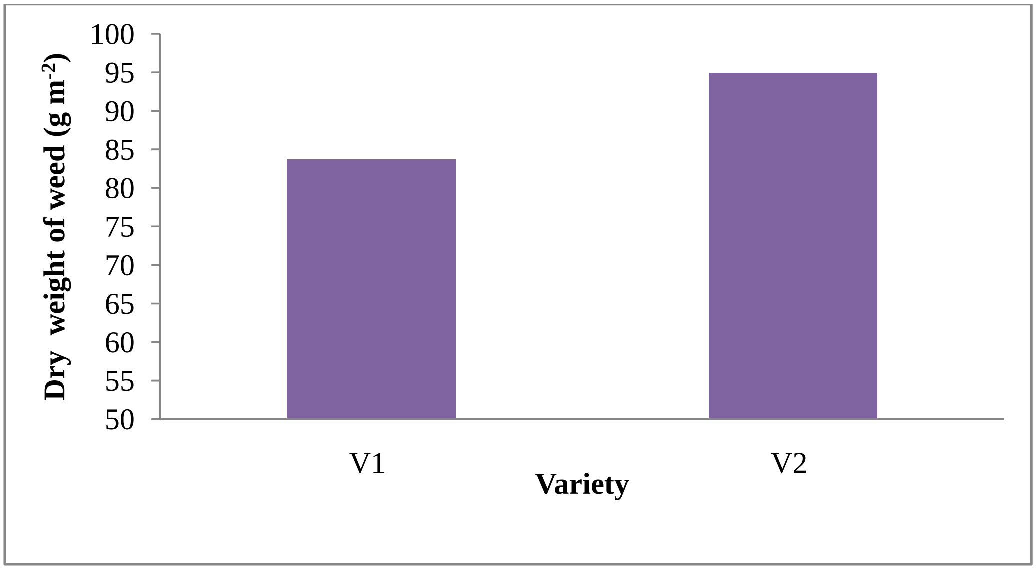
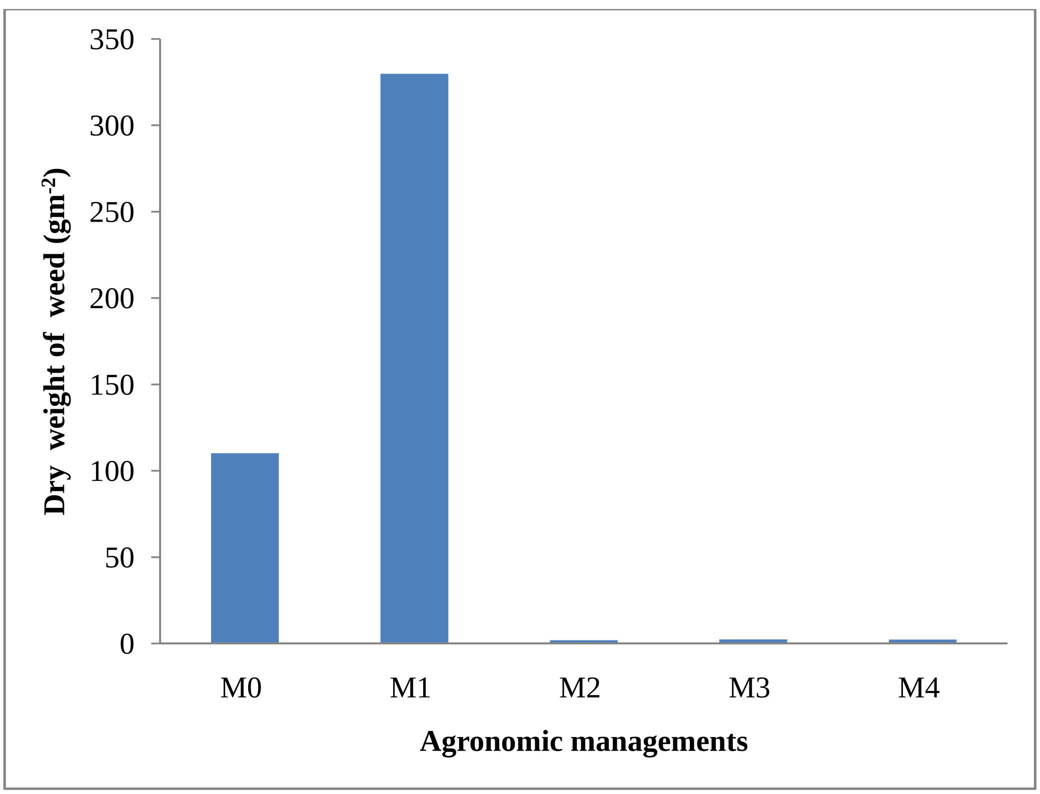


Figure 3. Effect of variety on dry weight of weed of *Aus* rice.



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 but all other managements, M_4: Recommended management

Figure 4. Effect of agronomic managements on dry weight weed of *Aus* rice (SE= 37.58)

There was significant effect on weed biomass by the interaction effect of variety and agronomic managements (Appendix III). The highest weed biomass (367.10 g m^{-2}) was observed in V_2M_1 (Nerica with no weeding) that was followed by (292.60 g m^{-2}) in V_1M_1 (Table 2), while the lowest weed dry weight (1.68 g m^{-2}) in V_2M_2 (Nerica with no fertilizer application) that was similar to $V_1M_{3,}$ $V_1M_{4,}$ $V_1M_{2,}$ V_2M_3 and V_2M_4 plots.

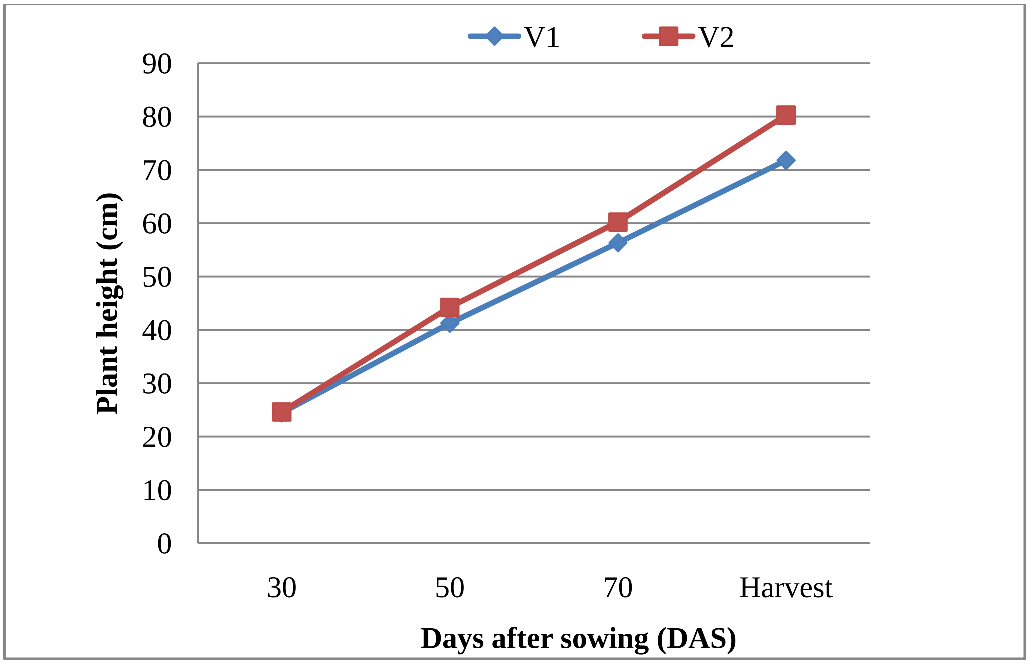
4.2 Yield and other crop characters of rice

4.2.1 Plant height

Plant height varied numerically at 30, 50 and 70 DAS and significantly at harvest of BRRI dhan65 and Nerica under the present trial (Appendix IV). At 30, 50, 70 DAS and at harvest the taller plant (24.61 cm, 44.25 cm, 60.23 cm and 80.28 cm, respectively) was recorded from V_2 (Nerica), whereas the shorter plant (24.44 cm, 41.27 cm, 56.32 cm and 71.81 cm) from V_1 (BRRI dhan65) (Fig. 5). Different varieties produced longest or smallest plant on the basis of their varietal characters.

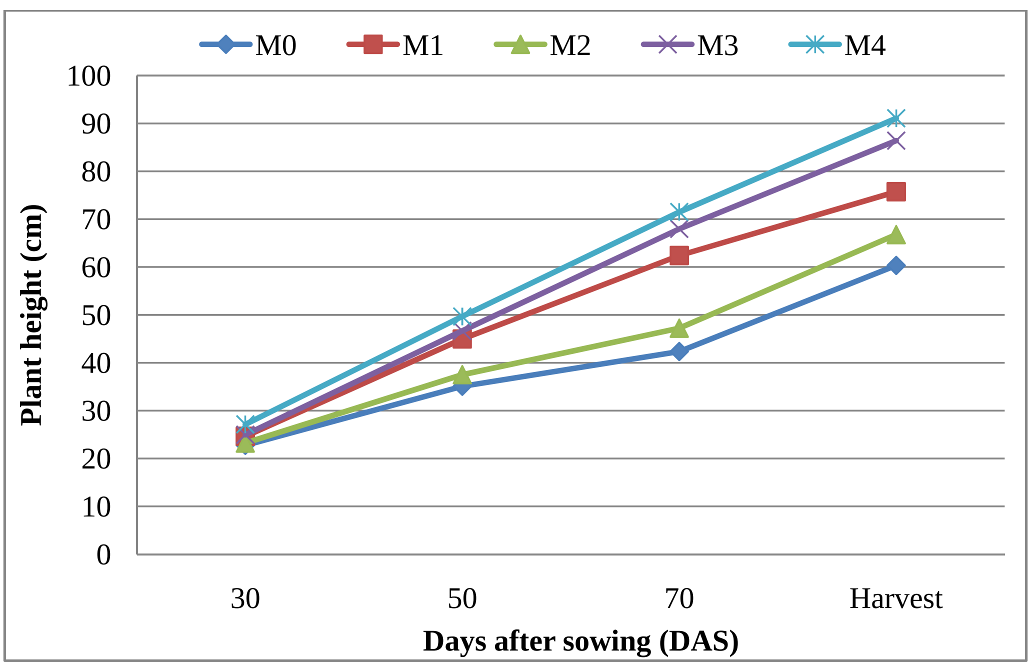
Different agronomic managements showed variation numerically on plant height at 30, 50 and 70 DAS and significantly at harvest (Appendix IV). At 30, 50, 70 DAS and at harvest, the tallest plant (27.11 cm, 49.66 cm, 71.49 cm and 91.07 cm, respectively) was observed from M_4 (recommended management), which was closely followed (24.94 cm, 46.63 cm, 67.94 cm and 86. 38 cm) by M_3 (no irrigation), while the shortest plant (22.73 cm, 35.07 cm, 42.33 cm and 60.31 cm, respectively) from M_0 (no management) (Fig. 6).

Interaction effect of variety and agronomic managements showed significant differences on plant height at 30, 50, 70 DAS and harvest (Appendix IV). At 30, 50, 70 DAS and harvest the tallest plant (27.33 cm, 47.66 cm, 74.52 cm and 94.48 cm, respectively) was observed from V_2M_4 (Nerica + recommended management), while the shortest (22.40 cm, 35.27 cm, 42.05 cm and 57.88 cm, respectively) from V_1M_0 (BRRI dhan65 + no management) (Table 3).



V$_1$: BRRI dhan65, V$_2$: Nerica

Figure 5. Effect of variety on plant height of *Aus* rice (SE=0.997 at harvest).



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 but all other managements, M_4: Recommended management

Figure 6. Effect of agronomic managements on plant height of *Aus* rice (SE= 1.78 at harvest)

Table 3. Interaction effect of variety and agronomic managements on plant height of *Aus* rice at different days

Treatments	Plant height (cm) at			
	30 DAS	50 DAS	70 DAS	Harvest
V_1M_0	22.40e	35.27f	42.05g	57.88f
V_1M_1	24.98bc	46.84c	59.16d	70.37d
V_1M_2	22.67e	37.92e	45.57f	61.11ef
V_1M_3	25.30b	49.58ab	66.36c	82.03c
V_1M_4	26.89a	51.65a	68.47bc	87.66b
V_2M_0	23.07de	34.88f	42.61fg	62.73e
V_2M_1	24.31b-d	43.09d	65.65c	81.07c
V_2M_2	23.78c-e	37.08ef	48.87e	72.42d
V_2M_3	24.59bc	43.67d	69.51b	90.73ab
V_2M_4	27.33a	47.66bc	74.52a	94.48a
SE	0.833	1.281	1.823	2.543
CV(%)	5.88%	5.19%	5.42%	5.79%

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 dhan65, V_2: Nerica, 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 but all other managements, M_4: Recommended management

4.2.2 Number of tillers hill^{-1}

Number of tillers hill^{-1} varied numerically at 30 and 50 DAS and significant at 70 DAS of BRRI dhan65 and Nerica under the present trial (Appendix V). At 30, 50 and 70 DAS the higher number of tillers hill^{-1} (1.46, 9.16 and 8.54, respectively) was recorded from V_1 (BRRI dhan65), whereas the lower number (1.33, 7.73 and 6.91, respectively) from V_2 (Nerica) (Table 4).

Different agronomic managements showed significant differences on number of tillers hill^{-1} at 30, 50 and 70 DAS (Appendix V). At 30, 50 and 70 DAS, the highest number of tillers hill^{-1} (2.00, 13.67 and 12.00, respectively) was observed from M_4 (recommended management), which was closely followed (1.83, 9.83 and 9.16) by M_3 (no irrigation), while the lowest number (1.00, 5.16 and 4.83, 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 30, 50 and 70 DAS (Appendix V). At 30, 50 and 70 DAS, the highest number of tillers hill^{-1} (2.00, 14.33 and 13.00, respectively) was observed from V_1M_4 (BRRI dhan65 + recommended management), while the lowest (1.00, 4.33 and 4.00, respectively) from V_2M_0 (Nerica + no management) (Table 5).

Table 4. Effect of variety and agronomic managements on number of tillers hill^{-1} of *Aus* rice at different days

Treatments	Number of tillers hill^{-1} at		
	30 DAS	50 DAS	70 DAS
Variety			
V_1	1.46	9.16	8.54b
V_2	1.33	7.73	6.91a
SE	NS	NS	0.49
CV(%)	26.08	28.19	17.42
Agronomic managements			
M_0	1.00b	5.16d	4.83d
M_1	1.16b	7.83c	7.50c
M_2	1.00b	5.83d	5.50d
M_3	1.83a	9.83b	9.16b
M_4	2.00a	13.67a	12.00a
SE	0.11	0.51	0.35
CV(%)	18.44	14.10	11.16

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 dhan65, V_2: Nerica, 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 but all other managements, M_4: Recommended management, NS= Not significant

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

Treatments	Number of tillers hill^{-1} at		
	30 DAS	50 DAS	70 DAS
V_1M_0	1.00d	6.00ef	5.66ef
V_1M_1	1.33c	8.66d	8.00c
V_1M_2	1.00d	6.00ef	6.00e
V_1M_3	2.00a	11.00c	10.33b
V_1M_4	2.00a	14.33a	13.00a
V_2M_0	1.00d	4.33g	4.00g
V_2M_1	1.00d	7.00e	7.00d
V_2M_2	1.00d	5.66f	5.00f
V_2M_3	1.66b	8.66d	8.00c
V_2M_4	2.00a	13.00b	11.00b
SE	0.15	0.73	0.50
CV(%)	18.44	14.10	11.16

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 dhan65, V_2: Nerica, 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 but all other managements, M_4: Recommended management

4.2.3 Number of leaves hill^{-1}

Number of leaves hill^{-1} varied numerically at 30 and 50 and statistically at 70 DAS of BRRI dhan65 and Nerica (Appendix VI). At 30, 50 and 70 DAS, the higher number of leaves hill^{-1} (4.78, 39.73 and 44.63, respectively) was recorded from V_1 (BRRI dhan65), whereas the lower (4.69, 32.97 and 34.80) from V_2 (Nerica) (Table 6).

Different agronomic managements showed significant variation on number of leaves hill^{-1} at 30, 50 and 70 DAS (Appendix VI). At 30, 50 and 70 DAS, the highest number of leaves hill^{-1} (5.38, 55.93 and 61.13, respectively) was observed from M_4 (recommended management), while the lowest d number of leaves hill^{-1} (3.96, 20.07 and 24.20, respectively) was recorded from M_0 (no management) (Table 6).

Table 6. Effect of variety and agronomic managements on number of leaves hill^{-1} of *Aus* rice at different days

Treatments	Number of leaves hill^{-1} at		
	30 DAS	**50 DAS**	**70 DAS**
Variety			
V_1	4.78	39.73	44.63b
V_2	4.69	32.97	34.80a
SE	NS	NS	1.98
CV(%)	23.88	30.14	13.63
Agronomic managements			
M_0	3.96c	20.07c	24.20d
M_1	4.82b	38.33b	38.30c
M_2	4.65b	23.87c	26.77d
M_3	4.88b	43.57b	48.17b
M_4	5.38a	55.93a	61.13a
SE	0.11	2.05	1.48
CV(%)	5.46	13.82	9.14

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 dhan65, V_2: Nerica, 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 but all other managements, M_4: Recommended management, NS= Not significant

Interaction effect of variety and agronomic managements showed significant differences on number of leaves hill^{-1} at 30, 50, 70, 90 DAS and harvest (Appendix VI). At 30, 50, 70, 90 DAS and harvest the highest number of leaves hill^{-1} (5.40, 60.00 and 70.40, respectively) was observed from V_1M_4 (BRRI dhan65 + recommended management), while the lowest (3.87, 17.07 and 20.53, respectively) from V_2M_0 (Nerica + no management) (Table 7).

Table 7. Interaction effect of variety and agronomic managements on number of leaves hill^{-1} of *Aus* rice

Treatments	Number of leaves hill^{-1} at		
	30 DAS	**50 DAS**	**70 DAS**
V_1M_0	4.07d	23.07e	27.87e
V_1M_1	4.87b	41.60c	41.07c
V_1M_2	4.80b	25.20e	30.40e
V_1M_3	4.80b	48.80b	53.40b
V_1M_4	5.40a	60.00a	70.40a
V_2M_0	3.87d	17.07e	20.53fF
V_2M_1	4.77b	35.07d	35.53d
V_2M_2	4.50c	22.53e	23.13f
V_2M_3	4.97b	38.33cd	42.93c
V_2M_4	5.37a	51.87b	51.87b
SE	0.15	2.90	2.09
CV(%)	5.46	13.82	9.14

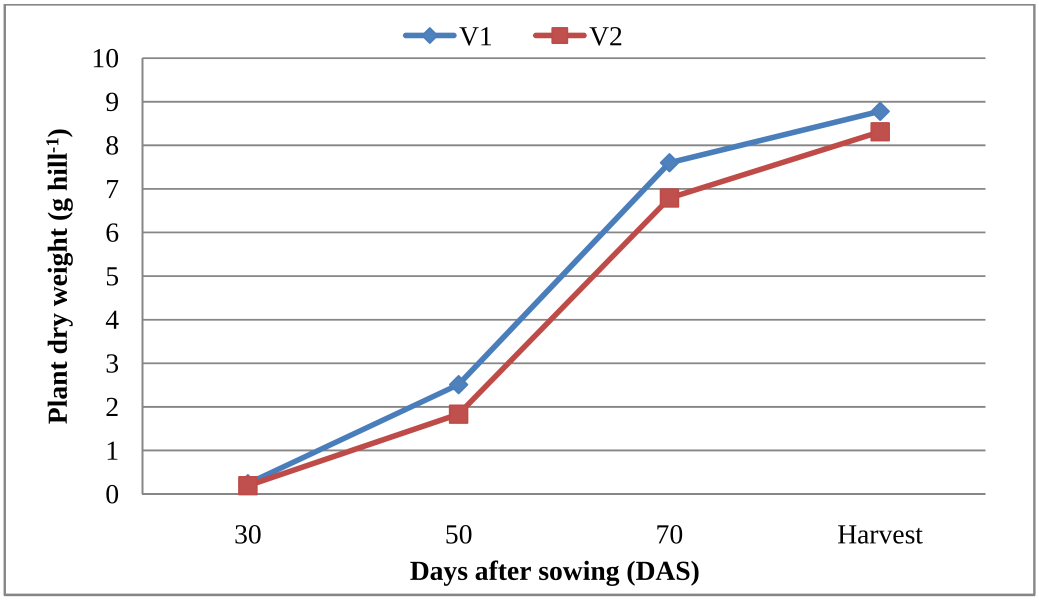
In a column mean values having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

V_1: BRRI dhan65, V_2: Nerica, 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 but all other managements, M_4: Recommended management

4.2.4 Dry matter weight hill^{-1}

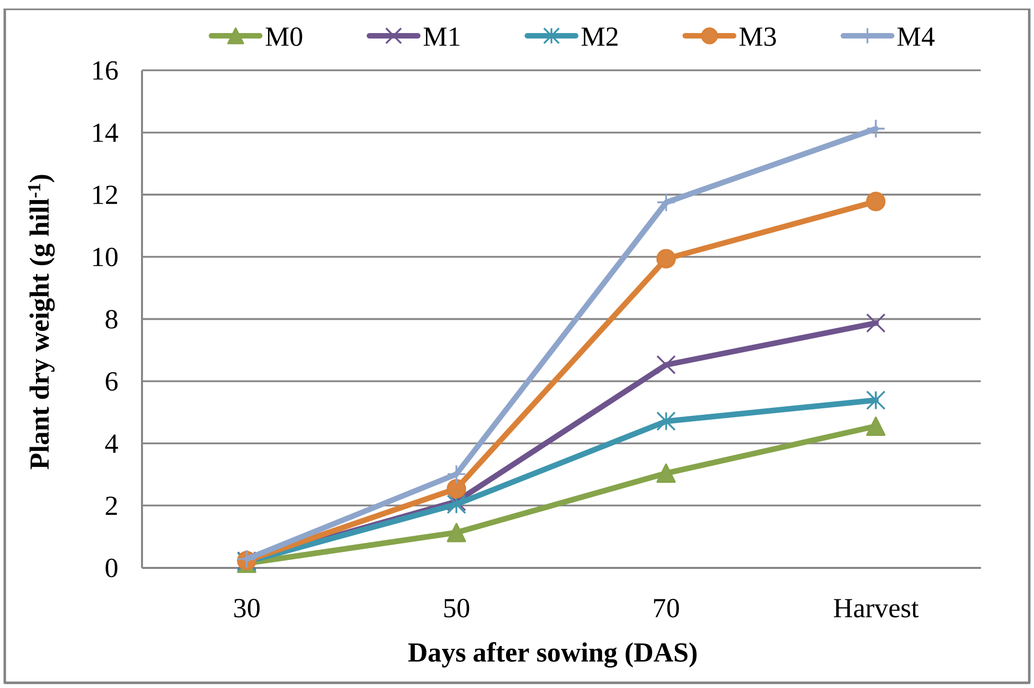
Dry matter weight hill^{-1} varied significantly at 30, 50, 70 DAS and at harvest of BRRI dhan65 and Nerica (Appendix VII). At 30, 50, 70 DAS and harvest the higher dry matter content hill^{-1} (0.24 g, 2.51 g, 7.60 g and 8.78 g, respectively) was recorded from V_1 (BRRI dhan65), whereas the lower (0.19 g, 1.83 g, 6.79 g and 8.31 g) from V_2 (Nerica) (Fig. 7). Amin *et al.* (2006) reported the variation of dry matter among different rice varieties.

Different agronomic managements showed significant variation on dry matter content hill^{-1} at 30, 50, 70 DAS and harvest (Appendix VII). At 30, 50, 70 DAS and at harvest, the highest dry matter content hill^{-1} (0.28g, 3.01g, 11.75g and 14.12g, respectively) was observed from M_4 (recommended management), which was closely followed (0.23 g, 2.54 g, 9.94 g and 11.78 g) by M_3 (no irrigation), 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).



V_1: BRRI dhan65, V_2: Nerica

Figure 7. Effect of variety on plant dry weight hill^{-1} of *Aus* rice (SE=0.997 at harvest).



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 but all other managements, M_4: Recommended management

Figure 8. Effect of agronomic managements on plant dry weight hill^{-1} of *aus* rice (SE= 0.11, 0.51, 0.35 and 0.81 at 30, 50, 70 DAS and harvest, respectively)

Interaction effect of variety and agronomic managements showed statistically differences on dry matter content hill^{-1} at 30, 50, 70 DAS and at harvest (Appendix VII). At 30, 50, 70 DAS and at harvest, the highest dry matter content hill^{-1} (0.31 g, 3.44 g, 12.06 g and 14.48 g, respectively) was observed from V_1M_4 (BRRI dhan65 + recommended management), while the lowest (0.13 g, 1.08 g, 2.84 g and 5.02 g, respectively) from V_2M_0 (Nerica + no management) (Table 8).

Table 8. Interaction effect of variety and agronomic managements on Plant dry weight of *Aus* rice

Treatments	Plant dry weight (g hill^{-1}) at			
	30 DAS	50 DAS	70 DAS	Harvest
V_1M_0	0.15de	1.18f	3.24f	4.09e
V_1M_1	0.26b	2.59bc	7.31d	6.41cd
V_1M_2	0.21c	2.43cd	5.66e	4.41de
V_1M_3	0.26b	2.91b	9.75c	11.46ab
V_1M_4	0.31a	3.44a	12.06a	14.48a
V_2M_0	0.13e	1.08f	2.84f	5.02de
V_2M_1	0.19cd	1.68e	5.76e	7.33c
V_2M_2	0.17c-e	1.65e	3.76fF	6.39cd
V_2M_3	0.21c	2.17d	10.14bc	10.81b
V_2M_4	0.26b	2.58bc	11.44ab	13.76ab
SE	0.02	0.76	0.50	1.14
CV(%)	19.32	17.64	16.98	25.64

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 dhan65, V_2: Nerica, 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 but all other managements, M_4: Recommended management

4.2.5 Number of effective tillers hill^{-1}

Number of effective tillers hill^{-1} at harvest varied numerically for BRRI dhan65 and Nerica under the present trial (Appendix VIII). The higher number of effective tillers hill^{-1} (5.24) was recorded from V_1 (BRRI dhan65), whereas the lower number (4.92) from V_2 (Nerica) (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} (8.50) was observed from M_4 (recommended management), while the lowest number (3.00) was recorded from M_0 (no management) which was closely followed (3.33) by M_2 (no fertilizer) and (3.50) by M_1 (no weeding) and (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} (9.33) was observed from V_1M_4 (BRRI dhan65 + recommended management), while the lowest (2.67) from V_1M_0 (BRRI dhan65 + no management) that was similar to V_1M_2 (3.00), V_1M_1 (3.33) and V_2M_0 (3.33) (Table 10).

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 *Aus* 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	5.24	1.72	6.96	17.53b
V_2	4.92	1.71	6.63	19.84a
SE	NS	NS	NS	0.35
CV(%)	28.63	46.15	18.98	5.13
Agronomic managements				
M_0	3.00c	1.00	4.00c	15.41c
M_1	3.50c	1.83	5.17c	17.99b
M_2	3.33c	1.83	5.33c	17.57b
M_3	7.00b	1.50	8.50b	20.57a
M_4	8.50a	2.33	10.67a	21.91a
SE	0.65	NS	0.87	0.73
CV(%)	21.55	27.83	22.36	6.72

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 dhan65, V_2: Nerica, 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 but all other managements, M_4: Recommended management, NS= Not significant

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

Number of non-effective tillers hill^{-1} at harvest varied numerically for BRRI dhan65 and Nerica under the present trial (Appendix VIII). The higher number of non-effective tillers hill^{-1} (1.72) was recorded from V_1 (BRRI dhan65), whereas the lower number (1.71) from V_2 (Nerica) (Table 9). Islam (1995) in an experiment with four rice cultivars *viz.* BR10, BR11, BR22 and BR23 found that the highest number of non bearing tillers hill^{-1} was produced by cultivar BR11 and the lowest number was produced by the cultivar BR10.

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 *Aus* 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	2.67d	1.33bc	4.00d	14.36e
V_1M_1	3.33d	1.67a-c	5.00cd	16.50d
V_1M_2	3.00d	2.00ab	5.00cd	16.31d
V_1M_3	7.67b	1.00bc	8.67b	19.29c
V_1M_4	9.33a	2.67a	11.67a	21.20b
V_2M_0	3.33d	0.67c	4.00d	16.45d
V_2M_1	3.67d	2.00ab	5.33cd	19.47c
V_2M_2	3.67d	1.67a-c	5.67c	18.83c
V_2M_3	6.33c	2.00ab	8.33b	21.84ab
V_2M_4	7.67b	2.00ab	9.67b	22.61a
SE	0.63	0.57	0.87	0.73
CV(%)	21.55	57.83	22.36	6.72

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 dhan65, V_2: Nerica, 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 but all other managements, M_4: Recommended management

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} (2.33) was observed from M_4 (recommended management), while the lowest number (1.00) 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} (2.67) was observed from V_1M_4 (BRRI dhan65 + recommended management), while the lowest (0.67) from V_2M_0 (Nerica + no management) (Table 10).

4.2.7 Number of total tillers hill^{-1}

Number of total tillers hill^{-1} varied numerically for BRRI dhan65 and Nerica under the present trial (Appendix VIII). The higher number of total tillers hill^{-1} (6.96) was recorded from V_1 (BRRI dhan65), whereas the lower number (6.63) from V_2 (Nerica) (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} (10.67) was observed from M_4 (recommended management), closely followed (8.50) by M_3 (no irrigation), whereas the lowest number (4.00) was recorded from M_0 (no management) which was statistically similar (5.17 and 5.33) to M_2 (no weeding) and M_3 (no fertilizer) respectively) (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} (11.67) was observed from V_1M_4 (BRRI dhan65 + recommended management), that was closely followed by (9.67) V_2M_4 (Nerica + recommended management), (8.67) V_1M_3 (BRRI dhan65 + no irrigation) and (8.33) V_2M_3 (Nerica + no irrigation), while the lowest (4.00) from V_1M_0 (BRRI dhan65 + no management) and V_2M_0 (Nerica + no management) (Table 10).

4.2.8 Length of panicle

Length of panicle varied significantly for BRRI dhan65 and Nerica under the present trial (Appendix VIII). The longer panicle (19.84 cm) was recorded from V_2 (Nerica), whereas the shorter (17.53cm) from V_1 (BRRI dhan65) (Table 9). BINA (1993) evaluated the performance of four varieties IRATOM 24, BR14, BINA13 and BINA19 and found that varieties differed significantly on panicle length.

Different agronomic managements showed significant differences on panicle length (Appendix VIII). The longest panicle (21.91 cm) was observed from M_4 (recommended management), which was statistically similar (20.57 cm) to

M_3 (no irrigation) and closely followed (17.99 cm) by M_2 (no weeding), whereas the shortest (15.41cm) was recorded from M_0 (no management) (Table 9).

Interaction effect of variety and agronomic managements showed statistically differences on panicle length (Appendix VIII). The longest panicle (22.61 cm) was observed from V_2M_4 (Nerica + recommended management), that similar to V_2M_3 (21.84 cm) and V_1M_4 (21.20 cm), while the shortest (14.36 cm) from V_1M_0 (BRRI dhan65 + no management) (Table 10).

4.2.9 Number of filled grains panicle^{-1}

Number of filled grains panicle^{-1} varied significantly for BRRI dhan65 and Nerica under the present trial (Appendix IX). The higher number of filled grains panicle^{-1} (49.09) was recorded from V_2 (Nerica), whereas the lower number (36.58) from V_1 (BRRI dhan65) (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} (71.67) was observed from M_4 (Recommended management), while the lowest number (26.33) was recorded from M_0 (no management) which was statistically similar to (27.83) by M_1 (no weeding) and (33.33) by M_2 (no fertilizer application) (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 (Nerica + recommended management) that similar to V_1M_4 (BRRI dhan65 + recommended management), while the lowest (20.00) from V_1M_0 (BRRI dhan65 + no management) that similar to V_1M_2 (22.00), V_1M_0 (25.00) and V_2M_1 (30.67) (Table 12).

4.2.10 Number of unfilled grains panicle^{-1}

Number of unfilled grains panicle^{-1} varied numerically for BRRI dhan65 and Nerica under the present trial (Appendix IX). The lower number of unfilled grains panicle^{-1} was recorded (23.71) from V_1 (BRRI dhan65), whereas the higher number (27.25) from V_2 (Nerica) (Table 11). BINA (1993) evaluated the performance of four varieties IRATOM 24, BR14, BINA13 and BINA19 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 lowest number of unfilled grains panicle^{-1} (19.33) was observed from M_0 (no management), which was closely followed (19.67) by M_2 (no fertilizer application), while the highest number (29.67) was recorded from M_1 (no weeding) and M_4 (recommended management) which was closely followed (29.17) by M_3 (no irrigation) (Table 11).

Table 11. Effect of variety and agronomic managements on number of filled, unfilled, total grains panicle^{-1} and weight of 1000 grains of *Aus* 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				
V_1	36.58b	23.71	60.29b	22.02
V_2	49.09a	27.25	76.34a	22.51
SE	2.26	NS	1.01	NS
CV(%)	14.46	13.73	4.04	6.71
Agronomic managements				
M_0	26.33c	19.33b	45.67b	20.36c
M_1	27.83c	29.67a	57.50b	21.96b
M_2	33.33c	19.67b	52.83b	22.31b
M_3	55.33b	29.17a	84.50a	23.11ab
M_4	71.67a	29.67a	101.3a	23.56a
SE	6.20	3.10	7.45	0.51
CV(%)	25.03	21.28	18.99	3.99

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 dhan65, V_2: Nerica, 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 but all other managements, M_4: Recommended management, NS= Not significant

Table 12. Interaction effect of variety and agronomic managements on number of filled, unfilled, total grains panicle^{-1} and weight of 1000 grains of *Aus* 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	20.00e	17.00ef	37.00d	20.78e
V_1M_1	25.00de	22.33de	47.33cd	21.62d
V_1M_2	22.00de	16.33f	38.33d	22.19cd
V_1M_3	47.67c	29.67bc	77.33b	22.59c
V_1M_4	68.67ab	33.33ab	102.00a	22.89bc
V_2M_0	32.67d	21.67d-f	54.33c	19.95e
V_2M_1	30.67de	37.00a	67.67b	22.30cd
V_2M_2	44.67c	23.00d	67.33b	22.42cd
V_2M_3	63.00b	28.67bc	91.67a	23.63ab
V_2M_4	74.67a	26.00cd	100.7a	24.22a
SE	4.20	3.13	5.59	0.51
CV(%)	20.03	16.28	13.99	3.99

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 dhan65, V_2: Nerica, 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 but all other managements, M_4: Recommended management

Interaction effect of variety and agronomic management showed significant differences on number of unfilled grains panicle^{-1} (Appendix IX). The lowest number of unfilled grains panicle^{-1} (16.33) was observed from V_1M_2 (BRRI dhan65 + no irrigation) that similar to V_1M_0 (17.00) and V_1M_0 (21.67), while the highest number (37.00) from V_2M_1 (Nerica + no weeding) and at par with (33.33) V_1M_4 (BRRI dhan65 + recommended management) (Table 12).

4.2.11 Number of total grains panicle^{-1}

Number of total grains panicle^{-1} varied significantly for BRRI dhan65 and Nerica under the present trial (Appendix IX). The higher number of total grains panicle^{-1} (76.34) was recorded from V_2 (Nerica), whereas the lower number (60.29) from V_1 (BRRI dhan65) (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} (101.34) was observed from M_4 (recommended management), which was statistically identical (84.50) by M_3 (no irrigation), while the lowest number (45.67) was recorded from M_0 (no management) which was closely followed (52.83) by M_2 (no fertilizer application) and (57.50) by M_1 (no weeding) (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} (102.00) was observed from V_1M_4 (BRRI dhan65 + recommended management) that similar to V_2M_4 (100.67) and V_2M_3 (91.67), while the lowest (37.00) from V_1M_0 (BRRI dhan65 + no management) that similar to V_1M_2 (38.33) (Table 12).

4.2.12 Weight of 1000 grains

Weight of 1000 grains was not varied significantly for BRRI dhan65 and Nerica under the present trial (Appendix IX). The higher weight of 1000 grains (22.51g) was recorded from V_2 (Nerica), whereas the lower weight (22.02g) from V_1 (BRRI dhan65) (Table 11).

Different agronomic managements showed significant differences on weight of 1000 grains (Appendix IX). The highest weight of 1000 grains (23.56 g) was observed from M_4 (recommended management), which was similar to M_3 (23.11 g), while the lowest weight (20.36 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 (24.22g) was observed from V_2M_4 (Nerica + recommended management) that similar to V_2M_3 (23.63 g), while the lowest weight (19.95 g) from V_1M_0 (Nerica + no management) that similar to V_2M_0 (20.78 g) (Table 12).

4.2.13 Grain yield

Grain yield was not varied significantly for BRRI dhan65 and Nerica under the present trial (Appendix X). The higher grain yield (0.96 t ha^{-1}) was recorded from V_2 (Nerica), whereas the lower yield (0.95 t ha^{-1}) from V_1 (BRRI dhan65) (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 (2.39 t ha^{-1}) was observed from M_4 (recommended management), which was closely followed (1.62 t ha^{-1}) by M_3 (no irrigation), while the lowest grain yield (0.14 t ha^{-1}) was recorded from M_0 (no management) which was statistically similar to (0.31 t ha^{-1}) by M_1 (no weeding) and (0.33 t ha^{-1}) by M_2 (no fertilizer application) (Table 13). No management reduced 94% grain yield of *aus* rice that followed by 87% for no weeding and 86% for no fertilizer application. No irrigation reduced 32% 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 (2.43 t ha^{-1}) was observed from V_1M_4 (BRRI dhan65 + recommended management) which was similar to (2.36 t ha^{-1}) V_2M_4 (Nerica + recommended management), while the lowest yield (0.12 t ha^{-1}) from V_1M_0 (BRRI dhan65 + no management) which similar to (0.15 t ha^{-1}) V_2M_0 (Nerica + no management), (0.23 t ha^{-1}) V_1M_1, (0.27 t ha^{-1}), (0.38 t ha^{-1}) V_2M_1 and V_2M_2 (Table 14).

4.2.14 Straw yield

Straw yield varied numerically for BRRI dhan65 and Nerica under the present trial (Appendix X). The higher straw yield (2.75 t ha^{-1}) was recorded from V_2 (Nerica), whereas the lower yield (2.67 t ha^{-1}) from V_1 (BRRI dhan65) (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.

Different agronomic managements showed significant differences on straw yield (Appendix X). The highest straw yield (5.30 t ha^{-1}) was observed from M_4 (recommended management), which was closely followed (3.87t ha^{-1}) by M_3 (no irrigation), while the lowest straw yield (0.94 t ha^{-1}) was recorded from M_0 (no management) which was similar to (1.45 t ha^{-1}) and (1.98 t ha^{-1}) by M_1 (no weeding) and M_2 (no fertilizer), respectively (Table 13). Moorthy and Das (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 13. Effect of variety and agronomic managements on grain, straw and biological yield and harvest index of *Aus* rice

Treatments	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
Variety				
V_1	0.95	2.67	3.63	19.45
V_2	0.96	2.75	3.71	21.52
SE	NS	NS	NS	NS
CV(%)	24.59	3.21	5.11	24.70
Agronomic managements				
M_0	0.14c	0.94c	1.08c	12.97c
M_1	0.31c	1.45c	1.77c	12.90c
M_2	0.33c	1.98c	2.29c	17.51b
M_3	1.62b	3.87b	5.48b	28.53a
M_4	2.39a	5.30a	7.70a	30.51a
SE	0.24	0.37	0.58	1.37
CV(%)	22. 08	18.32	17.24	11.61

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 dhan65, V_2: Nerica, 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 but all other managements, M_4: Recommended management, NS= Not significant

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

Treatments	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
V_1M_0	0.12c	1.03de	1.15d	10.74f
V_1M_1	0.23c	1.58d	1.82cd	12.28ef
V_1M_2	0.27c	1.32de	1.59d	15.82d
V_1M_3	1.70b	4.12b	5.82b	28.06b
V_1M_4	2.43a	5.31a	7.74a	30.38ab
V_2M_0	0.15c	0.85e	1.01d	15.19d
V_2M_1	0.38c	2.38c	2.77c	13.53de
V_2M_2	0.38c	1.58d	1.96d	19.20c
V_2M_3	1.53b	3.62b	5.15b	29.01ab
V_2M_4	2.36a	5.23a	7.66a	30.65a
SE	0.237	0.365	0.576	1.373
CV(%)	22. 08	18.32	17.24	11.61

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 dhan65, V_2: Nerica, 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 but all other managements, M_4: Recommended management

Interaction effect of variety and agronomic managements showed significant differences on straw yield (Appendix X). The highest straw yield (5.31 t ha^{-1}) was observed from V_1M_4 (BRRI dhan65 + compete management) that similar to (5.23 t ha^{-1}) V_2M_4 (Nerica + compete management), while the lowest yield (0.85 t ha^{-1}) from V_2M_0 (Nerica + no management) that similar to (1.03 t ha^{-1}) V_1M_0 (BRRI dhan65 + no management) (Table 14).

4.2.15 Biological yield

Biological yield per hectare varied numerically for BRRI dhan65 and Nerica under the present trial (Appendix X). The higher biological yield (3.71 t ha^{-1}) was recorded from V_2 (Nerica), whereas the lower yield (3.63 t ha^{-1}) from V_1 (BRRI dhan65) (Table 13).

Different agronomic managements showed significant differences on biological yield per hectare (Appendix X). The highest biological yield (7.70 t ha^{-1}) was observed from M_4 (recommended management), while the lowest biological yield (1.08 t ha^{-1}) was recorded from M_0 (no management) which was similar to (1.77 t ha^{-1}) and (2.29 t ha^{-1}) by M_1 (no weeding) and 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 (7.74 t ha^{-1}) was observed from V_1M_4 (BRRI dhan65 + recommended management) which is similar to (7.66 t ha^{-1}) V_2M_4 (Nerica + recommended management), while the lowest yield (1.01 t ha^{-1}) from V_2M_0 (Nerica + no management) that is similar to V_1M_0 (1.15 t ha^{-1}), V_1M_2 (1.59 t ha^{-1}) and V_2M_2 (1.96 t ha^{-1}) (Table 14).

4.2.16 Harvest index

Harvest index varied non-significantly for BRRI dhan65 and Nerica under the present trial (Appendix X). The maximum harvest index (21.52%) was recorded from V_2 (Nerica), whereas the minimum (19.45%) from V_1 (BRRI dhan65) (Table 13).

Different agronomic managements showed significant differences on harvest index (Appendix X). The maximum harvest index (30.51%) was observed from M_4 (recommended management), which was statistically similar (28.53%) by M_3 (no irrigation), while the minimum harvest index (12.90%) was recorded from M_1 (no weeding) which was similar to (12.97%) by M_0 (no management) (Table 13).

Interaction effect of variety and agronomic managements showed significant differences on harvest index (Appendix X). The maximum harvest index (30.65%) was observed from V_2M_4 (Nerica + recommended management) that similar to V_1M_4 (30.38%) and V_2M_3 (29.01%), while the minimum (10.74%) from V_1M_0 (BRRI dhan65 + no management) that was similar to (12.28%) V_1M_1 (BRRI dhan65 + no weeding) (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 March, 2018 to June, 2018 to study the growth and yield of *Aus* rice as affected by agronomic managements. The experiment comprised as two factors. Factor A: Variety: 2 levels; BRRI dhan65-V_1; Nerica-V_2; Factor B: Agronomic management: 5 levels; No management-M_0; No weeding- M_1; No fertilizer application-M_2; No irrigation-M_3 and Recommended management-M_4. 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 *Aus* rice.

Weed data were recorded at 65 DAS, it was found that the higher numbers of weeds (277.73 m^{-2}) were found in the Nerica cultivated plot whereas the lower number (174.93 m^{-2}) was found in BRRI dhan65. The maximum weight of weed biomass (94.91 g m^{-2}) was found in the Nerica cultivated plots, whereas the lower weight (83.72 g m^{-2}) was found in BRRI dhan65.

The lowest weed population (26.67 m^{-2}) was recorded in M_4, while the highest weed population (520.70 m^{-2}) was found in the M_0. The lowest weight of weed biomass (1.96 g m^{-2}) was recorded in M_2, while the highest weight (329.90 g m^{-2}) was found in the M_1 plot.

The maximum (732.00 m^{-2}) weed population was observed in V_2M_0 and the lowest (24.00 m^{-2}) population observed in V_2M_4. The maximum (367.10 g m^{-2}) weed biomass was observed in V_1M_1 and lowest weight (1.68 g m^{-2}) observed in V_1M_2.

At 30, 50, 70 DAS and harvest the taller plant (24.61 cm, 41.27 cm, 60.23 cm and 80.28 cm, respectively) was recorded from V_2, whereas the shorter plant (24.44 cm, 44.25 cm, 56.32 cm and 71.81 cm) from V_1.

At 30, 50 and 70 DAS the higher number of tillers hill^{-1} (1.46, 9.16 and 8.54, respectively) was recorded from V_1, whereas the lower number (1.33, 7.73 and 6.91, respectively) from V_2. At 30, 50 and 70 DAS, the higher number of leaves hill^{-1} (4.78, 39.73 and 44.63, respectively) was recorded from V_1, whereas the lower (4.69, 32.97 and 34.80) from V_2. At 30, 50, 70 DAS and harvest the higher dry matter weight hill^{-1} (0.24 g, 2.51 g, 7.60 g and 8.78 g, respectively) was recorded from V_2, whereas the lower (0.19 g, 1.83 g, 6.79 g and 8.31 g) from V_1. The higher number of effective tillers hill^{-1} (5.24) was recorded from V_1, whereas the lower number (4.92) from V_2. The higher number of non-effective tillers hill^{-1} (1.72) was recorded from V_1, whereas the lower number (1.71) from V_2. The higher number of total tillers hill^{-1} (6.87) was recorded from V_1, whereas the lower number (6.60) from V_2. The longer panicle (19.84 cm) was recorded from V_2, whereas the shorter (17.53cm) from V_1. The higher number of filled grains panicle^{-1} (49.09) was recorded from V_2, whereas the lower number (36.58) from V_1. The lower number of unfilled grains panicle^{-1} was recorded (23.71) from V_1, whereas the higher number (27.25) from V_2. The higher number of total grains panicle^{-1} (76.34) was recorded from V_2, whereas the lower number (60.29) from V_1. The higher weight of 1000 grains (22.51g) was recorded from V_2, whereas the lower weight (22.02g) from V_1. The higher grain yield (0.96 t ha^{-1}) was recorded from V_2 , whereas the lower yield (0.95 t ha^{-1}) from V_1. The higher straw yield (2.75 t ha^{-1}) was recorded from V_2, whereas the lower yield (2.67 t ha^{-1}) from V_1. The higher biological yield (3.71 t ha^{-1}) was recorded from V_2, whereas the lower yield (3.63 t ha^{-1}) from V_1. The maximum harvest index (21.52%) was recorded from V_2, whereas the minimum (19.45%) from V_1.

At 30, 50, 70 DAS and at harvest, the tallest plant (27.11 cm, 49.66 cm, 71.49 cm and 91.07 cm, respectively) was observed from M_4, while the shortest plant (22.73 cm, 35.07 cm, 42.33 cm and 60.31 cm, respectively) from M_0. At 30, 50 and 70 DAS, the highest number of tillers hill^{-1} (2.00, 13.67 and 12.00, respectively) was observed from M_4, while the lowest number (1.00, 5.16 and 4.83, respectively) from M_0. At 30, 50 and 70 DAS, the highest number of leaves hill^{-1} (5.38, 55.93 and 61.13, respectively) was observed from M_4, while the lowest d number of leaves hill^{-1} (3.96, 20.07 and 24.20, respectively) was recorded from M_0. At 30, 50, 70 DAS and at harvest, the highest dry matter weight hill^{-1} (0.28g, 3.01g, 11.75g and 14.12g, respectively) was observed from M_4, 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} (8.50) was observed from M_4, while the lowest number (3.00) was recorded from M_0. The highest number of non-effective tillers hill^{-1} (2.33) was observed from M_4, while the lowest number (1.00) was recorded from M_0. The highest number of total tillers hill^{-1} (10.67) was observed from M_4, whereas the lowest number (4.00) was recorded from M_0. The longest panicle (21.91 cm) was observed from M_4, whereas the shortest (15.41cm) was recorded from M_0. The highest number of filled grains panicle^{-1} (71.67) was observed from M_4, while the lowest number (26.33) was recorded from M_0. The lowest number of unfilled grains panicle^{-1} (19.33) was observed from M_0, while the highest number (29.67) was recorded from M_1. The highest number of total grains panicle^{-1} (101.34) was observed from M_4, while the lowest number (45.67) was recorded from M_0. The highest weight of 1000 grains (23.56 g) was observed from M_4, while the lowest weight (20.36 g) was recorded from M_0. The highest grain yield (2.39 t ha^{-1}) was observed from M_4, while the lowest grain yield (0.14 t ha^{-1}) was recorded from M_0. No management reduced 94% yield of *Aus* rice whereas the reduction was 87, 86 and 32% for no weeding, no fertilizer and no irrigation, respectively. The highest straw yield (5.30 t ha^{-1}) was observed from M_4, while the lowest straw yield (0.94 t ha^{-1}) was recorded from M_0. The highest biological yield (7.70 t ha^{-1}) was observed from M_4, while the lowest biological yield (1.08 t ha^{-1}) was recorded from M_0. The maximum harvest index (30.51%) was observed from M_4, while the minimum harvest index (12.90%) was recorded from M_1.

At 30, 50, 70 DAS and at harvest the tallest plant (27.33 cm, 47.66 cm, 74.52 cm and 94.48 cm, respectively) was observed from V_2M_4, while the shortest (22.40 cm, 35.27 cm, 42.05 cm and 57.88 cm, respectively) from V_1M_0. At 30, 50 and 70 DAS, the highest number of tillers hill^{-1} (2.00, 14.33 and13.00, respectively) was observed from V_1M_4, while the lowest (1.00, 4.33 and 4.00, respectively) from V_2M_0. At 30, 50, 70 DAS and at harvest the highest number of leaves hill^{-1}

(5.40, 60.00 and 70.40, respectively) was observed from V_1M_4, while the lowest (3.87, 17.07 and 20.53, respectively) from V_2M_0. At 30, 50, 70 DAS and at harvest, the highest dry matter content hill^{-1} (0.31 g, 3.44 g, 12.06 g and 14.48 g, respectively) was observed from V_1M_4, while the lowest (0.13 g, 1.08 g, 2.84 g and 5.02 g, respectively) from V_2M_0. The highest number of effective tillers hill^{-1} (9.33) was observed from V_1M_4, while the lowest (2.67) from V_1M_0. The highest number of non-effective tillers hill^{-1} (2.67) was observed from V_1M_4, while the lowest (0.67) from V_2M_0. The highest number of total tillers hill^{-1} (11.67) was observed from V_1M_4, while the lowest (4.00) from V_1M_0 and V_2M_0. The longest panicle (22.61 cm) was observed from V_2M_4, while the shortest (14.36 cm) from V_1M_0. The highest number of filled grains panicle^{-1} (74.67) was observed from V_2M_4, while the lowest (20.00) from V_1M_0. The lowest number of unfilled grains panicle^{-1} (16.33) was observed from V_1M_2, while the highest number (37.00) from V_2M_1. The highest number of total grains panicle^{-1} (102.00) was observed from V_1M_4, while the lowest (37.00) from V_1M_0. The highest weight of 1000 seeds (24.22g) was observed from V_2M_4, while the lowest weight (19.95 g) from V_1M_0. The highest grain yield (2.43 t ha^{-1}) was observed from V_1M_4, while the lowest yield (0.12 t ha^{-1}) from V_1M_0. The highest reduction in BRRI dhan65 was 95% in no management that followed by 89% for no weeding & no fertilizer treatments whereas the rate was 94, 84% for the other variety Nerica. The highest straw yield (5.31 t ha^{-1}) was observed from V_1M_4, while the lowest yield (0.85 t ha^{-1}) from V_2M_0. The highest biological yield (7.74 t ha^{-1}) was observed from V_1M_4, while the lowest yield (1.01 t ha^{-1}) from V_2M_0. The maximum harvest index (30.65%) was observed from V_2M_4 (Nerica + recommended management), while the minimum (10.74%) from V_1M_0.

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 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 hHigh 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 (ºC)		*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 *Aus* rice as influenced by variety and 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**	**260129.73**	**11522.62**
Variety (A)	1	79258.80^{NS}	938.22 ^{NS}
Error (a)	2	68306.80	1723.86
Agronomic managements (B)	4	418747.33**	121592.83**
Interaction (A×B)	4	49641.46**	1976.76**
Error (b)	16	74315.60	4237.41

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

Appendix IV. Analysis of variance of the data on plant height of *Aus* rice as influenced by variety and agronomic managements

Source of variation	Degrees of freedom	Mean square			
		Plant height at			
		30 DAS	50 DAS	70 DAS	Harvest
Replication	2	27.039	99.002	164.230	426.154
Variety (A)	1	0.205^{NS}	66.424^{NS}	114.622^{NS}	539.158**
Error (a)	2	6.181	72.436	75.418	7.466
Agronomic managements (B)	4	17.663**	231.183**	992.468**	999.677**
Interaction (A×B)	4	1.012**	8.061**	8.792**	10.840**
Error (b)	16	2.084	4.926	9.969	19.395

**: 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 *Aus* rice as influenced by variety and agronomic managements

Source of variation	Degrees of freedom	Mean square		
		Number of tillers hill^{-1} at		
		30 DAS	50 DAS	70 DAS
Replication	2	5.597	28.901	12.705
Variety (A)	1	0.133^{NS}	15.265^{NS}	20.172*
Error (a)	2	0.133	5.669	1.812
Agronomic managements (B)	4	1.383**	65.835**	49.775**
Interaction (A×B)	4	0.050**	0.649**	0.619**
Error (b)	16	0.067	1.577	0.749

**: 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 number of leaves hill^{-1} of *Aus* rice as influenced by variety and agronomic managements

Source of variation	Degrees of freedom	Mean square		
		Number of leaves at		
		30 DAS	50 DAS	70 DAS
Replication	2	3.052	327.20	397.72
Variety (A)	1	0.065^{NS}	342.73^{NS}	724.23*
Error (a)	2	1.281	120.03	29.30
Agronomic managements (B)	4	1.570**	1290.75**	1410.83**
Interaction (A×B)	4	0.05**	12.38**	40.28**
Error (b)	16	0.067	25.25	13.17

**: 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 dry matter hill^{-1} of *Aus* rice as influenced by variety and agronomic managements

Source of variation	Degrees of freedom	Mean square			
		Dry matter hill^{-1} at			
		30 DAS	50 DAS	70 DAS	Harvest
Replication	2	0.0071	3.5781	28.2165	58.8694
Variety (A)	1	0.0172^{NS}	3.4340^{NS}	4.9695^{NS}	1.6615^{NS}
Error (a)	2	0.0024	1.0278	21.7021	1.0748
Agronomic managements (B)	4	0.0169**	2.9153**	78.2760**	47.7801**
Interaction (A×B)	4	0.0004**	0.162**	1.269**	2.104**
Error (b)	16	0.0017	0.1465	2.5020	3.9080

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

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

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	17.796	0.505	21.233	19.661
Variety (A)	1	0.768^{NS}	0.001^{NS}	0.533^{NS}	39.975*
Error (a)	2	2.116	0.625	1.633	0.918
Agronomic managements (B)	4	36.922**	1.339^{NS}	45.717**	39.637**
Interaction (A×B)	4	1.991**	0.915**	1.617**	0.524**
Error (b)	16	1.258	1.024	2.267	1.576

**: 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 seeds of *Aus* rice as influenced by variety and agronomic managements

Source of variation	Degrees of freedom	Mean square			
		Number of filled grains plant^{-1}	Number of unfilled grains plant^{-1}	Number of total grains plant^{-1}	Weight of 1000 Seed
Replication	2	1068.14	24.628	1094.31	6.600
Variety (A)	1	1173.88*	94.200^{NS}	1932.98**	1.801^{NS}
Error (a)	2	38.36	12.247	7.60	2.230
Agronomic managements (B)	4	2362.56**	178.390**	3332.19**	9.139**
Interaction (A×B)	4	75.19**	102.441**	186.78**	1.066**
Error (b)	16	115.20	28.868	166.55	0.791

**: 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 *Aus* rice as influenced by variety and agronomic managements

Source of variation	Degrees of freedom	Mean square			
		Grain yield	Straw yield	Biological yield	Harvest index
Replication	2	1.621	7.540	16.110	95.80
Variety (A)	1	0.000^{NS}	0.043^{NS}	0.050^{NS}	31.87^{NS}
Error (a)	2	0.055	0.008	0.035	25.60
Agronomic managements (B)	4	5.975**	19.963**	47.545**	432.26**
Interaction (A×B)	4	0.025**	0.363**	0.553**	4.71**
Error (b)	16	0.168	0.400	0.995	5.66

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