PERFORMANCE OF AUS RICE VARIETIES WITH SUPPLEMENTAL IRRIGATION, FERTILIZER AND WEED MANAGEMENTS

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CERTIFICATE

This is to certify that the thesis entitled **'PERFORMANCE OF AUS RICE VARIETIES WITH SUPPLEMENTAL IRRIGATION, FERTILIZER AND WEED MANAGEMENTS'** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka-1207, in partial fulfilment of the requirements for the degree of **DOCTOR OF PHILOSOPHY in AGRONOMY**, embodies the result of a piece of *bonafide* research work carried out by **MD. MAINUL BASHER**, Registration No.: **13-05804** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that any help or source of information, received during the course of this investigation has duly been acknowledged.

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TO

MY BELOVED PARENTS

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PERFORMANCE OF AUS RICE VARIETIES WITH SUPPLEMENTAL IRRIGATION, FERTILIZER AND WEED MANAGEMENTS

ABSTRACT

Field experiments were initiated in the month of April and ending in August through the year 2015 to 2017 at Sher-e-Bangla Agricultural University. In Experiment-I, twelve Aus rice varieties BR-3, BR-14, BR-16, BRRI dhan27, BRRI dhan42, BRRI dhan48, BRRI dhan55, BRRI dhan65, China (Muladi local), Kali Shait-ta (Muladi local), Benamuri (Muladi local) and Abdul Hye (Jhalkathi local) were tested under two irrigation regimes (with and without irrigation). Results showed significantly higher grain yield (4.22 t ha^{-1}) under irrigated as compared to that of the non-irrigated one (3.90 t ha^{-1}). Out of twelve, the local varieties yielded 27% lower (2.90-3.61 with an average of 3.26 t ha^{-1}) than the modern varieties (3.85-5.22, average 4.46 t ha^{-1}). Experiment-II was conducted with two regimes of irrigation (with and without) and four varieties (BRRI dhan14, BRRI dhan48, BRRI dhan55 and BRRI dhan65) found outstanding in first experiment. Results revealed that the irrigated crop produced the higher grain yield (5.17 t ha^{-1}), while the non-irrigated ones (4.44 t ha^{-1}). Across the varieties, BRRI dhan14, BRRI dhan48 and BRRI dhan55 out yielded (4.95-5.30 t ha^{-1}). But the combined effect of varieties BRRI dhan14 and BRRI dhan48 with irrigation gave significantly higher grain yield (5.63 and 5.69 t ha^{-1}). In the Experiment-III, three levels of fertilizer (recommended, 20% higher the recommended and 20% lower than recommended) and four varieties (BRRI dhan14, BRRI dhan48, BRRI dhan55 and BRRI dhan65) were tested. The recommended and higher dose contributed the significantly higher grain yield (5.23 and 4.95 t ha^{-1}). Among the varieties, BRRI dhan14, BRRI dhan48 and BRRI dhan55 yielded significantly higher (5.01-5.40 t ha^{-1}). In Experiment-IV, four varieties (BRRI dhan14, BRRI dhan48, BRRI dhan55 and BRRI dhan65) were subjected to two weeding treatments (un-weeded and hand weeded) and results showed that the weeded crop had significantly higher grain yield (5.18 t ha^{-1}) compared to the unweeded one (4.66 t ha^{-1}). Under weeded condition, the variety BRRI dhan48 produced much higher grain yield (5.73 t ha^{-1}) compared with those of other varieties. In the Experiment-V, BRRI dhan48 was grown under two irrigation regimes (with or without supplemental irrigation), two fertilizer doses (recommended and 20% higher the recommended) and three weeding methods (hand weeding, pre-emergence herbicide and weeding by BRRI hand weeder). Combination of irrigation, recommended fertilizer and weeding by pre-emergence herbicide showed the highest grain yield (5.79 t ha^{-1}) of the variety.

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LIST OF ABBREVIATIONS

ABBREVIATION	FULL WORD
AEZ	Agro-Ecological Zone
BBS	Bangladesh Bureau of Statistics
BRRI	Bangladesh Rice Research Institute
CV	Coefficient of Variance
DAT	Days after transplanting
et al.	and others
ETS	Early Tillering Stage
FAO	Food and Agriculture Organization
FAOSTAT	Food and Agriculture Organization Corporate
FS	Flowering Stage
GFS	Grain Filling Stage
IRRI	International Rice Research Institute
kg	Kilogram
LAI	Leaf area index
LSD	Least significant difference
m^2	Square meter
MS	Maturity Stage
Mt ha^{-1}	Metric ton per hectare
MTS	Maximum Tillering Stage
MV	Modern varieties
PE	Panicle Emergence
PI	Panicle Initiation
t ha^{-1}	Ton per hectare
TDM	Total dry matter
UNDP	United Nations Development Program
USDA	United States Department of Agriculture
viz.	Namely

Chapter 1

Introduction

CHAPTER 1

INTRODUCTION

Rice (*Oryza sativa* L.), belonging to the family Poaceae, is the principal staple food for more than 50% of the world's population (Jahan *et al.*, 2017), especially for the 90% population contributing 30% to total calorie intake of the Asian people (FAO, 2018; Hien *et al.*, 2006). The world production of rice amounts 474.86 million metric tons from 159.64 million hectares of land (USDA, 2015). In Bangladesh 11.39 million hectares of land is used for rice production which is about 72.24% of total cropped area, with annual production of 34.71 million tons (BBS, 2017). Bangladesh ranks 4th in both area and production and 6th in the production of per hectare yield of rice (Sarkar *et al*., 2016).

However, due to the continuous increase in world's population, it is estimated that in comparison to the rice production of the year 2011, additional 114 million tonnes of milled rice need to be produced by 2035 which is equivalent to overall increase of 26 per cent in the next 25 years (Kumar and Ladha, 2011). Likewise, the population in Bangladesh will swell progressively to 223 million by the year of 2030 which will demand additional more than 48 million tons of food grains (Bhuiyan *et al*., 2014). To meet up the food supply for this over population, Bangladesh needs to increase rice production around 37.26 million tons from the year of 2020 (BRRI, 2016).

Rice is grown in three seasons namely Aus (mid-March to mid-August), Aman (mid-June to November) and Boro (Mid December to mid-June). Aus, Aman and Boro rice covers about 8.35%, 30.75% and 33.14%, respectively of the total crop areas of Bangladesh and producing 2,134; 13,656 and 18,014 thousands tons, respectively of which boro rice has the maximum productivity while the aus the least productivity (BBS, 2017). According to FAO (2018) the average yield of rice in Bangladesh is about 3.12 t ha^{-1} which is very low compared to other rice growing countries of the world, like China (6.30 t ha^{-1}), Japan (6.60 t ha^{-1}) and South Korea (6.30 t ha^{-1}).

The Aus rice area and production is decreasing continuously comparing to Boro, which is dominated rice crop in Bangladesh. Boro rice cultivation fully depends on irrigation and the pressure of ground water is increasing day by day and ground water level is going down but moreover boro rice cultivation is strongly competitive to othe rabi crops such as wheat, oilseeds, maize, pulses and spices. Furthermore, due to the increased irrigation cost and reduced market price, farmers frequently suffers loss in growing boro rice.

Aus rice requires only 5% supplemental irrigation and the pressure of ground water is required to be low for Aus than Boro. It is necessary to transfer Boro cultivated area to Aus and also make sure the food security of the country (Rahman *et al*., 2016). The government of Bangladesh has also launched an incentive programme for farmers with an attempt to rejuvenate Aus rice cultivation (Uddin and Dhar, 2018).

Generally, variety is the key component for producing higher yield of rice depending upon their differences in genotypic characters, input requirements and off course the prevailing environmental conditions during the entire growing season (Haque and Biswas, 2011; Huang and Yan,2016). Very recently various new aus rice varieties were developed by Bangladesh Rice Research Institute (BRRI). Farmers are also growing some local varieties for centuries. So, it is also essential to compare how much more productive the modern high yielding varieties compared to the local ones.

Water is one of the most important requirements of rice production. Rice production under irrigated condition is the leading consumer of water in the agricultural sector, and its sustainability is intimidated by increasing water scarcity (Arora, 2006). Aus paddy is planted during the month March-April and so may suffer from soil moisture stress demanding suppelemental irrigation during the early part of the vegetative stage and the scarcity of soil moisture in this vegetative stage may be crucial in determing the later growth and in turn the yield of the Aus rice (Rahman *et al*., 2016; Islam *et al*., 2017). Moreover, although the start of rainfall in Bangladesh initiates in the month of March, its pattern is erratic and not uniform during the later months posing the crop to suffer from soil moisture stress if not irrigated. So, it is essential to evaluate the performance of Aus rice varieties both in the rainfed and supplemental (when needed at low soil moisture condition) irrigated condition after having been sown in March or April.

Fertilizers today hold the key role to success of production systems of Bangladesh agriculture being responsible for over 50% of the total crop production. Among the production factors affecting crop yield, essential nutrient is the single most important factor that plays a dominant role in yield increase if other production factors are not limiting. However, in Bangladesh, there is tendency to use indiscriminate amount of nitrogenous fertilizers and very limited amount of other nutrients' containing high analysis chemical fertilizers (Rahman *et al.*, 2008). Excess use of fertilizer nutrients implies increase of cost and decrease of returns and risk of environmental pollution. In the contrary application of inadequate and unbalanced fertilization to crops not only results in low crop yields but also deteriorate the soil health (Sharma *et al.*, 2003).

Weeds are often called plants out of place and they are unwanted, prolific, competitive, often harmful to the environment and they occur in the every rice field of the world which is one of the major among several other constrains. Any delay in weeding will lead to increased weed biomass as a result drastic reduction in yield (BRRI, 2008; Kishore *et al.*, 2016). As suggested by Di Tomaso (1995), manipulating fertilization strategies reduces weed interference in crops. Varying fertilizer doses (Cathcart and Swanton, 2003), application timings (Blackshaw *et al.*, 2004) and methods (Mesbah and Miller, 1999) can modify weed crop competition for better yield harvest.

So, it is essential to generate a package for the production of aus rice optimizing the irrigation benefits, fertilizer application and weed control. Under this circumstance the present research work has been taken with the following objectives:

Objectives:

- To identify productive Aus rice varieties to be grown under irrigated and non irrigated conditions;
- To evaluate of the efficacy of varying doses of fertilizer for Aus rice varieties;
- To examine the performance of different methods of weed control in Aus rice and
- To evaluate the interaction effect of irrigation, fertilizer and weed control methods on the growth and yield of Aus rice.

Chapter 2
Review of literature

CHAPTER 2

REVIEW OF LITERATURE

Rice is the staple food more than three billion people in the world and around ninety per cent of rice is grown and consumed in south and Southeast Asia, the highly populated area. Bangladesh produces different high yielding rice varieties and most of them have excellent production and eating quality for regular consumption. Most of the high yielding rice varieties of Bangladesh have been developed by IRRI, BRRI and BINA. Variety itself is the genetical factor which contributes a lot for producing yield and yield components. Different researcher reported the effect of rice varieties on yield contributing component and grain yield.

Rice yields are comparatively stagnating in post green revolution era mainly due to different factors related to crop production (Prakash, 2010). The reasons for low productivity of rice includes various factors like erratic rainfall, drought, weed, insect pest diseases, unavailability of quality seeds, non adoption of recommended production technology and plant protection technology although the major reason attributed to prevalence of local varieties instead of high yielding rice varieties (Mandira *et al*., 2016).

Some of the important and informative works and research findings related to the morpho-physiological attributes, yield contributing characters and yield of different rice varieties, so far been done at home and abroad, reviewed in this chapter under the following headings:

2.1 Varietal performance of rice

Improving and increasing the world’s food supply depends upon the selection, development and improvement of rice varieties with better yield potential (Khush, 2005). High yielding varieties typically yield 10 to 20% more than conventional varieties on similar soil due to the heterotic effect (Zhou *et al*., 2012) although they usually have lower milling quality than conventional rice varieties. The growth process of rice plants under a given agro-climatic condition differs due to specific rice variety (Alam *et al*., 2012).

Hossain and Deb (2003) reported that although farmers got about 16% yield advantage in the cultivation of high yielding compared to the popularly grown inbred varieties, the yield gains were not stable. Now a days different high yielding rice variety are available in Bangladesh which have more yield potential than conventional rice varieties (Akbar, 2004).

Aus, Aman and Boro rice covers about 8.35%, 30.75% and 33.14% of the total crop areas of Bangladesh (BBS, 2017). During May, June and July, there is no way to cultivate crops other than rice due to monsoon. So, farmers can be encouraged to grow short duration Aus rice in fallow land during May-July period by utilising maximum rainfall and then cultivating Aman rice during August to December. Compared with conventional cultivars, the high yielding varieties have larger panicles, heavier seeds, resulting in an average rice grain yield increase of 7.27% (Bhuiyan *et al*., 2014). This variety however, needs further evaluation under different adaptive condition to interact with different agro-climatic conditions.

2.1.1 Plant height of different rice varieties

Jisan *et al*. (2014) carried out and experiment at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh with a view to examine the yield performance of some transplant *Aman* rice varieties as influenced by different levels of nitrogen. The experiment consisted of four varieties viz. BRRI dhan49, BRRI dhan52, BRRI dhan56, BRRI dhan57 and four levels of nitrogen. Data revealed that among the varieties, BRRI dhan52 produced the tallest plant (117.20 cm), whereas the lowest plant height (97.45 cm) was produced by BRRI dhan57.

An experiment was conducted by Haque and Biswash (2014) with five varieties of high yielding rice and two checks from Bangladesh Rice Research Institute

(BRRI). Varieties was Sonarbangla-1, Jagoron, Hira, Aloron, Richer, BRRI hybrid dhan1 and two checks was BRRI dhan28 and BRRI dhan29 and the highest plant height was 101.5 cm was recorded from BRRI dhan28 and the lowest plant height from Richer (82.5 cm).

Bhuiyan *et al*. (2014) carried out an experiment with aimed to determine the adaptability and performance of different high yielding rice varieties and to identify the best high yielding rice variety in terms of plant growth. Based on the findings of the study it was revealed that the different high yielding rice varieties had significant effects on plant height at maturity.

To study the effect of nitrogen fertilizer and seedling age on Giza 178, H1 and Sakha 101 field experiments was conducted by Salem *et al*. (2011) at the Rice Research and Training Center (RRTC), Sakha, Kafr-El Sheikh Governorate, Egypt during summer seasons. The results indicated that Sakha 101 variety surpassed than other varieties in terms of plant height.

Khalifa (2009) conducted a field experiment at the experimental farm of Rice research and training centre (RRTC), Sakha, Kafr-El sheikh governorate, Egypt rice season for physiological evaluation of some high yielding rice varieties under different sowing dates. Four varieties of rice H_1, H_2, GZ 6522 and GZ 6903 was evaluated at six different sowing dates. Results indicated that H_1 rice variety surpassed other varieties in terms of plant height.

Masum *et al*. (2008) observed that plant height of rice was affected by varieties in *Aman* season where Nizershail produced the taller plant height than BRRI dhan44 at different days after transplanting.

Mandavi *et al.* (2004) found from their experiment that plant height was negatively correlated with grain yield. Thus, in improved genotypes, plant height was not a limiting factor for grain yield because of reduced lodging and conducted better translocation of assimilates.

Murthy *et al.* (2004) conducted an experiment with six varieties of rice genotypes namely Mangala, Madhu, J-13, Sattari, CR 666-16 and Mukti, and the findings revealed that the variety Mukti gave the longest plant compared to the others of their experiment.

Ghosh (2001) carried out an experiment with four rice hybrids and four high yielding rice cultivars and concluded that hybrids have higher plant height as compared with high yielding varieties. Pruneddu and Spanu (2001) conducted an experiment and found that plant height ranged from less than 65 cm to 80–85 cm in Mirto, Tejo, Gladio, Lamone and Timo.

Chen-Liang *et al.* (2000) reported that the cross between Peiai 64s and the new plant type lines had longest plant height compared to the others. On the other hand, Xu and Li (1998) observed that the maintainer lines was generally shorter than restorer line.

An experiment was carried out at Anonymous (1998) to find out varietal performance of advance line (BINA 8-110-2-6) along with three check varieties - Iratom 24, BR26 and BRRI dhan27. The result indicated that BINA 8-110-2-6 appeared similar to BRRI dhan27 in terms of plant height.

Munoz *et al.* (1996) observed that IR8025A rice cultivar produced 16% longer plant than the commercial variety Oryzica Yacu-9. Hosain and Alam (1991) found that the plant height in modern rice varieties BR3, BR11, BR14 and Pajam was 90.4, 94.5, 81.3 and 100.7 cm, respectively.

Miah *et al.* (1990) conducted an experiment where rice cv. Nizersail and mutant lines Mutant NSI and Mutant NSS was planted and found that plant height was greater in Mutant NSI than Nizersail. Shamsuddin *et al*. (1988) conducted a field trial with nine different rice varieties and observed that plant height differed significantly among the varieties tested and Mutant NSI produced the tallest plant (108.60 cm).

2.1.2 Tillering pattern of different rice varieties

Sarkar *et al*. (2016) carried out an experiment to evaluate the performance of five hybrid rice varieties namely Shakti 2, Suborna 8, Tia, Aloron and BRRI hybrid dhan 2 in *Aman* season with an inbred BRRI dhan33 as checked. The result showed that the hybrid varieties exhibited superiority in respect of tillers hill^{-1} and these hybrid varieties showed higher effective tillers hill^{-1}.

Haque and Biswash (2014) experimented with five varieties of hybrid rice which was collected from different private seed companies and one hybrid and two checks from Bangladesh Rice Research Institute (BRRI). Varieties were Sonarbangla-1, Jagoron, Hira, Aloron, Richer, BRRI hybrid dhan1 and two checks was BRRI dhan28 and BRRI dhan29. In case of no. of effective tillers, Hira showed the best performance (17.7) and Sonarbangla-1 showed the least performance (13.3).

Bhuiyan *et al*. (2014) conducted an experiment with aimed to determine the adaptability and performance of different high yielding rice varieties and to identify the best high yielding variety in terms of yield and recommend it to rice farmers. Based on the findings of the study, the different high yielding rice varieties had significant effects on number of tillers, number of productive tillers. RGBU010A × SL8R is therefore recommended as planting material among high yielding varieties because it produced more productive tillers.

Jisan *et al*. (2014) carried out and experiment at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh with a view to examine the yield performance of some transplant *Aman* rice varieties as influenced by different levels of nitrogen. The experiment consisted of four varieties viz. BRRI dhan49, BRRI dhan52, BRRI dhan56, BRRI dhan57 and four levels of N. Among the varieties, BRRI dhan52 produced the highest number of effective tillers hill^{-1} (11.28), while the lowest values of these parameters were produced by BRRI dhan57.

A field experiment was conducted by Khalifa (2009) at the experimental farm of Rice research and training centre (RRTC), Sakha, kafr-El sheikh governorate, Egypt for physiological evaluation of some high yielding rice varieties under different sowing dates. Four rice H_1, H_2, GZ 6522 and GZ 6903 was evaluated at six different sowing dates. Results indicated that H_1 rice variety surpassed other varieties in consideration of effective and total tillers hill^{-1}.

Masum *et al*. (2008) stated that number of total tillers hill^{-1} was significantly influenced by cultivars at all stages of crop growth. Nizersail was achieved maximum (25.63) tiller at 45 DAT, then with advancement to age it declined up to maturity, whereas in the case of BRRI dhan44, maximum (18.92) tiller production was observed around panicle initiation stage at 60 DAT.

Murthy *et al.* (2004) conducted an experiment with six varieties of rice genotypes Mangala, Madhu, J-13, Sattari, CR 666-16 and Mukti, and observed that Mukti gave the highest tillers hill^{-1} compared to the others. Song *et al.* (2004) found that high yielding produced a significantly higher number of tillers than their parental species and Minghui-63 had the least number of tillers.

Bhowmick and Nayak (2000) conducted an experiment with two hybrids (CNHR2 and CNHR3) and two high yielding varieties (IR36 and IR64) of rice and five levels of nitrogenous fertilizers. They observed that CNHR2 produced more number of productive tillers (413.4/m^2) than other tested varieties.

Devaraju *et al*. (1998) in a study with two rice hybrids, Karnataka Rice Hybrid 1 (KRHI) and Karnataka Rice Hybrid-2 (KRH2), using HYV IR20 as the check, found that IR20, the tiller number was higher than that of KRH2.

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 by BR10. Chowdhury *et al*. (1993) reported that the cultivar BR23 showed superior performance over Pajam in respect of number of productive tillers hill^{-1}.

2.1.3 Dry matter content of different rice varieties

Sarkar *et al*. (2016) carried out an experiment to evaluate the performance of five hybrid rice varieties namely Shakti 2, Suborna 8, Tia, Aloron and BRRI hybrid dhan 2 in *Aman* season with an inbred BRRI dhan33 as checked. The result showed that the hybrid varieties exhibited superiority in respect of total dry matter (TMD) hill^{-1} and the highest TDM hill^{-1} (84.0 g) was observed Tia and lowest TDM hill^{-1} (70.10 g) was observed in BRRI dhan33.

Field experiments were conducted by Haque *et al*. (2015) including two popular indica variety (BRRI hybrid dhan2 and Heera2) and one elite inbred (BRRI dhan45) rice varieties. Both hybrids accumulated higher amount of biomass before heading and exhibited greater remobilization of assimilates to the grain in early plantings compared to the inbred variety.

In order to evaluate the response to planting date in rice hybrids line dry method of working was carried out by Shaloie *et al.* (2014) at the Agricultural Research Station, Agriculture and Natural Resources Research Center of Khuzestan Shavuor. Hybrid rice Hb2 and Hb1 was used in the sub plots. Results showed traits was significantly affected in terms of dry matter and mentioned trait was more in hybrid Hb_2 than Hb_1.

Xie *et al.* (2007) found that Shanyou-63 variety gave the higher yield (12 t ha^{-1}) compared to Xieyou46 variety (10 t ha^{-1}). Masum *et al*. (2008) found that total dry matter production differed due to varieties. Total dry matter of BRRI dhan44 Nizershail significantly varied at different sampling dates.

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

Mandavi *et al.* (2004) carried out an experiment to study on the morphological and physiological indicators of rice genotypes, a field experiment was conducted at the Rice Research Institute of Iran. In that study, Onda had the greater total dry matter (TDM) among other genotypes (this genotype also had the highest grain yield). Higher TDM was obtained from improved genotype than traditional genotypes (1445 and 1626 GDD, respectively). At flowering the dry matter weight was higher for Jasesh and was lower for Ramazan Ali Tarom (923.93 g m^{-2} and 429 g m^{-2}, respectively). So the photosynthetic potential of improved genotypes was higher as reflected by their TDM which had positive correlation with grain yield of rice.

Sharma and Haloi (2001) conducted an experiment in Assam during the kharif season with 12 varieties of scented rice cultivars and observed that cv. Kunkuni Joha consistently maintained a higher rate of dry matter production at all growth stages and the highest dry matter accumulation at the panicle initiation stage.

Evans and Fisher (1999) reported that achieving higher yield depends on increasing total crop biomass, because there is little scope to further increase the proportion of that biomass allocated to grain.

Son *et al*. (1998) reported that dry matter production of four inbred lines of rice (low-tillering large panicle type), YR15965ACP33, YR17104ACP5, YR16510-B-B-B-9, and YR16512-B-B-B-10, and cv. Namcheonbyeo and Daesanbyeo, was evaluated at plant densities of 10 to 300 plants m^{-2} and reported that dry matter production of low-tillering large panicle type rice was lower than that of Namcheonbyeo, regardless of plant density.

2.1.4 Yield attributes of different rice varieties

Sarkar *et al*. (2016) carried out an experiment to evaluate the performance of five hybrid rice varieties namely Shakti 2, Suborna 8, Tia, Aloron and BRRI hybrid dhan2 in *Aman* season with an inbred BRRI dhan33 as checked and these hybrid varieties also showed higher 1000-grain over the inbred.

Dou *et al*. (2016) carried out an experiment with the objective to determine the effects of water regime/soil condition (continuous flooding, saturated, and aerobic), cultivar ('Cocodrie' and 'Rondo'), and soil texture (clay and sandy loam) on rice grain yield, yield components and water productivity using a greenhouse trial. The spikelet number of Cocodrie was 29% greater than that of Rondo, indicating that rice cultivar had greater effect on spikelet number. Results indicated that cultivar selection is an important factors in deciding what water management option to practice.

Field experiments were conducted by Haque *et al*. (2015) including two popular indica variety (BRRI hybrid dhan2 and Heera2) and one elite inbred (BRRI dhan45) rice varieties. Filled grain (%) declined significantly at delayed planting in the high yielding variety compared to elite inbred due to increased temperature impaired inefficient transport of assimilates.

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

Haque and Biswash (2014) experimented with five varieties of high yielding rice which was collected from different private seed companies and one hybrid and two checks from Bangladesh Rice Research Institute (BRRI). Varieties were Sonarbangla-1, Jagoron, Hira, Aloron, Richer, BRRI hybrid dhan1 and two checks were BRRI dhan28 and BRRI dhan29. In panicle length status, Richer showed the best performance (27.7 cm) while BRRI dhan28 showed the least performance (26 cm). Number of filled grains $panicle^{-1}$ was the highest for BRRI dhan29 (163.3), whereas, Jagoron only 118. Number of total grains was highest in BRRI dhan29 (201.7) and for Jagoron it was only 133.7. On the other hand, for 1000-grain weight, Aloron was the best than other variety.

Bhuiyan *et al*. (2014) conducted an experiment with aimed to determine the adaptability and performance of different high yielding rice varieties and to identify the best rice variety in terms of yield and recommend it to rice farmers. Based on the findings of the study, the different rice varieties evaluated had significant effects on number of filled and unfilled grains, length of panicle and yield. RGBU010A × SL8R is therefore recommended as planting material among different rice varieties because it produced longer panicles and heavy seeds. In the absence of this variety, RGBU02A × SL8R, RGBU003A × SL8R and RGBU0132A × SL8R may also be used as planting material.

In order to evaluate the response to planting date in rice Line dry method of working, was carried out by Shaloie *et al*. (2014) at the Agricultural Research Station, Agriculture and Natural Resources Research Center of Khuzestan Shavuor. Hybrid rice Hb2 and Hb1 was used in the sub plots. Results showed traits was significantly affected in terms of panicle length, fertility percentage, and mentioned traits was more in hybrid Hb_2 than Hb_1.

Jisan *et al*. (2014) carried out and experiment at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh with a view to examine the yield performance of some transplant *Aman* rice varieties as influenced by different levels of nitrogen. The experiment consisted of four varieties viz. BRRI dhan49, BRRI dhan52, BRRI dhan56, BRRI dhan57 and four levels of N. Data revealed that variety exerted significant influence on yield contributing characters. Among the varieties, BRRI dhan52 produced the grains panicle^{-1} (121.5) and 1000-grain weight (23.65 g), whereas the lowest values of these parameters was produced by BRRI dhan57.

Forty five aromatic rice genotypes were evaluated by Fatema *et al*. (2011) to assess the genetic variability and diversity on the basis of nine characters. Significant variations were observed among the genotypes for all the characters. Thousand grain weight have been found to contribute maximum towards genetic diversity in 45 genotypes of aromatic rice.

Two field experiments was conducted by Salem *et al*. (2011) at the Rice Research and Training Center (RRTC), Sakha, Kafr-El Sheikh Governorate, Egypt during summer seasons to study the effect of nitrogen fertilizer and seedling age on Giza 178, H1 and Sakha 101. The results indicated that Sakha 101 variety surpassed than other varieties in terms of 1000 seeds weight.

Islam *et al.* (2010) studied yield potential of 16 rice genotypes including 12 hybrids, 3 inbreds and 1 New Plant Type (NPT) at the International Rice Research Institute (IRRI) farm under optimum crop management to achieve maximum attainable yield during the wet season (WS) of 2004 and dry season (DS) of 2005. Yield and yield components was determined at maturity. Hybrid produced higher spikelets panicle^{-1} and 1000-grain weight than inbred rice. Spikelet filling percent was higher in inbred than hybrid rice. The NPT rice genotype had the lowest spikelet filling percent, but the highest 1000-grain weight across the season.

A field experiment was conducted by Khalifa (2009) at the experimental farm of Rice research and training centre (RRTC), Sakha, kafr-El sheikh governorate, Egypt rice season for physiological evaluation of some high yielding rice varieties under different sowing dates. Four rice H_1, H_2, GZ 6522 and GZ 6903 was evaluated at six different sowing dates. Results indicated that H_1 rice variety surpassed other varieties for studied characters except for number of days to panicle initiation and heading date.

Islam *et al.* (2009) conducted pot experiments during T. *Aman* season in net house at Bangladesh Rice Research Institute (BRRI). Hybrid variety Sonarbangla-1 and inbred modern variety BRRI dhan31 was used in both the seasons. BRRI dhan3l had higher panicles plant^{-1} than Sonarbangla-1, but Sonarbangla-1 had higher number of grains panicle^{-1}, 1000-grain weight.

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

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

Chaturvedi *et al.* (2004) evaluated newly released commercial rice hybrids (DRRH 1, PHB 71, Pro-Agro 6201, KHR 2, ADTHR 1, UPHR 1010 and Pant Sankar Dhan 1) and two high yielding varieties as checks (Pant Dhan 4 and Pant Dhan 12) for their agronomic and morpho-physiological traits in a field experiment. Hybrids although could not excel the best HYV owing to high percentage of spikelet sterility but they showed potential for higher yield as these produced large sink (higher number of spikelets m^{-2}).

Obulamma *et al.* (2004) recorded hybrid APHR 2 significantly higher grain yield than hybrid DRRH 1. The increased grain yield was due to increase in number of panicles m^{-2} and number of filled grain panicle^{-1} in hybrid APHR 2 than hybrid DRRH 1.

Guilani *et al*. (2003) carried out an experiment on crop yield and yield components of rice cultivars (Anboori, Champa and LD183) in Khusestan, Iran. They observed that grain number panicle^{-1} was not significantly different among cultivars. The highest grain number panicle^{-1} was obtained with Anboori. Grain fertility percentages were different among cultivars. Among cultivars, LD183 had the highest grain weight.

Ahmed *et al*. (1997) conducted an experiment to compare the grain yield and yield components of seven modern rice varieties (BR4, BR5, BR10, BR11, BR22, BR23, and BR25) and a local improved variety, Nizersail. The fertilizer dose was

60-60-40 kg ha^{-1} of N, P_2O_5 and K_2O, respectively for all the varieties and found that percent filled grain was the highest in Nizersail followed by BR25 and the lowest in BR11 and BR23.

Anonymous (1994) studied the performance of BR14, BR5, Pajam, and Tulsimala and reported that Tulsimala variety produced the highest number of filled grains $panicle^{-1}$ and BR14 the lowest.

2.1.5 Yield of different rice varieties

Yield test of 41 entries, 32 new hybrids, 8 male parents restore lines and 1 inbred variety, was conducted by Huang and Yan (2016) on the farm of University of Arkansas at Pine Bluff (UAPB). Results showed that the yields of 7 hybrids were 25.7%-30.7% higher than check Francis. Hybrid 28s/BP23R had the highest yield, 10846.6 kg/hectare and over check by 30.7%. The yield of hybrid 28s/PB-24, was 10628.9 kg/hectare and over check by 28.1%. The yields of hybrid 28s/PB-22 and 33A/PB24 were 10549.8 and 10539.8 kg/hectare and over check by 27.1% and 27.0%, respectively.

Sarkar *et al*. (2016) carried out an experiment to evaluate the performance of five hybrid rice varieties namely Shakti 2, Suborna 8, Tia, Aloron and BRRI hybrid dhan 2 in *Aman* season with an inbred BRRI dhan33 as checked. The highest grain yield was achieved from Tia (7.82 t ha^{-1}), which was closely followed by Shakti 2 (7.65 t ha^{-1}). These two hybrid varieties produced 24.0% higher yield over the inbred BRRI dhan33.

A study was conducted by Mandira *et al*. (2016) in South Tripura district of Tripura for three consecutive kharif seasons to evaluate the performance of rice variety gomati at farmers field under rainfed conditions. The gomati variety of rice was found superior over farmers' existing practices with local varieties. Rice variety gomati with improved production technologies followed in FLDs, increased mean grain yield by 41.62% over farmers' existing practices with only Rs. 1817 ha-1 extra expenditure on inputs.

A study was design by Wagan *et al*. (2015) to compare the economic performance of high yielding and conventional rice production and reported that total costs per hectare of high yielding rice was 148992.23 Rs per hectare which was more then conventional rice was 140661.68 Rs per hectare. On an average higher yield (196.14 monds per hectare) was obtained from high yielding rice while conventional rice yield (140.14 monds per hectare) was less then high yielding rice. There was 16.64 percent increase in high yielding rice yield comparing with conventional rice which gives additional income to poor farmers.

Field experiments were conducted by Haque *et al*. (2015) including two popular indica hybrids (BRRI hybrid dhan2 and Heera2) and one elite inbred (BRRI dhan45) rice varieties. Both hybrid varieties out yielded the inbred. However, the hybrids and inbred varieties exhibited statistically identical yield in late planting. Results suggest that greater remobilization of shoot reserves to the grain rendered higher yield of hybrid rice varieties.

Kanfany *et al*. (2014) conducted an experiment by at the Africa Rice Sahel Regional Station during two wet seasons with the aim of assessing the performances of introduced hybrid cultivars along with an inbred check cultivar under low input fertilizer levels. There were significant cultivar effects for all traits. The grain yield of rice hybrids (bred by the International Rice Research Institute) was not significantly higher than that of the check cultivar widely grown in Senegal.

An experiment was conducted by Hosain *et al*. (2014) at the research farm of Sher-e-Bangla Agricultural University (SAU), Dhaka during *Aus season* (March to July 2010) to observe the effect of transplanting dates on the yield and yield attributes of exotic hybrid rice varieties. The experiment comprised of three rice varieties (two hybrids-Heera2, Aloron and one inbred- BRRI dhan48). BRRI dhan48 produced the highest grain yield (5.51 t ha^{-1}).

Jisan *et al*. (2014) carried out and experiment at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh with a view to examine the yield performance of some transplant *Aman* rice varieties as influenced by different levels of nitrogen. The experiment consisted of four varieties viz. BRRI dhan49, BRRI dhan52, BRRI dhan56, BRRI dhan57 and four levels of N. Data revealed that highest grain yield (5.69 t ha^{-1}) was obtained from BRRI dhan52 followed by BRRI dhan49 (5.15 t ha^{-1}) and the lowest one (4.25 t ha^{-1}) was obtained from BRRI dhan57.

Bhuiyan *et al*. (2014) conducted an experiment with aimed to determine the adaptability and performance of different hybrid rice varieties and to identify the best hybrid rice variety in terms of yield and recommend it to rice farmers. Findings revealed that different hybrid rice varieties had significant effects on yield. RGBU010A × SL8R is therefore recommended as planting material among hybrid rice varieties because it produced favorable yield.

Haque and Biswash (2014) experimented with five varieties of hybrid rice which was collected from different private seed companies and one hybrid and two checks from Bangladesh Rice Research Institute (BRRI). Varieties were Sonarbangla-1, Jagoron, Hira, Aloron, Richer, BRRI hybrid dhan1 and two checks were BRRI dhan28 and BRRI dhan29. In case of biological yield (g), BRRI dhan29 showed highest yield (49.6 g) and Hira only 18 g.

An experiment was carried out by Alam *et al*. (2012) at Agronomy Field Laboratory, Department of Agronomy and Agricultural Extension, University of Rajshahi during the kharif season to study the effect of variety, spacing and number of seedlings $hill^{-1}$ on the yield potentials of transplant *Aman* rice. The experiment consisted of three high yielding varieties viz. BRRI dhan32, BRRI dhan33 and BR11, four levels of spacing and four levels of number of seedlings $hill^{-1}$ viz. 2 seedlings $hill^{-1}$, 3 seedlings $hill^{-1}$, 4 seedlings $hill^{-1}$ and 5 seedlings $hill^{-1}$. Data revealed that variety had significant effects on almost all the yield component characters and yield and among the rice varieties BR11 produced the highest grain yield (5.92 t ha^{-1}).

Samonte *et al*. (2011) reported that the two elite lines recommended for release are high yielding in Texas. RU0703190 is also very early maturing conventional long grain rice. The high yield potential of these new releases will impact grain production of rice farmers and their income.

Tabien and Samonte (2007) observed that several elite lines at the multi-state trials had high yield potential relative to the check varieties and these can be released as new varieties after series of yield trials. With improved yield, the new varieties are expected to increase rice production. The elite lines generated are also potential germplasm for rice improvement projects. The initial effort to identify high biomass rice will enhance the development of dedicated feedstock for bioenergy production.

Swain *et al*. (2006) reported from their experiment that the control cultivar IR64, with high translocation efficiency and 1000-grain weight and the lowest spikelet sterility recorded a grain yield of 5.6 t ha^{-1} that was statistically similar to the hybrid line PA6201.

Several *indica/japonica* (I/J) lines was screened and evaluated by Roy (2006) for higher grain yield in the *Boro* season. The highest grain yield of 9.2 t ha^{-1} was obtained from selected I/J line IR58565-2B-12-2-2, which was equal to that of indica hybrid CNHR3 and significantly higher than that of modern variety IR36.

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.

Patel (2000) studied the varietal performance of Kranti and IR36. He observed that Kranti produced significantly higher grain and straw yield than IR36 did. The mean yield increased with Kranti over IR36 was 7.1 and 10.0% for grain and straw, respectively.

Julfiquar *et al*. (1998) reported that BRRI evaluated 23 hybrids along with three standard checks during *Boro* season. It was reported that five hybrids (IR58025A/IR54056, IR54883, PMS8A/IR46R) out yielded the check varieties (BR14 and BR16) with significant yield difference. Two hybrids out yielded the check variety of same duration yielded by more than 1 t ha^{-1}.

Kamal *et al.* (1998) conducted an experiment to assess the yield of 9 modern varieties (MV) and 6 local improved varieties (LIV) and observed that modern rice variety BR11 gave the highest grain yield followed by BR10, BR23, Binasail and BR4.

Chowdhury (1997) undertook a research on BINA-19, BR14, BR3 and Iratom-24 varieties with different methods of transplanting. He found that the yields for BINA-19, BR14, BR3 and Iratom-24 was 6.49 t ha^{-1}, 6.22 t ha^{-1}, 6.22 t ha^{-1}, 5.75 t ha^{-1} and 5.60 t ha^{-1}, respectively.

Nematzadeh *et al*. (1997) reported that local high quality rice cultivars Hassan Sarai and Sang-Tarom was crossed with improved high yielding cultivars Amol 3, PND160-2-1 and RNR1446 in all possible combinations and released in 1996 under the name Nemat, which gave an average grain yield of 8 t ha^{-1}, twice as much as local cultivars.

Radhakrisna *et al.* (1996) conducted a trial at Mamdya, Karnataka and found that hybrid cultivar KRH-2 gave an average yield of 9.3 t ha^{-1} with yield advantage of 1.5 t ha^{-1} over the best check variety Jaya.

Chowdhury *et al*. (1995) studied seven varieties of rice, of which three was native (Maloti, Nizersail and Chandrashail) and four was improved (BR3, BR11, Pasam and Mala). Straw and grain yields was recorded and found that both the grain and straw yields were higher in the improved than the native varieties. Liu (1995) conducted a field trial with new indica hybrid rice You 92 and observed that an average yield of 7.5 t ha^{-1} which was 10% higher than that of standard hybrid Shanyou 64.

Leenakumari *et al.* (1993) evaluated eleven hybrid cultivars against four standard check varieties-Jaya, Rasi, IR20 and Margala. They concluded that hybrid cultivar OR 1002 gave the highest yield of 7.9 t ha^{-1} followed by the hybrid cultivar OR 1001 (6.2 t ha^{-1}). Among the control varieties, Jaya rice varities gave the highest yield (8.4 t ha^{-1}).

Ali *et al*. (1993) carries out an experiment and reported that among the cv. BR22 gave the highest grain yield from most of the sowing dates for both of the experimental years.

Chowdhury *et al*. (1993) reported that the cultivar BR23 showed superior performance over Pajam in respect of yield and yield contributing characters i.e. grain yield straw yield.

Suprihatno and Sutaryo (1992) conducted an experiment with seven IRRI hybrids and 13 Indonesian hybrids using IR64 and way-seputih. They observed that TR64 was highest yielding, significantly out yielding IR64616H, IR64618, IR64610H and IR62829A/IR54 which in turn out yielded way-seputih.

Chandra *et al*. (1992) conducted an experiment with different hybrid and local varieties and reported that hybrid IR58025A out yielded the IR62829A hybrids and the three control varieties Jaya, IR36 and hybrids IR58025A x 9761-191R and IR58025A IR58025A x 1R35366-62-1-2-2-3R.

Hossain and Alam (1991) conducted an experiment on farmers production technology in haor area and found that the grain yield of modern rice varieties of *Boro* rice was 2.12, 2.18, 3.17, 2.27 and 3.05 t ha^{-1}, with BR14, BR11, BR9, IR8 and BR3, respectively.

2.2 Irrigation management of rice

Water is one of the most important factors in rice production. Many investigators and researchers have reported that water requirement in rice field varies with crop species and the growth stages of crop. Initially, crop needs less amount of water and reaches its peak at the reproductive stages to fulfill the crop demand. When supply of water is less than the demand, the crop faces the water stress. If the crop is subjected to water stress, it affects the physical characters of rice plant, growth, yield and nutrient status of the soil.

In consequence, rice production in Asia is increasingly constrained by water limitation (Arora, 2006) and increasing pressure to reduce water use in irrigated production as a consequence of global water crisis (Tuong and Bouman, 2002). Irrigated lowland rice consumes more than 50% of total freshwater, and irrigated flooded rice requires two or three times more water than other cereal crops, such as wheat and maize (Sarkar *et al.,* 2016). For 1 kg of rice, it is estimated that farmers use 3 to 4 thousand litres of water whereas it actually needs 1.0 to 1.5 thousand litres only. Thus, for irrigation farmers have to pay about 30-40% of the extra cost. This might be due to their ignorance about the need of water for rice cultivation as well as consequence of misuse of water. In addition, rice production is facing increasing competition with rapid urban and industrial development in terms of freshwater resource (Bouman and Tuong, 2001). The need for "more rice with less water" is crucial for food security, and irrigation plays a greater role in meeting future food needs than it has in the past (Tuong *et al.,* 2005). This issue will necessitate the development of substitute irrigated rice production systems that involve less water than conventional flooded rice (Bouman *et al.,* 2005). Different water saving techniques for rice production have been evolved by researchers such as alternate wetting and drying-AWD (Bouman and Tuong, 2001; Belder *et al.,* 2004), saturated soil culture (Tuong *et al.,* 2005), direct dry seeding (Rahman, 2016), and also aerobic rice culture (Bouman *et al.,* 2005). These have been found to be effective in reducing water use efficiency and improving water productivity, but there are debates on whether these water-saving techniques will increase or decrease rice yields (Bouman *et al.*, 2007).

Despite the constraints of water scarcity, rice production and productivity must rise in order to address the growing demand for rice driven largely by population growth and rapid economic development in Asia. Producing more rice with less water is therefore a formidable challenge for achieving food, economic, social, and water security for the region (Facon, 2000). In other words, the efficiency of water use in irrigated rice production systems must be significantly increased. Water saving is the main issue in maintaining the sustainability of rice production when water resources are becoming scarce (Arif *et al.*, 2012).

A large part of the variation in annual rice yield generally may be merely due to variations in timing and the quantity of irrigation water applied (Bertolacci *et al.*, 2006; Prasad *et al.*, 2006; Ghinassi, 2007; Ghinassi *et al.*, 2007). The cultivation of rice in flooded fields requires about 2500-3000 m^3 water to produce one ton of rice grain (Bouman *et al.*, 2002). Rice is usually grown in lowland areas under continuous flooded conditions. It is estimated that over 75 percent of the world's rice is produced using continuous flooding water management practices (Van der Hoek *et al.*, 2001).

According to Sharma, (1989) the continuous flooding method is very inefficient as about 50-80 percent of the total water input is wasted through surface runoff, seepage, and percolation. Other disadvantages of continuous flooding are: high emissions of methane (Wassmann *et al.*, 2009; FAO, 2010); greater vulnerability to water shortages than other cropping systems (Wassmann, 2010); leaching of soluble nutrients, blocking of soil microbial activities, and reduced mineralization and nutrient release from the soil complexes (Uphoff and Randriamiharisoa, 2002). Water, it is said, may become as precious as oil during this century (Arif *et al.*, 2012). Even though the total amount of water made available by the hydrologic cycle is enough to provide world's current population with adequate freshwater, most of this water is concentrated in specific regions leaving other areas water-deficit (Pimentel *et al.*, 1999).

Because of the uneven distribution of water resources and population densities worldwide, water demands already exceeded supplies in nearly 80 countries with more than 40% population of the world (Bennett, 2000). In Asia, with relatively more suitable growing conditions for rice production has declined due to increasing water stress (Aggarwal *et al*., 2000; Tao *et al*., 2004). So, it is necessary to determine the tolerable limit of drying duration of rice field to obtain satisfactory yield. Many scientists and researchers have also reported the influence of irrigation on the increase of yield and yield components of rice. Some of their findings are summarized below.

Pascual and Wang (2017) conducted a field experiment to determine the most suitable ponded water depth for enhancing water saving in paddy rice irrigation. Different ponded water depths treatments (2 cm, 3 cm, 4 cm and 5 cm) were applied weekly from transplanting to early heading. The highest rainwater productivity (2.07 kg m^{-3}) was achieved in 5 cm and the lowest in 2 cm (1.62 kg m^{-3}). The highest total water productivity, (0.75 kg m^{-3}) and irrigation water productivity (1.40 kg m^{-3}) was achieved in 2 cm. The total amount of water saved in 4 cm, 3 cm and 2 cm was 20, 40, and 60 %, respectively. Weekly application of 4 cm ponded water depth from transplanting to heading produced the lowest yield reduction (1.57 %) and grain production loss (0.06 kg) having no significant impact on yield loss compared to 5 cm. Thus, they assert that the weekly application of 4 cm along with rainfall produced the best results for reducing lowland paddy rice irrigation water use and matching the required crop water.

Haque *et al.* (2015) conducted a field experiment in *boro* season with a view to find out the influence of water level on growth and yield of *boro* rice. They reported that stagnation of water and continuous 2-5 cm standing water in the field had no significant effect on number of effective tillers $hill^{-1}$, panicle length, number of grains $panicle^{-1}$, number of filled grains $panicle^{-1}$, number of unfilled grains panicle^{-1}, 1000-grain weight, grain, straw and biological yield of *boro* rice. Field WUE was significantly higher (6.10 kg ha^{-1} mm^{-1}) at continuous saturated condition and lower (4.57 kg ha^{-1} mm^{-1}) at submerged condition.

Ibraheem (2015) indicated that irrigation intervals had significant influence on growth parameters while; irrigation has the most influenced on yield attributes. Higher paddy yields (3.83 and 3.75 t ha^{-1}) and harvest index (45.10 and 44.89%) were recorded with 3 days irrigation interval closely followed by 6 days irrigation interval in both years respectively.

Timon *et al.* (2015) showed that there were significant differences in paddy yield, harvest index and irrigation water productivity. Six days interval irrigation management was placed to one group with 3 days irrigation interval on paddy yield and harvest index; higher water productivity of 3.58 and 3.51 kg ha^{-1} mm^{-1} were recorded with 6 days irrigation interval in both seasons respectively. Therefore, it can be recommended that 6-day interval irrigation which had better irrigation water productivity and saved up 29% irrigation water be adopted for rice cultivation under clay loam soils of guinea savanna zone of Nigeria.

Ghosh *et al.* (2014) conducted a field experiment to explore the potentiality of growing rice varieties under limited supply of irrigation water. Water management practices exerted significant influence on plant height, grain and straw yield and under continuous flooding irrigation-CF produced the highest grain yield (3.38 t ha^{-1}). Limited supply of irrigation water at different stages of growth decreased grain yield ranging from 27.5 to 43.5% compared to that in CF. Rice genotypes exhibited differential response to water management practices that was applied in this experiment. Though genotype UPLRi -7 produced the highest grain yield (4.39 t ha^{-1}) under CF, under limited water supply IR-36 was still the best variety producing the highest average grain yield (3.31 t ha^{-1}).The present research work pointed out that without ensuring adequate supply of irrigation water rice cultivation during *boro* season may not be profitable in the Red and Laterite zone of West Bengal.

Fonteh *et al.* (2013) carried out a study to compare the performance of local varieties of rice under different water management practices. The study indicates that the various water management practice do not significantly affect plant height. Between 39 and 47 % of the irrigation water used under continuous flooding as is practiced by most farmers in sub-Saharan Africa can be saved by the adoption of intermittent irrigation at 3-5 cm depth. The water use efficiency in intermittent irrigation with an application of 3 cm is about 100% greater than that in continuous flooding irrigation with the same depth. For intermittent irrigation with a depth of 5 cm, the improvement is about 80%. Intermittent irrigation produces yields which are not significantly different from continuous flooding irrigation but with a water use efficiency of up to 100% higher. Intermittent water application with a depth of 3 cm had a water productivity of about 88 % higher than that obtained with continuous flooding irrigation. Intermittent irrigation with applied depths of 3-5 cm should therefore be promoted in sub-Saharan Africa to ensure food security while at the same time mitigating climate change through reduced production of methane.

Jafari *et al.* (2013) found that number of total tillers hill^{-1} was decreased with flooding. Total spikelets number hill^{-1} in flooding irrigation was higher than deficit irrigation. Grain yield in flooding irrigation was 31 kg ha^{-1} higher than that of deficit system.

Talpur *et al.* (2013) conducted the study to evaluate the effect of different water depths on the growth and yield of rice crop. Result indicated that 5 cm is optimum water depth for vegetative and mid stage (transplanting to mid drainage) of the rice crop growth, while 10 cm water depth is appropriate for mid drainage till late stage (mid drainage to harvesting) of the rice crop and the same (10 cm) is found suitable for maximum yield.

Tilahun-Tadesse *et al.* (2013) conducted a field experiment to determine appropriate water management practices for rainfed lowland rice production. Results of the experiment indicated that with continuous flooding, LAI, CGR, NAR, plant height, number of tillers and productive tillers, number of filled spiklets, grain yield and biomass yield were highly depressed but improved when drainage and aeration was practiced. Compared to continuous flooding, a grain yield increment of 26% was obtained due to draining and re-flooding the water from 15-days to one month interval.

Akter (2012) conducted an experiment to evaluate the effect of irrigation and moisture retainer on the growth and yield of *boro* rice (BRRI dhan29). It was observed that the highest grain yield (7.08 t ha^{-1}) was obtained from eight irrigations, but the average highest straw yield was obtained from ten irrigations (6.71 t ha^{-1}).

Lin *et al.* (2011) reported that intermittent water application with system of rice intensification (SRI) management, grain yield increased by 10.5 and 11.3%, compared to standard irrigation practice (continuous flooding). They also reported that intermittent irrigation with organic material application improved the functioning of rhizosohere and increased yield of rice.

Mostafazadeh-Fard *et al.* (2010) conducted a field experiment to determine the effect of different irrigation water managements on yield and WUE of rice in cracked paddy soils. They reported that the highest grain yield (3.279 t ha^{-1}) belonged to the 3-4 mm crack and irrigation to fill up the cracks and up to 5 cm of ponding at the soil surface and the lowest grain yield (2.04 t ha^{-1}) belonged to irrigation to fill up the cracks and up to the start of ponding and 2.5 cm. The reduction of depth of ponding (irrigation to fill up the cracks and up to the start of ponding vs. irrigation to fill up the cracks and up to 5 cm of ponding at the soil surface) caused 36.5% improvement in water use efficiency. On cracked paddy soils, based on the development of crack width, the irrigation schedule can be planned to save water without considerable reduction of crop yield. The results of this study can be applied to cracked paddy soils of the study area in order to save irrigation water.

Wang *et al.* (2010) investigated a field experiment consisting of three levels of 1, 4 and 7 cm irrigation water depth. The trends were found that tiller number hill^{-1} and LAI increased as the irrigation water depth increased. The yields of 1, 4 and 7 cm irrigation water depth treatments were 0.62, 1.38 and 2.62 t ha^{-1}, respectively. Panicle density of 1 cm and 4 cm irrigation water depth treatments both contributed more to yield compared to seed weight panicle^{-1} while seed weight panicle^{-1} at the 7 cm irrigation water depth treatment contributed over panicle density. Spikelets panicle^{-1} was maximum in 7 cm irrigation water depth treatment. They concluded that increasing water depth up to 7 cm increased rice grain yield mainly by increasing rice spikelets panicle^{-1} and percent filled spikelet and alleviating the tillering inhibition.

Amiri *et al.* (2009) studied the effect of irrigation method on growth and yield of rice varieties. They showed that plant height, panicle length, 100-grain weight and number of grains panicle^{-1} and yield in submerge and 5 day interval irrigation management are placed to one group, therefore it can be recommended that 5 day interval irrigation are placed on submerge irrigation.

Juraimi *et al.* (2009) conducted an experiment to evaluate the effect of different flooding treatments on rice growth and yield. The results showed that the response of rice plant to water soil availability varies with its growing stage. At an early stage of rice plant growth (15 and 30 DAS-days after sowing), flooding treatments were found to not affect the growth of rice plant significantly. However, from 45 DAS onwards, the effect was significantly pronounced. All flooding regimes significantly favored rice plant height and the number of tillers as compared to non-flooded regimes.

In the study of Juraimi *et al.* (2009), positive correlation was observed between the grain yield and yield components. The significant higher number of tillers, high spikelets panicle^{-1} and high 1000-grain weight had contributed to higher grain yield of rice in early flooding until the 55 DAS (days after sowing that followed by saturated condition until maturity, early flooding until 30 DAS that also followed by saturated condition until maturity and early flooding until 30 DAS followed by saturated condition until maturity as compared to continuous saturated condition until maturity and continuous field capacity condition throughout the experiment period. Shorter duration of flooding (early flooding until 55 DAS followed by saturated condition until maturity; early flooding until 30 DAS followed by saturated condition until maturity) was found to give a similar performance to continuous flooding, and thus, these methods might save on water use without reducing yields, while over watering might just increase vegetative growth.

Sariam (2009) conducted a planthouse study to evaluate the effect of irrigation practice on rice root growth and yield. He found that total root length increased rapidly from maximum tillering to panicle initiation stage irrespective of irrigation practice, and after heading, under flooded and non flooded-saturated conditions. At maturity, total root dry weight of rice grown under non flooded-field capacity was only 25% of the total root dry weight of rice grown under flooded and non flooded-saturated conditions. Shoot dry weight and grain yield of rice did not differ significantly between flooded and non flooded-saturated, but significantly lower under non flooded-field capacity condition. Results suggested that reducing irrigation water and maintaining the soil at non flooded-saturated conditions will not affect root as well as shoot growth and yield of irrigated rice.

Islam *et al.* (2005) conducted a study to see the effect of water stress on the growth and yield of three drought tolerant T. *aman* rice mutants developed by BINA viz. Y-1281, PR-26305-M-32 and MR-219. He observed that the mutant MR-219 was superior to the other two mutants and in all cases treatment with 3 cm standing water and then stress up to 80% field capacity was the optimum water stress condition which produced the highest yield.

Venkatesan *et al.* (2005) showed that yield was affected due to water stressing. However yield reduction was less in 40% stress treatment compared to 60% stress treatment in various stages. Again, a scrutiny of yield obtained shows more yield reduction in stress treatment given in panicle initiation and flowering stages than in tillering stage when compared with no stress condition. Therefore, reproductive phase was more critical than the vegetative phase. The study has shown that the yield reduction was less when 40% stress treatment was imposed in tillering stage only. This indicates that a still milder stress in tillering stage may fetch a comparable yield with the yield of no stress condition and at the same time will result in considerable water saving.

Afroja (2004) observed that irrigation water levels have a significant effect on vegetative growth and yield contributing characters of rice. She observed that treatment with 1-7 cm continuous standing water gave the highest yield of 7.39 t ha^{-1}, whereas, treatment with no irrigation gave the lowest yield of 3.98 t ha^{-1}.

Islam and Sarkar (2004) reported that it is important to develop irrigation scheduling of rice for cracking soils on the basis of crack size rather than estimating crop water requirements based on evapotranspiration demand. During winter dry season a huge number of cracks developed on the puddled field due to water shortage. They found that the size and the number of cracks depend on the irrigation interval, the intensity and duration of drought. As a result the size of the cracks ranged from 10 to 30 mm wide and normally the major cracks went below the puddle layer of 70-100 mm, and almost all the cracks were interlinked and remained active throughout the growing season. Therefore, irrigation application efficiency should be increased in cracking soils by reducing seepage and drainage losses in paddies.

Alam and Mondal (2003) reported that irrespective of water treatments, BRRI dhan29 produced the highest grain yield (5.94 t ha^{-1}) followed by IR69690H (5.63 t ha^{-1}) and IR68877H (5.22 t ha^{-1}). The highest water productivity was found in 7 cm standing irrigation water application 3 days after disappearing of standing water treatment followed by 7 cm irrigation water application after disappearing of standing water and continuous 3-7 cm standing water. Therefore, maintaining continuous standing water in the hybrid rice fields is not necessary for optimum yield. Rather, application of irrigation water 3 days after standing water disappeared from the field could be practiced for obtaining optimum yield of hybrid rice, with minimum water application.

Balasubramanian and Krishnarajan (2003) carried out an experiment to find out suitable irrigation regimes during kharif and Rabi season. They concluded that continuous submergence of the rice crop in 2.5 (instead of 5.0) cm of water is a desirable practice to achieve higher grain yield and water productivity.

Islam (2003) conducted field experiments to study the impact of supplemental irrigation on T. *aman* cultivation. The results indicated that the highest WUE, water productivity and benefit cost ratio (BCR) were obtained with one or two supplemental irrigations and the average yield was maximum with three or more supplemental irrigations. The lowest BCR was found under treatment with no irrigation.

Qinghua *et al.* (2002) carried out an experiment in rainproof containers to study the response of different varieties (Sanyou 10 and 923 and Zhensan 97B) of rice to three water treatments (flooded, intermittent and dry condition) and observed that grain yields in the dry cultivation treatment amounted to 6.3, 6 and 3.7 t ha^{-1} for the varieties Sanyou 10 and 923 and Zhensan 97B, respectively. Under intermittent irrigation, yields of Sanyou 10 and 923 were 8% and 10% higher, 9.5 and 8.8 t ha^{-1}, respectively than under flooded condition. The highest yield of Zhensan 97B (5.3 t ha^{-1}) was obtained under flooded condition.

Sarkar *et al.* (2002) conducted field experiments in two consecutive years on T. *aman* rice to assess the need and amount of supplemental irrigation for its cultivation at two agro-ecological zones of Bangladesh (Mymensingh and Rangpur). The results revealed that supplemental irrigation did not have any significant effect on the grain and straw yield of rice. But a significant varietal yield difference was found at Mymensingh in 1993 where variety BR-22 produced significantly increased grain and straw yield with supplemental irrigation upto saturation. In most of the cases, the highest harvest index was obtained with continuous standing water, whereas, water use efficiency was always highest under rainfed condition.

Uphoff and Randriamiharisoa (2002) observed that continuous flooding-CF irrigation constrain root growth of rice and contribute to root degeneration and it also limit soil microbial life to anaerobic populations. Keeping paddy fields flooded also restricts biological nitrogen fixation to anaerobic processes and affect plant growth.

Ganesh (2001) conducted three-year field trial during kharif seasons to evaluate the effect of different moisture regimes on the grain and straw yields of three rice genotypes (KRH-l, KRH-2 and IR-64). He found the grain and straw yields were the highest in maintaining 2.5 cm submergence from transplanting to 15 DAT and 5.0 cm submergence until 10 days before harvest, followed by maintaining 5 cm submergence after the disappearance of the ponded water and maintaining soil moisture between field saturation and field capacity. No significant differences in straw and grain yields were observed among the rice cultivars.

Islam *et al.* (2001) documented his experimental report conducted in the plastic vinyl house to evaluate the effects of soil moisture deficit on root growth of six selected upland rice cultivars: They concluded that water deficit imposed at early and later vegetative stage significantly affected root penetrability but water deficit during reproductive stage did not affect root growth. They observed that in most cultivars, stressed plants showed significantly deeper root penetration than control plants. During stress, plant extended their roots to a deeper zone in all stages than control plants.

Panigrahi (2001) developed a water balance simulation model to estimate the different water balance parameters for various treatments of dry seeded upland rainfed rice grown in wet season. The various water saving irrigation (WSI) treatments include: (T_0) rainfed - without any provision of supplemental irrigation and surface runoff and WSI techniques; (T_1) supplemental irrigation applied at 20% MAD (management allowable deficit) of SAT (saturation moisture content in the effective root zone) during the reproductive stage; (T_2) supplemental irrigation applied at 20% MAD of SAT during crop development and the reproductive stage; (T_3) supplemental irrigation applied at 20% MAD of SAT during crop development, reproductive stage and maturity stages; (T_4) supplemental irrigation applied at 20% MAD of SAT during all four stages; and (T_5) supplemental irrigation applied at SAT in all the stages. He compared water requirement, irrigation use efficiency (IUE) and WUE of rice for different treatments and found that yield and water balance parameters were successfully fitted to normal distributions `and probable values. The predicted yield of rice at 50% probability of exceedance was found to be 2280, 3060, 3125, 3250, 3400 and 4001 kg ha^{-1} for treatments T_0, T_1, T_2, T_3, T_4 and T_5, respectively. T_1 was found to be the best, with a minimum net water requirement of 1056.4 mm, and a maximum 85% saving of supplemental irrigation (compared to treatment TS), and the highest IUE (29.8 kg ha^{-1} mm^{-1}) and WUE (2.9 kg ha^{-1} mm^{-1}), respectively.

Sarkar (2001) carried out a field experiment to assess the performance of summer rice cv. IET 4786 under stress (intermittent ponding) and non-stressed (continuous ponding) situations. In case of intermittent ponding, irrigation was given when soil moisture tension at 20 cm depth attained the suction value of 0-20 Mpa. He divided entire irrigation period into 3 stages, i.e. early (1_1 to 30 DAT), middle (31 to 60 DAT) and late (61 to 80 DAT) stages. Intermittent ponding was imposed at single, i.e. early (I_2), middle (I_3) and late (I_4) stages, or at 3 stages, i.e. early + middle (I_5), early + late (I_6) and middle + late stages. There were 2 more irrigation regimes, i.e. continuous ponding maintained throughout the entire irrigation period (I_1) and intermittent ponding maintained during the entire irrigation period (I_8). He found that the highest grain yield (6.79 t ha^{-1}) was attained under (I_1), followed by yielding of 6.71 t ha^{-1} under (I_2). Grain yield markedly decreased under I_3, I_5, I_7 regimes and lowest value of 5.37 t ha^{-1} was recorded under I8. The lowest level of water expense efficiency value was obtained under I_7 regime, while the highest (5.99 kg ha^{-1} mm^{-1}) was under I_2 regime. Although, grain yield attained the lowest value under I_8, minimum level of water expense value (910.4 mm) was responsible towards water expense efficiency value (5.71 kg ha^{-1} mm^{-1}) under this treatment.

Yadav *et al.* (2001) conducted pot experiments on ten rice cultivars to determine the effects of 10 days drought stress during tillering and flowering stages. They found that higher recovery was observed at tillering than flowering stage. Ten days duration of drought at flowering stage resulted in a drop in OP along with LWP in all the cultivars.

Balasubramanian and Krishnarajan (2000) revealed that highest actual soil available nutrients and highest grain yield was recorded with irrigation applied to 5 cm depth one day after disappearance of ponded water than saturated condition. Similarly, the same irrigation regime recorded the highest net returns and benefit cost ratio.

Jun *et al.* (2000) found that the WUE is generally lower for production of rice than other crops. They put four sets of conditions with two replications: continuous flooding irrigation treatments (CFI) and three intermittent irrigation treatments designated II-O, II-1 and II-2, in which plants were re-irrigated when the water potential of the soil fell below 0, -10 and -20 kpa at a depth of 5 cm, respectively. They found that there was no significant difference in dry matter production and grain yield between CFI and II-0, but both were significantly greater than in the case of II-1 and II-2.

Patel (2000) carried out an experiment and stated that water-management system of continuous submergence required maximum quantity of water (1.535 mm) without any significant increase in grain yield of rice than saturation till tillerring and submergence till ripening (1.340 mm) and the maximum WUE were significantly higher (3.04 kg ha^{-1} mm^{-1}) at continuous saturation system than WUE (2.60 kg ha^{-1} mm^{-1}) at continuous submergence condition.

2.3 Fertilizer management of rice

It is reported that chemical fertilizers today hold the key to success of production systems and being responsible for about 50% of the total crop production. Nutrient imbalance can be minimized by judicious application of different fertilizers. In Bangladesh, there is tendency to use indiscriminate amount of nitrogenous fertilizers and very limited amount of other nutrients' containing high analysis chemical fertilizers (Rahman *et al*., 2008). Intensive crop cultivation using high yielding varieties with imbalanced fertilization has lead to mining out the inherent plant nutrients and thereby fertility status of soils severely declined. On an average to produce one ton of rice grain of high-yielding varieties is removed about 22 kg N, 7 kg P_2O_5, 32 kg K_2O, 5 kg MgO, 4 kg CaO, 1 kg S and 40 g Zn from the soil (Chaudhary *et al*., 2007). Emergence of widespread multi-nutrient deficiencies, depletion of native nutrient reserves, imbalanced fertilization are of utmost concern, causing serious stagnation in yields and declining productivity of various rice ecosystems (Mangala, 2006). Excess use of fertilizer nutrients implies increase of cost and decrease of returns and risk of environmental pollution. Application of inadequate and unbalanced fertilization to crops not only results in low crop yields but also deteriorate the soil health (Sharma *et al.*, 2003).

Judicious use of N is a key factor in rice based production system which can increase crop yield and reduce production cost. N is a constituent of compounds such as amino acids, proteins, RNA, DNA and several phytohormones is thereby an essential macro element for plants (Wang and Schjoerring, 2012). N management is essential for rice under aerobic culture as the N use efficiency is be in the range of 40 to 60%, application of N at right time is perhaps the simplest agronomic solution for improving the use efficiency of N (Ganga *et al.*, 2012). N fertilization is the major agronomic practice that affects the yield and quality of rice crop, which requires as much as possible at early and mid tillering, stages to maximize panicle number and during reproductive stage to produce optimum spikelets per panicle and percentage filled spikelets (Sathiya and Ramesh, 2009).

But excessive N application would lead to increased production cost and negative effects of blocking agricultural sustainable development such as environmental pollution and rice quality decline. N split application at three growth stages (transplanting, tillering and panicle emergence) should be followed to obtain higher paddy yield and greater economic benefits (Ehsanullah *et al.*, 2001). Rate and timing of N application are critical in terms of their effects on yield, N increase plant height, panicle number, leaf size, spikelet number and number of filled spikelets and ultimately the highest yield (Shakouri *et al*., 2012).

Lukman *et al*. (2016) reported that the combined application of cow dung and NPK fertilizer significantly increased most of the results obtained with regards to locations compared to the control plots. The growth and yield parameters of rice considered were significantly affected by the treatments except one thousand grain weight. Application of 8 t ha^{-1} of cowdung in combination with 400 kg ha^{-1} NPK 20:10:10 gave the highest grain yield (5.77 t ha^{-1}) at Sokoto and it is recommended that application of 12 t ha^{-1} of cowdung in combination with 300 kg ha^{-1} NPK 20:10:10 resulted in the best soil nutrient enrichment and yield of rice in Sokoto and Talata Mafara.

Imrul *et al.* (2016) carried out a field experiment to investigate the influence of N and phosphorus (P) on the growth and yield of BRRI dhan57. They reported that 120 kg N and 35 kg P ha^{-1} treatment gave the highest effective tillers $hill^{-1}$, length of panicle, filled grains $panicle^{-1}$, 1000 grain weight (20.85 g), grain yield (4.95 t ha^{-1}), straw yield (5.39 t ha^{-1}) and biological yield (10.34 t ha^{-1}).

An experiment was carried out by Pandey *et al*. (2014) at research farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh India. Experiment was comprised of different levels of inorganic fertilizer (NPK) and its conjunction with different organic fertilizers. Yield and yield attributing characters was significantly increased with increasing fertilizer levels from 50:30:20 kg, NPK ha^{-1} to 150:80:60 kg, NPK ha^{-1} during both the year of experiment. Grain yield and yield attributes were significant among different treatments. Application of

100:60:40 kg NPK ha^{-1} + blending of N with cowdung urine (T_9) or poultry manure (T_{10}) resulted higher effective tillers, panicle length, and test weight which is statistically at par to that of inorganic level 150:80:60 kg NPK ha^{-1} (T_1).

Islam *et al*. (2014) found that the yield contributing characters like plant height, effective tillers hill^{-1}, panicle length and grains panicle^{-1} of BRRI dhan49 were significantly influenced by the application of manures and fertilizers. The highest grain yield of 4.87 t ha^{-1} was observed in the treatment T_3 [PM + STB–CF (HYG)] and the lowest value of 3.61 t ha^{-1} was found in T_0 i.e. control condition. The straw yield also ranged from 4.10 to 5.51 t ha^{-1} due to the different treatments. The NPKS uptake by BRRI dhan49 was markedly influenced by manures and fertilizers under this field conditions. Based on overall experimental results, the treatment T_3 [PM + STB–CF (HYG)] was found to be the best combination of manures and fertilizers for obtaining the maximum yield and quality of BRRI dhan49 rice variety.

Sarkar (2014) found that the application of 75% RD of inorganic fertilizers + 50% cowdung showed superiority in terms of plant height (123.3 cm) and total tillers hill^{-1} (13.87) where those were also highest in combination of BRRI dhan34 × 75% RD of inorganic fertilizers + 50% cowdung. Nutrient management of 75% RD of inorganic fertilizers + 50% cowdung (5 t ha^{-1}) gave the highest grain yield (3.97 t ha^{-1}) and the lowest grain yield (2.87 t ha^{-1}) was found in control. The highest grain yield (4.18 t ha^{-1}) was found in BRRI dhan34 coupled with 75% RD of inorganic fertilizers + 50% cowdung and the lowest grain yield (2.7 t ha^{-1}) was found in BRRI dhan37 in control.

Islam *et al*. (2013) studied to evaluate the effect of nitrogen supplied from organic sources and inorganic source (urea) on the yield and nitrogen use efficiency of BRRI dhan28. The treatments were T_0 (Control), T_1 (100% N from RFD), T_2 (70% N from RFD, RFD + 30% N from CD), T_3 (70% N from RFD + 30% N from PM), T_4 (70% N from RFD + 30% N from CoM), T_5 [70% N from RFD + 30% N from (CD + PM + CoM)], T_6 [100% N from (CD + PM + CoM), T_7 [100% N from RFD

+ 30% N from (CD + PM + CoM)]. The highest grain yield of 5847 kg ha^{-1} was observed in the treatment T_7 and the lowest grain yield of 2426 kg ha^{-1} was found in T_0. The highest N uptake (138.9 kg ha^{-1}) was found in T_7 followed by T_1 (119.8 kg ha^{-1}).

An experiment was conducted by Rattanapichai *et al*. (2013) to study the effects of various soil conditioners, soil conditioner doses (0, 1.56, 3.12 and 6.25 tons ha^{-1}) and NPK fertilizers (16-8-8 and 16-16-8) on growth and yield of rice grown in acid sulfate soil in Thailand, a Rangsit (Rs) soil series. The result showed that application of soil conditioner caused an increase in tillers per plants, biomass and grain yield as well as silicon uptake. However, there was no effect on native phosphorus in soil and phosphorus uptake. The 16-16-8 fertilizer application increased the number of tillers per plants; shoots dry matter and grain yield were higher than in 16-8-8 fertilizer model.

Sukristiyonubowo *et al*. (2013) reported that the application of 2 ton ha^{-1} $year^{-1}$ dolomite, 2 ton ha^{-1} $season^{-1}$ rice straw compost and mineral fertilizers (200 kg urea, 100 kg SP-36 and 100 kg KCl ha^{-1} $season^{-1}$) improve the rice yield by combined addition of organic matter (straw compost), lime and mineral fertilizer. With these applications the rice yield was observed about 3.5-4.2 tons ha^{-1} $season^{-1}$ can be reached under weathered soils.

Hossain (2013) conducted an experiment to investigate the effects of inorganic fertilizers alone and in combination with different organic fertilizers in order to achieve high yield and sustainable soil chemical and organic matter balance. The experiment was conducted at the field laboratory of Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh. The treatment combinations were T_1 (NPK), T_2 (NPK+ FYM), T_3 (NPK+ Vermicompost), T_4 (NPK+ Rotten Rice Straw) and T_5 (NPK+ Poultry Manure). The results showed that grain and straw yields were significantly influenced by the treatments. The highest grain yield was obtained in T_2 followed by T_3 and T_5. The grain yield of wheat due to different treatment followed the order of: $T_2>T_3>T_5>T_4>T_1$ with the record of 2.48, 2.28, 1.83, 1.82 and 1.59 t ha^{-1}, respectively.

Tasnin (2012) observed that the height of rice plant, number of leaves, number of tillers and dry matter accumulation per hill was significantly higher with application of 50% recommended NPK through fertilizers + 50% N through gliricidia, which was closely followed by 50% recommended NPK through fertilizers + 50% N through FYM. Rice supplied with 50% recommended NPK through fertilizers + 50% N through gliricidia produced higher number of panicles per hill, length of panicles, number of grains and weight of grains per panicle. They also observed that Application of 50% recommended NPK through fertilizers + 50% N through gliricidia, 50% recommended NPK through fertilizers + 50% N through FYM to rice recorded 105.41 and 103.33% higher grain yield compared to that of 100% recommended NPK, respectively, while 50% recommended NPK through fertilizers + 50% N through gliricidia produced higher straw yield of rice followed by 50% FYM substitution.

Vetayasuporn (2012) conducted an experiment to determine the effects of organic–chemical fertilizer and chemical fertilizer (NPK 16:16:8) on the growth and yield of rice in acidic soil of Roi-Et province, Northeast Thailand. Five treatments were compared consisting of: T_1 (control without fertilizer); T_2 (312.5 kg ha^{-1} organic-chemical fertilizer); T_3 (625 kg ha^{-1} organic–chemical fertilizer); T_4 (937.5 kg ha^{-1} organic–chemical fertilizer) and T_5 (chemical fertilizer; 312.5 kg ha^{-1} NPK 16:16:8). Yield of rice grains under all treatments increased between 2-4 times when compared to the control (1.37 t ha^{-1}). Application of organic-chemical fertilizer alone showed 2-2.5 times (2.66-3.43 t ha^{-1}) increased yield of grains over the control. However, maximum grain yield (5.57 t ha^{-1}) was obtained from T_5 (RDF-chemical fertilizer) which also gave the highest all yield parameters such as number of grain per panicle (108.20), total number panicle per hill (14.82), plant height (62.48 cm) and percentage of filled grain (82.17%).

Basu *et al*. (2012) conducted a field experiment to study the quality aspect of rice (cv. BRRI dhan28) as response to chemical fertilizers and organic manure (cowdung) comprised of four doses of chemical fertilizers (0, 0.5, 0.75 and full recommended dose) and four cowdung doses (0, 1.0, 1.5, two times of full recommended dose). The grain yield ranged from 1.92 to 4.58 t ha^{-1}. The highest grain yield was observed in treatment containing the full recommended dose of chemical fertilizers along with the double dose of cowdung (F_1M_3) and it was the lowest in without chemical fertilizers and recommended dose of cowdung (F_0M_1).

Dey (2012) found that the highest grain (6.20 t ha^{-1}) and straw yields (7.75 t ha^{-1}) were produced by the T_7 (USG at transplanting + 50% PKS at transplanting + 50% PKS at maximum tillering) treatment. The P, K and S uptake by BRRI dhan29 significantly increased due to split fertilization. So, split application of P, K and S fertilizers along with USG exerted a beneficial effect on yield contributing characters, resulting in higher grain and straw yields for BRRI dhan29 as compared to their single application.

Hossaen *et al*. (2011) studied on yield and yield attributes of Boro Rice due different organic manure and inorganic fertilizer. At 30, 50, 70, 90 DAT and at harvest stage the tallest plant (24.18, 31.34, 44.67, 67.05 and 89.00 cm) and the greatest number of total tillers $hill^{-1}$ (5.43, 11.64, 21.01 and 17.90) at same DAT was found from T_5 (70% NPKS +2.4 t PM ha^{-1}) and the lowest was observed from T0 (control) in every aspect. The maximum number of effective tillers $hill^{-1}$ (13.52), the longest panicle (24.59 cm), maximum number of total grains $plant^{-1}$ (97.45), the highest weight of 1000 seed (21.80 g), the maximum grain yield (7.30 t ha^{-1}) and straw yield (7.64 t ha^{-1}) was found from T_5 treatment while the lowest number of effective tillers $hill^{-1}$ (6.07), the shortest panicle (16.45 cm), the minimum grains $plant^{-1}$ (69.13), the lowest weight of 1000 seed (16.73 g), the lowest grain yield (2.06 t ha^{-1}) and straw yield (4.63 t ha^{-1}) was recorded from T_0.

Naing *et al*. (2010) investigated the effect of organic and inorganic fertilizers on growth and yield of five upland black glutinous rice varieties and soil property.

Four fertilizer treatments (control, FYM or cattle manure @ 10 t ha^{-1}, NPK at the rate of 50-22-42 kg N-P-K ha^{-1}, the combination of the FYM and NPK were used as treatments. Number of tillers and panicles per hill and grains per panicle, thousand grain weight, number of filled and unfilled grains and grain yield were recorded at harvest time. The results from both years indicated that using the combination of FYM cattle manure and inorganic fertilizers increased tiller and panicle number $hill^{-1}$, grain number $panicle^{-1}$ and grain yield.

An experiment was conducted by Islam *et al.* (2008) to determine the response and the optimum rate of nutrients (NPK) for Chilli- Fallow-T. *aman* cropping pattern. They found that grain yield influenced significantly due to application of different rates of nutrients and 60-19-36 kg ha^{-1} NPK maximized the yield of T. Aman rice varieties in respect of yield and economics.

Muangsri *et al*. (2008) found that the effect of rice straw and rice hull in combination NPK fertilizer on yield of rice grown on Phimai soil series. The treatments consisted of the control, rice straw at the rate of 0.75, 1.5 and 3.0 g kg^{-1} soil in combination with NPK fertilizers, 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 without fertilizer were the lowest. Yield of rice plant grown on the soil amended with rice straw in combination with NPK fertilizer showed to be higher than that of rice plant grown on the soil amended with only NPK fertilizer.

Ndaeyo *et al.* (2008) carried out an experiment with five rice varieties (WAB340-8-8-2HI, WAB881-10-37-18-8-2-HI, WAB99-1-1, WAB224-8-HB, WAB189-B-B-B-8-HB) and four rates of NPK (15:15:15) fertilizer (0, 200, 400 and 600 kg ha^{-1}). The results showed that 600 kg ha^{-1} NPK (15:15:15) fertilizer rate significantly increased plant height, number of leaves and tillers per plant in both years. The 400 kg ha^{-1} rate increased the number of panicles per plant, length of central panicle per plant and the overall grain yield, straw yield over other rates by 4-32% and 2-21% in 2005 and 2006, respectively.

A field experiment was conducted by Rahman *et al.* (2007) a using rice (cv. BRRI dhan29) as a test crop and found that application of NPKS had a significant positive effect on tillers ha^{-1}, plant height, panicle length and grains $panicle^{-1}$. They also indicated that application of NPKS fertilizer at a recommended rate (20 kg S/ha) might be necessary for obtaining higher grain yield as well as straw yield.

Amin *et al.* (2006) conducted an experiment to evaluate the effect of increased plant density and fertilizer dose on yield of rice variety IR-6. They found that increased fertilizer dose of NPK increased plant height.

Jumei *et al.* (2005) conducted a field experiment in southern China, to study the effects of organic and inorganic N fertilizers on ammonia volatilization and rice yield in paddy soil. Four treatments were PK treatment as control, NPK treatment (urea as N), NPKM treatment (half chemical fertilizers + half manure), M treatment (pig manure as N), same amount of N, P, K either organic or inorganic forms (N 150 kg m^{-2}, P_2O_5 100.5 kg m^{-2} and K_2O 109.5 kg m^{-2}) were applied in each plot. The rice yields of NPKM, NPK, M treatments were increased by 68.6%, 68.1% and 60.0% respectively for early rice, and increased by 72.0%, 69.6% and 34.2% for late rice compared with control treatment.

Hossain *et al.* (2005) carried out a study to assess the effects of nitrogen (30, 60, 90 and 120 kg ha^{-1} N) and phosphorus (20, 40 and 60 kg ha^{-1} P_2O_5) on the growth and yield of rice/sorghum inter-crop. Application of nitrogen up to 90 kg ha^{-1} enhanced the growth and yield of rice crop and application of phosphorus @ 40 kg ha^{-1} P_2O_5 resulted in higher growth and yield of rice crop.

Saha *et al.* (2004) conducted an experiment with the objectives to create and compare a suitable fertilizer recommendation model for lowland rice. Five different fertilizer recommendation models were tested and compared with one check plot. Results showed that the application of different fertilizer models significantly influenced panicle length, spikelet number per panicle, total grains per panicle, number of filled grain and unfilled grain per panicle. The combination of NPK gave the highest result (120-13-70-20 kg ha^{-1} NPKS).

Saleque *et al*. (2004) studied with six treatments viz. absolute control (T_1), 1/3 of RFD (T_2), 2/3 of RD (T_3), full doses of RF (T_4), T_2 + 5 t cowdung and 2.5 t ash ha^{-1} (T_5) and T_3 + 5 t cowdung ha^{-1} + 2.5 t ash ha^{-1} (T_6) were compared. The results showed that application of cowdung and ash (T_5 and T_6) increased rice yield by about 1 t ha^{-1} year^{-1} over that obtained with chemical fertilizer alone.

Singh *et al.* (2003) conducted an experiment and reported that crop growth rate and relative growth rate such as total dry matter production was significantly influenced by NPK fertilizers. The tiller number and total dry matter production are closely correlated with yield depending on the rice cultivar which can be greatly enhanced by applying proper nutrient.

Rasheed *et al.* (2003) observed from an experiment that the effect of different NP levels i.e., 0-0, 25-0, 50-25, 75-50, 100-75 and 125-100 kg ha^{-1} on yield and yield attributes of rice Bas-385. Yield attributes (No. of effective tillers per hill, spikelet per panicle, normal kernels per panicle, 1000-grain weight) were improved linearly with increasing NP levels up to 100-75 kg ha^{-1}. The NP level of 100-75 kg ha^{-1} resulted in the highest grain yield of 4.53 t ha^{-1}.

Haq *et al.* (2002) carried out a field experiment with twelve treatments combination of N, P, K, S and Zn with objectives to find out the optimum doses of N, P, K, S, Zn for rice cultivation. They found that all the treatments significantly increased the grain and straw yields of BRRI dhan30 rice over control. 90 kg N + 50 kg P_2O_5 + 40 kg K_2O + 10 kg S + 4 kg Zn ha^{-1} gave the highest grain and straw yields.

Asif *et al.* (2000) carried out an experiment and found that NPK levels significantly increased the panicle length, number of primary and secondary branches panicle^{-1} when NPK fertilizer applied in 180-90-90 kg ha^{-1} this might be attributed to the adequate supply of NPK for the plant and produced the highest yield compared to other.

2.4 Weed management of rice

The prevailing climatic and edaphic conditions are very much favorable for luxuriant growth of numerous species of weeds that strongly compete with rice plant. High competitive ability of weeds exerts a serious negative effect on crop production causing significant losses in crop yield. Any delay in weeding will lead to increased weed biomass as a result drastic reduction in yield. In Bangladesh, weed infestation reduces the grain yield by 70-80% in Aus rice (early summer), 30-40% for transplanted *aman* rice (autumn) and 22-36% for modern *boro* rice cultivars (winter rice) (Mamun, 1995; BRRI, 2008).

Kishore *et al.* (2016) observed that both chemical and mechanical methods of weed control were superior over weedy check. The lowest weed density, dry weight, and highest WCE (weed control efficiency), maximum length of panicle, number of panicle (m^{-2}), and 1000-grain weight and grain yield of 30.40 and 32.60 q ha^{-1} were recorded with two HW (hand weeding) which was at par with Butachlor @ 1.0 kg ha^{-1} fb one HW over rest of the weed management practices.

Antralinaa *et al.* (2015) aimed to study the effect of difference weed control methods on rice yield. The results showed that weed control using herbicides containing Bispyribac sodium and 2, 4 D + Methyl metsulfuron showed similar results as manual weed control on rice yield. Chowdhury *et al.* (2015) reported that Sunrice® 150WG as pre-emergence herbicide controlled weeds very successfully which performed better in response of yield contributing characters of rice. Application of Sunrice® 150WG achieved highest grain yield which was 50.73%, 32.07%, 11.95% and 5.25% higher than the yield obtained from control, one HW, two HW and Topstar® 400SC treated plots, respectively.

Chauhana *et al.* (2015) conducted a field study to evaluate the performance of five rice establishment methods and four weed control treatments on weed management, and rice yield. They observed that the weed-free plots and herbicide treatments produced 84-614% and 58-504% higher rice grain yield, respectively, than the weedy plots in 2012, and a similar trend was observed in 2013.

Ahmed *et al.* (2014) conducted the experiments in the *aman* seasons of 2012 and 2013 in Bangladesh to evaluate the effect of weed infestation level (partially-weedy and weed-free) on weed and crop growth in DSR. Under weed-free conditions, higher crop yields (5.1 and 5.2 t ha^{-1} in the 2012 and 2013 seasons, respectively) were obtained at the seeding rate of 40 kg ha^{-1} and thereafter, yield decreased slightly beyond 40 kg seed ha^{-1}.

Irrigation scheduled at seven days interval during vegetative stage and four days interval during reproductive stage resulted in significantly higher weed density, weed dry matter production and NPK removal by weeds and higher panicle number and weight, filled spikelets $panicle^{-1}$ grain and yield than that of irrigation scheduled once in two days (Pasha *et al.*, 2011).

Ismail *et al.* (2011) conducted an experiment to determine the efficacy of different methods of weed control and their profitability in interspecific and intra-specific upland rice varieties. Results showed that three hoe weeding at 25, 45 and 65 DAS, twice at 25 and 45 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} compared to other treatments.

Nahar *et al.* (2010) carried out a field experiment to study the effect of spacing and weeding regime on the performance of transplant *aman* rice cv. BRRI dhan41 and observed that weeding regime had significant effect on all the parameters except 1000 grain weight.

Malek (2008) conducted an experiment to study effect of weeding regime on performance of transplanted Aus rice (cv. BR26). He obtained the highest grain yield due to two times weeding at 15 and 30 DAT and lowest value was obtained from no weeding treatment.

Aktaruzzaman (2007) reported that weeding regimes exerted significance influence on all the crop characters studied except panicle length and the highest grain yield was obtained from weed free treatment and the lowest value was obtained from no weeding treatment. Hasanuzzaman *et al*. (2007) stated that plant height was significantly affected by different weeding treatments.

Ranjit and Suwanketnikom (2005) initiated an experiment in Nepal to assess the performance of rice (*Oryza sativa*) under dry direct seeded environment with different weed management treatments. Both Anilofos and Bispyribac-sodium reduced narrow leaf and broad leaf weeds compared with the unweeded control. Promising grain yield could be achieved with the Anilofos or Bispyribac-sodium with additional physical or mechanical control methods in dry direct seeded rice.

Singh (2005) conducted an experiment at Bihar, India to assess the effectiveness of Beushening (a kind of mechanical weed control) in controlling weeds as well as to make a comparison between Beushening and chemical weed control. It was found that standard practice of Beushening along with one hand weeding (HW) 40 days after sowing (DAS) was better in controlling weeds than other chemical treatments with or without one HW 40 DAS and both practices of Beushening as effective as two HWs (25 and 40 DAS) in terms of grain yield. Ferrero (2003) estimated that without weed control, at a yield level of 7.00 to 8.00 t ha^{-1}, yield loss can be as high as about 90%.

From the above cited literature, it is observed that varieties, irrigation, fertilizers and weed management had a significant influence on yield attributes and yield of rice. The literature further explores that the grain yield of Aus rice can be increased by the increase of number of tiller hill^{-1}, grains panicle$^{-1,}$ panicle length and 1000-grains weight by adopting suitable varieties with appropriate irrigation, fertilizer and weed management.

Chapter 3

Materials and Methods

CHAPTER 3

MATERIALS AND METHODS

Field experiments were conducted to evaluate the performance of Aus rice varieties with supplemental irrigation, fertilizer and weed managements. The details of the materials and methods i.e. experimental location, period, soil and climatic condition, materials used, treatment and design, growing of crops, data collection and analysis procedure that followed for these experiments has been presented under the following headings:

3.1 Description of the experimental site

3.1.1 Location of the experiment

The present research works were conducted at Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka. The location of the site is $23^0 46^/ 19.9^{//}$N latitude and $90^0 22^/ 15.1^{//}$ E longitude with an elevation of 9.0 meter from sea level. A map of the experimental location presented in Appendix I.

3.1.2 Experimental period

The experiment was conducted during the period of April to August, 2015 as 1st year, April to August, 2016 as 2nd year and April to August, 2017 as 3rd year.

3.1.3 Soil characteristics

The soil belonged 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. The details have been presented in Appendix II.

3.1.4 Climatic condition

The geographical location of the experimental site was under the subtropical climate and its climatic conditions is characterized by high temperature, heavy rainfall during Kharif-1 season (March-June) and scanty rainfall during Rabi season (October-March) associated with moderately low temperature. Details of the meteorological data of air temperature, relative humidity, rainfall and sunshine hour in experimental period has been presented in Appendix III.

3.2 Experimental details

3.2.1 Experiment-1: Growth and Yield Performance of Different Aus Rice Varieties under Irrigated and Non-irrigated Condition

3.2.1.1 Experimental period

The experiment was conducted during the period of April to August, 2015.

3.2.1.2 Planting material

Total 12 rice varieties were used as the test crops in this experiment.

3.2.1.3 Treatment of the experiment

The experiment comprised of two factors.

Factor A: Irrigation (2 levels)

i. I_0: No irrigation

ii. I_1: Supplemental irrigation

Factor B: Rice varieties (12 varieties)

i. V_1: BR-3

ii. V_2: BR-14

iii. V_3: BR-16

iv. V_4: BRRIdhan27

v. V_5: BRRI dhan42

vi. V_6: BRRI dhan48

vii. V_7: BRRI dhan55

viii. V_8: BRRI dhan65

ix. V_9: China (Muladi local)

x. V_{10}: Kali Shait-ta (Muladi local)

xi. V_{11}: Benamuri (Muladi local)

xii. V_{12}: Abdul Hye (Jhalkathi local)

As such there were 24 (2×12) treatments combinations viz. I_0V_1, I_0V_2, I_0V_3, I_0V_4, I_0V_5, I_0V_6, I_0V_7, I_0V_8, I_0V_9, I_0V_{10}, I_0V_{11}, I_0V_{12}, I_1V_1, I_1V_2, I_1V_3, I_1V_4, I_1V_5, I_1V_6, I_1V_7, I_1V_8, I_1V_9, I_1V_{10}, I_1V_{11} and I_1V_{12}.

3.2.1.4 Experimental design and layout

The two factors experiment was laid out in split-plot design with three replications. An area of 784.75 m^2 (21.5 m × 36.5 m) was divided into 3 blocks. The two levels of irrigation were assigned in the main plot and 12 rice varieties in the sub-plot. The size of the each unit plot was 2.0 m × 2.0 m. The space between two blocks, main and sub plots and two plots were 1.5 m, 1.5 m and 1.0 m, respectively. Each plot and sub-plot were separated by raised border.

3.2.1.5 Growing of crops

Seed collection and sprouting

Seeds were collected from BRRI (Bangladesh Rice Research Institute), Gazipur and local market just 20 days ahead of the sowing of seeds in seed bed. For raising seedlings, clean seeds were immersed in water in a bucket for 24 hours then it was taken out of water and kept in gunny bags. The seeds started sprouting after 48 hours which were suitable for sowing in 72 hours.

Raising of seedlings

The nursery bed was prepared by puddling with repeated ploughing followed by laddering. The sprouted seeds were sown on beds on 11 April, 2015 as uniformly as possible. Irrigation was gently provided to the bed as and when needed. No fertilizer was used in the nursery bed.

3.2.1.6 Land preparation

The plot selected for conducting the experiment was opened in the 26th April 2015 with a power tiller, and left exposed to the sun for a week. After that the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain good puddle condition. Weeds and stubbles were removed and organic and inorganic manures were mixed with the soil. The experimental plot was partitioned into unit plots in accordance with the experimental design.

3.2.1.7 Fertilizers and manure application

The fertilizers N, P, K, S, Zn and B in the form of urea, TSP (Triple Super Phosphate), MoP (Muriate of Potash), gypsum, zinc sulphate and borax, respectively were applied @ 150 kg, 50 kg, 75 kg, 5.0 kg, 2.0 kg and 1.0 kg ha^{-1} (BRRI, 2016). The entire amount of TSP, MoP, gypsum, zinc sulphate and borax were applied during the final preparation of experimental plot. Urea was applied in two equal installments as top dressing at tillering and panicle initiation stages.

3.2.1.8 Transplanting of seedling

Twenty five days old seedlings were carefully uprooted from the seedling nursery and transplanted on 7th May, 2015 in well puddled plot with maintaining distance of 20 cm × 15 cm. One seedling was transplanted for each hill. After one week of transplanting all plots were checked for any missing hill, which was filled up with extra seedlings of the same source whenever required.

3.2.1.9 Intercultural operations

Intercultural operations were done to ensure normal growth of the crop. Plant protection measures were followed as and when necessary. The following intercultural operations were done:

Irrigation and drainage

Irrigation was provided as per treatment. In case of supplemental irrigation it was maintain a water saturation condition in the experimental field and irrigation was provided accordingly. The plot was finally dried out at 15 days before harvesting.

Weeding

Weedings were done to keep the plots free from weeds, which ultimately ensured better growth and development of rice plants. The newly emerged weeds of the experimental plots were uprooted carefully at 20 DAT and 40 DAT by hand weeding.

Insect and pest control

There was no infection of diseases in the field but leaf roller (*Chaphalocrosis medinalis*) was found in the field and used Malathion @ 1.12 L ha^{-1} at 30 DAT with using a hand sprayer.

3.2.1.10 Harvesting, threshing and cleaning

The crop was harvested at full maturity when 80-90% of the grains were turned into straw colored. The harvested crop was bundled separately, properly tagged and brought to threshing floor. Enough care was taken during threshing and cleaning period of rice grain. Fresh weight of rice grain and straw were recorded plot wise from 1 m^2 area. The grains were dried up to moisture content 14%, then cleaned and weighed for individual plot. Yields of rice grain and straw were collected from 1 m^2 and recorded from each plot and then converted to hectare yield and expressed in t ha^{-1}.

3.2.1.11 Data recording

Plant height

Plant height of rice was recorded in centimeter (cm) at Early Tillering Stage (ETS), Maximum Tillering Stage (MTS), Flowering Stage (FS), Grain Filling Stage (GFS) and Maturity Stage (MS). Data were recorded as the average of 5 plants selected at random from the inner rows of each plot. The height was measured from the ground level to the tip of the panicle or flag leaf.

Number of tillers hill^{-1}

Number of tillers hill^{1} was recorded at ETS, MTS, FS and GFS. Data were recorded as the average of 5 plants selected at random from the inner rows of each plot.

Crop duration

Crop duration was recorded by counting the number of days required to harvest in each plot.

Effective tillers hill^{-1}

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

Non-effective tillers hill^{-1}

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

Total tillers hill^{-1}

The total number of tiller hill^{-1} was counted by adding the number of effective tillers hill^{-1} and non-effective tillers hill^{-1}. Data on total tillers hill^{-1} were counted from 5 selected hills and average value was recorded.

Panicle length

The length of panicle was measured with a meter scale from 5 selected panicle and the average length was recorded as per panicle in cm.

Filled grains panicle^{-1}

The total numbers of filled grain were collected randomly from selected 5 panicle of a plot on the basis of grain in the spikelet and then average numbers of filled grains panicle^{-1} was recorded.

Unfilled grains panicle^{-1}

The total numbers of unfilled grain was collected randomly from selected 5 plants of a plot on the basis of empty grain in the spikelet and then average numbers of unfilled grains panicle^{-1} was recorded.

Total grains panicle^{-1}

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

Weight of 1000-grain

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

Grain yield

Grains obtained from each unit plot were sun-dried and weighed carefully. The dry weight of grains of central 1 m^2 area in each plot were taken the final grain yield $plot^{-1}$ and finally converted to ton $hectare^{-1}$ ($t\ ha^{-1}$).

Straw yield

Straw obtained from each unit plot were sun-dried and weighed carefully. The dry weight of straw of central 1 m^2 area was taken from each plot and finally converted to ton $hectare^{-1}$ ($t\ ha^{-1}$).

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.

Harvest index

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

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

3.2.2 Experiment-2: Yield Performance of Selected Aus Rice Varieties under Irrigated and Non-irrigated Condition

3.2.2.1 Experimental period

The experiment was conducted during the period of April to August, 2016.

3.2.2.2 Planting material

Total 4 selected rice variety were used as the test crops in this experiment.

3.2.2.3 Treatment of the experiment

The experiment comprised of two factors.

Factor A: Irrigation (2 levels)

i. I_0: No irrigation

ii. I_1: Supplemental irrigation

Factor B: Rice varieties (4 varieties)

i. V_1: BR-14

ii. V_2: BRRI dhan48

iii. V_3: BRRI dhan55

iv. V_4: BRRI dhan65

As such there were 8 (2×4) treatments combinations viz. I_0V_1, I_0V_2, I_0V_3, I_0V_4, I_1V_1, I_1V_2, I_1V_3 and I_1V_4.

3.2.2.4 Experimental design and layout

The two factors experiment was laid out in split-plot design with three replications. An area of 290.25 m^2 (21.5 m × 13.5 m) was divided into 3 blocks. The two levels of irrigation were assigned in the main plot and 4 rice variety in the sub-plot. The size of the each unit plot was 2.0 m × 2.0 m. The space between two blocks, main and sub plots and two plots were 1.5 m, 1.5 m and 1.0 m, respectively. Each plot and sub-plot were separated by raised border.

3.2.2.5 Growing of crops

Seed collection and sprouting

Seeds were collected from BRRI (Bangladesh Rice Research Institute), Gazipur just 20 days ahead of the sowing of seeds in seed bed. For seedling raising clean seeds were immersed in water in a bucket for 24 hours. The imbibed seeds were then taken out of water and kept in gunny bags. The seeds started sprouting after 48 hours which were suitable for sowing in 72 hours.

Raising of seedlings

The nursery bed was prepared by puddling with repeated ploughing followed by laddering. The sprouted seeds were sown on beds on 08 April, 2016 as uniformly as possible. Irrigation was gently provided to the bed as and when needed. No fertilizer was used in the nursery bed.

3.2.2.6 Land preparation

The plot selected for conducting the experiment was opened in the 17th April 2016 with a power tiller, and left exposed to the sun for a week. After one week the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain good puddle condition. Weeds and stubbles were removed. The experimental plot was partitioned into unit plots in accordance with the experimental design. Organic and inorganic manures as indicated below were mixed with the soil of each unit plot.

3.2.2.7 Fertilizers and manure application

The fertilizers N, P, K, S, Zn and B in the form of urea, TSP (Triple Super Phosphate), MoP (Muriate of Potash), Gypsum, zinc sulphate and borax, respectively were applied @ 150 kg, 50 kg, 75 kg, 5.0 kg, 2.0 kg and 1.0 kg ha^{-1} (BRRI, 2016). The entire amount of TSP, MoP, gypsum, zinc sulphate and borax were applied during the final preparation of experimental plot. Urea was applied in two equal installments as top dressing at tillering and panicle initiation stages.

3.2.2.8 Transplanting of seedling

Twenty five days old seedlings were carefully uprooted from the seedling nursery and transplanted on 04 May, 2016 in well puddled plot with maintaining distance of 20 cm × 15 cm. One seedling was transplanted for each hill. After one week of transplanting all plots were checked for any missing hill, which was filled up with extra seedlings of the same source whenever required.

3.2.2.9 Intercultural operations

Intercultural operations were done to ensure normal growth of the crop. Plant protection measures were followed as and when necessary. The following intercultural operations were done:

Irrigation and drainage

Irrigation was provided as per treatment and in case of supplemental irrigation water saturation condition in the experimental field and irrigation was provided accordingly. The plot was finally dried out at 15 days before harvesting.

Weeding

Weedings were done to keep the plots free from weeds, which ultimately ensured better growth and development. The newly emerged weeds were uprooted carefully at 20 DAT and 40 DAT by sickles.

Insect and pest control

There was no infection of diseases in the field but leaf roller (*Chaphalocrosis medinalis*) was found in the field and used Malathion @ 1.12 L ha^{-1} at 30 DAT with using a hand sprayer.

3.2.2.10 Harvesting, threshing and cleaning

The crop was harvested at full maturity when 80-90% of the grains were turned into straw colored. The harvested crop was bundled separately, properly tagged and brought to threshing floor. Enough care was taken during threshing and cleaning period of rice grain. Fresh weight of rice grain and straw were recorded plot wise from 1 m^2 area. The grains were dried up to moisture content 14%, then cleaned and weighed for individual plot. Yields of rice grain and straw were collected from 1 m^{-2} and recorded from each plot and then converted to hectare yield and expressed in t ha^{-1}.

3.2.2.11 Data recording

Plant height

Plant height of rice was recorded in centimeter (cm) at Early Tillering Stage (ETS), Maximum Tillering Stage (MTS), Flowering Stage (FS), Grain Filling Stage (GFS) and Maturity Stage (MS). Data were recorded as the average of 5 plants selected at random from the inner rows of each plot. The height was measured from the ground level to the tip of the panicle or flag leaf.

Number of tillers $hill^{-1}$

Number of tillers $hill^1$ was recorded at ETS, MTS, FS and GFS. Data were recorded as the average of 5 plants selected at random from the inner rows of each plot.

Leaf area index

Leaf area index (LAI) was measured in terms of total leaf area (cm^2) per square meter of the land area at the time of ETS, MTS, FS and GFS. Data were recorded as the average of 05 plants selected at random the inner rows of each plots and their area were measured with Portable Area Meter Model LI-3000, USA. The leaf area index (LAI) was worked out by using the formula of Yoshida (1981).

$$\text{Leaf area index} = \frac{\text{Total leaf area (cm}^2\text{)}}{\text{Unit land area (cm}^2\text{)}}$$

Crop duration

Crop duration was recorded by counting the number of days required to harvest in each plot.

Effective tillers hill^{-1}

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

Non-effective tillers hill^{-1}

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

Total tillers hill^{-1}

The total number of tiller hill^{-1} was counted by adding the number of effective tillers hill^{-1} and non-effective tillers hill^{-1}. Data on total tillers hill^{-1} were counted from 5 selected hills and average value was recorded.

Panicle length

The length of panicle was measured with a meter scale from 5 selected panicle and the average length was recorded as per panicle in cm.

Filled grains panicle^{-1}

The total numbers of filled grain were collected randomly from selected 5 panicle of a plot on the basis of grain in the spikelet and then average numbers of filled grains panicle^{-1} was recorded.

Unfilled grains panicle^{-1}

The total numbers of unfilled grain was collected randomly from selected 5 plants of a plot on the basis of empty grain in the spikelet and then average numbers of unfilled grains panicle^{-1} was recorded.

Total grains panicle^{-1}

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

Weight of 1000-grain

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

Grain yield

Grains obtained from each unit plot were sun-dried and weighed carefully. The dry weight of grains of central 1 m^2 area in each plot were taken the final grain yield plot^{-1} and finally converted to ton hectare^{-1} (t ha^{-1}).

Straw yield

Straw obtained from each unit plot were sun-dried and weighed carefully. The dry weight of straw of central 1 m^2 area was taken from each plot and finally converted to ton hectare^{-1} (t ha^{-1}).

Biological yield

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

$$\text{Biological yield} = \text{Grain yield} + \text{Straw yield.}$$

Harvest index

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

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

3.2.3 Experiment-3: Productivity of Aus Rice Varieties Under Different Fertility Regime

3.2.3.1 Experimental period

The experiment was conducted during the period of April to August, 2016.

3.2.3.2 Planting material

Total 4 selected rice variety were used as the test crops in this experiment.

3.2.3.3 Treatment of the experiment

The experiment comprised of two factors.

Factor A: Fertilizer (3 levels)

i. F_1: Recommended fertilizer dose-RFD

ii. F_2: 20% added with RFD

iii. F_3: 20% less with RFD

Factor B: Rice variety (4 varieties)

i. V_1: BR-14

ii. V_2: BRRI dhan48

iii. V_3: BRRI dhan55

iv. V_4: BRRI dhan65

Recommended fertilizer dose-RFD (150, 50, 75, 5.0, 2.0 and 1.0 kg ha^{-1} of N, P, K, S, Zn and B, respectively) as per BRRI, 2016.

As such there were 12 (3×4) treatments combinations viz. F_1V_1, F_1V_2, F_1V_3, F_1V_4, F_2V_1, F_2V_2, F_2V_3, F_2V_4, F_3V_1, F_3V_2, F_3V_3 and F_3V_4.

3.2.3.4 Experimental design and layout

The two factors experiment was laid out in split-plot design with three replications. An area of 430 m^2 (21.5 m × 20.0 m) was divided into 3 blocks. The three levels of fertilizers were assigned in the main plot and 4 rice variety in the sub-plot. The size of the each unit plot was 2.0 m × 2.0 m. The space between two blocks and two plots were 1.5 m and 1.0 m, respectively. Each plot were separated by raised border.

3.2.3.5 Growing of crops

Seed collection and sprouting

Seeds were collected from BADC (Bangladesh Agricultural Development Corporation), BRRI (Bangladesh Rice Research Institute), Gazipur and local market just 20 days ahead of the sowing of seeds in seed bed. For seedling raising clean seeds were immersed in water in a bucket for 24 hours. The imbibed seeds were then taken out of water and kept in gunny bags. The seeds started sprouting after 48 hours which were suitable for sowing in 72 hours.

Raising of seedlings

The nursery bed was prepared by puddling with repeated ploughing followed by laddering. The sprouted seeds were sown on beds on 08 April, 2016 as uniformly as possible. Irrigation was gently provided to the bed as and when needed. No fertilizer was used in the nursery bed.

3.2.3.6 Land preparation

The plot selected for conducting the experiment was opened in the 17th April 2016 with a power tiller, and left exposed to the sun for a week. After one week the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain good puddle condition. Weeds and stubbles were removed. The experimental plot was partitioned into unit plots in accordance with the experimental design. Organic and inorganic manures as indicated below were mixed with the soil of each unit plot.

3.2.3.7 Fertilizers and manure application

Fertilizers were applied as per treatment i.e., recommended fertilizer dose-RFD, 20% added with RFD and 20% less with RFD. As recommended doses the fertilizers N, P, K, S, Zn and B in the form of urea, TSP (Triple Super Phosphate), MoP (Muriate of Potash), Gypsum, zinc sulphate and borax, respectively were applied @ 150 kg, 50 kg, 75 kg, 5.0 kg, 2.0 kg and 1.0 kg ha^{-1} (BRRI, 2016). The entire amount of TSP, MoP, gypsum, zinc sulphate and borax were applied during the final preparation of experimental plot. Urea was applied in two equal installments as top dressing at tillering and panicle initiation stages.

3.2.3.8 Transplanting of seedling

Twenty five days old seedlings were carefully uprooted from the seedling nursery and transplanted on 04 May, 2016 in well puddled plot with maintaining distance of 20 cm × 15 cm. One seedling was transplanted for each hill. After one week of transplanting all plots were checked for any missing hill, which was filled up with extra seedlings of the same source whenever required.

3.2.3.9 Intercultural operations

Intercultural operations were done to ensure normal growth of the crop. Plant protection measures were followed as and when necessary. The following intercultural operations were done:

Irrigation and drainage

Supplemental irrigation was provided for water saturation condition in the experimental field. The plot was finally dried out at 15 days before harvesting.

Weeding

Weedings were done to keep the plots free from weeds, which ultimately ensured better growth and development. The newly emerged weeds were uprooted carefully at 20 DAT and 40 DAT by sickles.

Insect and pest control

There was no infection of diseases in the field but leaf roller (*Chaphalocrosis medinalis*) was found in the field and used Malathion @ 1.12 L ha^{-1} at 30 DAT with using a hand sprayer.

3.2.3.10 Harvesting, threshing and cleaning

The crop was harvested at full maturity when 80-90% of the grains were turned into straw colored. The harvested crop was bundled separately, properly tagged and brought to threshing floor. Enough care was taken during threshing and cleaning period of rice grain. Fresh weight of rice grain and straw were recorded plot wise from 1 m^2 area. The grains were dried up to moisture content 14%, then cleaned and weighed for individual plot. Yields of rice grain and straw were collected from 1 m^{-2} and recorded from each plot and then converted to hectare yield and expressed in t ha^{-1}.

3.2.3.11 Data recording

Plant height

Plant height of rice was recorded in centimeter (cm) at Early Tillering Stage (ETS), Maximum Tillering Stage (MTS), Flowering Stage (FS), Grain Filling Stage (GFS) and Maturity Stage (MS). Data were recorded as the average of 5 plants selected at random from the inner rows of each plot. The height was measured from the ground level to the tip of the panicle or flag leaf.

Number of tillers $hill^{-1}$

Number of tillers $hill^{1}$ was recorded at ETS, MTS, FS and GFS. Data were recorded as the average of 5 plants selected at random from the inner rows of each plot.

Total dry matter m^2

Total dry matter m^{-2} was recorded at ETS, MTS, FS and GFS by drying plant sample. Data were recorded as the average of 5 sample $hill^{-1}$ collected at random from the inner rows of each plot and converted in m^{-2} and expressed in gram (g).

Crop duration

Crop duration was recorded by counting the number of days required to harvest in each plot.

Effective tillers hill^{-1}

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

Non-effective tillers hill^{-1}

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

Total tillers hill^{-1}

The total number of tiller hill^{-1} was counted by adding the number of effective tillers hill^{-1} and non-effective tillers hill^{-1}. Data on total tillers hill^{-1} were counted from 5 selected hills and average value was recorded.

Panicle length

The length of panicle was measured with a meter scale from 5 selected panicle and the average length was recorded as per panicle in cm.

Filled grains panicle^{-1}

The total numbers of filled grain were collected randomly from selected 5 panicle of a plot on the basis of grain in the spikelet and then average numbers of filled grains panicle^{-1} was recorded.

Unfilled grains panicle^{-1}

The total numbers of unfilled grain was collected randomly from selected 5 plants of a plot on the basis of empty grain in the spikelet and then average numbers of unfilled grains panicle^{-1} was recorded.

Total grains panicle^{-1}

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

Weight of 1000-grain

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

Grain yield

Grains obtained from each unit plot were sun-dried and weighed carefully. The dry weight of grains of central 1 m^2 area in each plot were taken the final grain yield plot^{-1} and finally converted to ton hectare^{-1} (t ha^{-1}).

Straw yield

Straw obtained from each unit plot were sun-dried and weighed carefully. The dry weight of straw of central 1 m^2 area was taken from each plot and finally converted to ton hectare^{-1} (t ha^{-1}).

Biological yield

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

$$\text{Biological yield} = \text{Grain yield} + \text{Straw yield.}$$

Harvest index

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

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

3.2.4 Experiment-4: Effect of Weed Management on the Yield Attributes and Yield of Different Aus Rice Varieties

3.2.4.1 Experimental period

The experiment was conducted during the period of April to August, 2016.

3.2.4.2 Planting material

Total 4 selected rice variety were used as the test crops in this experiment.

3.2.4.3 Treatment of the experiment

The experiment comprised of two factors.

Factor A: Weed management (2 levels)

i. W_0: Control

ii. W_1: Hand weeding at 20 and 40 DAT

Factor B: Rice varieties (4 varieties)

i. V_1: BR-14

ii. V_2: BRRI dhan48

iii. V_3: BRRI dhan55

iv. V_4: BRRI dhan65

As such there were 8 (2×4) treatments combinations viz. W_0V_1, W_0V_2, W_0V_3, W_0V_4, W_1V_1, W_1V_2, W_1V_3 and W_1V_4.

3.2.4.4 Experimental design and layout

The two factor experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. An area of 290.25 m^2 (21.5 m × 13.5 m) was divided into 3 blocks for distribution the treatment combinations. The size of the each unit plot was 2.0 m × 2.0 m. The space between two blocks, main and sub plots and two plots were 1.5 m, 1.5 m and 1.0 m, respectively. Each plot and sub-plot were separated by raised border.

3.2.4.5 Growing of crops

Seed collection and sprouting

Seeds were collected from BADC (Bangladesh Agricultural Development Corporation), BRRI (Bangladesh Rice Research Institute), Gazipur and local market just 20 days ahead of the sowing of seeds in seed bed. For seedling raising clean seeds were immersed in water in a bucket for 24 hours. The imbibed seeds were then taken out of water and kept in gunny bags. The seeds started sprouting after 48 hours which were suitable for sowing in 72 hours.

Raising of seedlings

The nursery bed was prepared by puddling with repeated ploughing followed by laddering. The sprouted seeds were sown on beds on 08 April, 2016 as uniformly as possible. Irrigation was gently provided to the bed as and when needed. No fertilizer was used in the nursery bed.

3.2.4.6 Land preparation

The plot selected for conducting the experiment was opened in the 17th April 2016 with a power tiller, and left exposed to the sun for a week. After one week the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain good puddle condition. Weeds and stubbles were removed. The experimental plot was partitioned into unit plots in accordance with the experimental design. Organic and inorganic manures as indicated below were mixed with the soil of each unit plot.

3.2.4.7 Fertilizers and manure application

The fertilizers N, P, K, S, Zn and B in the form of urea, TSP (Triple Super Phosphate), MoP (Muriate of Potash), Gypsum, zinc sulphate and borax, respectively were applied @ 150 kg, 50 kg, 75 kg, 5.0 kg, 2.0 kg and 1.0 kg ha^{-1} (BRRI, 2016). The entire amount of TSP, MoP, gypsum, zinc sulphate and borax were applied during the final preparation of experimental plot. Urea was applied in two equal installments as top dressing at tillering and panicle initiation stages.

3.2.4.8 Transplanting of seedling

Twenty five days old seedlings were carefully uprooted from the seedling nursery and transplanted on 04 May, 2016 in well puddled plot with maintaining distance of 20 cm × 15 cm. One seedling was transplanted for each hill. After one week of transplanting all plots were checked for any missing hill, which was filled up with extra seedlings of the same source whenever required.

3.2.4.9 Intercultural operations

Intercultural operations were done to ensure normal growth of the crop. Plant protection measures were followed as and when necessary. The following intercultural operations were done:

Irrigation and drainage

Supplemental irrigation was provided for water saturation condition in the experimental field. The plot was finally dried out at 15 days before harvesting.

Weeding

Weedings were done as per treatment of the experiment. The newly emerged weeds were uprooted carefully at 20 DAT and 40 DAT by sickles as per treatment and in control plot no weeds were uprooted.

Insect and pest control

There was no infection of diseases in the field but leaf roller (*Chaphalocrosis medinalis*) was found in the field and used Malathion @ 1.12 L ha^{-1} at 30 DAT with using a hand sprayer.

3.2.4.10 Harvesting, threshing and cleaning

The crop was harvested at full maturity when 80-90% of the grains were turned into straw colored. The harvested crop was bundled separately, properly tagged and brought to threshing floor. Enough care was taken during threshing and cleaning period of rice grain. Fresh weight of rice grain and straw were recorded plot wise from 1 m^2 area. The grains were dried up to moisture content 14%, then cleaned and weighed for individual plot. Yields of rice grain and straw were collected from 1 m^{-2} and recorded from each plot and then converted to hectare yield and expressed in t ha^{-1}.

3.2.4.11 Data recording

Weed population

From the 1m^2 area of every plot, the total weeds were uprooted and counted at Early Tillering Stage (ETS), Maximum Tillering Stage (MTS), Flowering Stage (FS) and Grain Filling Stage (GFS) and recorded.

Plant height

Plant height of rice was recorded in centimeter (cm) at ETS, MTS, FS, GFS and Maturity Stage (MS). Data were recorded as the average of 5 plants selected at random from the inner rows of each plot. The height was measured from the ground level to the tip of the panicle or flag leaf.

Number of tillers hill^{-1}

Number of tillers hill^{1} was recorded at ETS, MTS, FS and GFS. Data were recorded as the average of 5 plants selected at random from the inner rows of each plot.

Crop duration

Crop duration was recorded by counting the number of days required to harvest in each plot.

Effective tillers hill^{-1}

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

Non-effective tillers hill^{-1}

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

Total tillers hill^{-1}

The total number of tiller hill^{-1} was counted by adding the number of effective tillers hill^{-1} and non-effective tillers hill^{-1}. Data on total tillers hill^{-1} were counted from 5 selected hills and average value was recorded.

Panicle length

The length of panicle was measured with a meter scale from 5 selected panicle and the average length was recorded as per panicle in cm.

Filled grains panicle^{-1}

The total numbers of filled grain were collected randomly from selected 5 panicle of a plot on the basis of grain in the spikelet and then average numbers of filled grains panicle^{-1} was recorded.

Unfilled grains panicle^{-1}

The total numbers of unfilled grain was collected randomly from selected 5 plants of a plot on the basis of empty grain in the spikelet and then average numbers of unfilled grains panicle^{-1} was recorded.

Total grains panicle^{-1}

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

Weight of 1000-grain

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

Grain yield

Grains obtained from each unit plot were sun-dried and weighed carefully. The dry weight of grains of central 1 m^2 area in each plot were taken the final grain yield plot^{-1} and finally converted to ton hectare^{-1} (t ha^{-1}).

Straw yield

Straw obtained from each unit plot were sun-dried and weighed carefully. The dry weight of straw of central 1 m^2 area was taken from each plot and finally converted to ton $hectare^{-1}$ ($t\ ha^{-1}$).

Biological yield

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

$$\text{Biological yield} = \text{Grain yield} + \text{Straw yield.}$$

Harvest index

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

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

3.2.5 Experiment-5: Performance of Aus Rice Under Varying Irrigation Regime, Fertilizer Dose and Weeding Method

3.2.5.1 Experimental period

The experiment was conducted during the period of April to August, 2017.

3.2.5.2 Planting material

Rice variety BRRI dhan48 were used as the test crops in this experiment.

3.2.5.3 Treatment of the experiment

The experiment comprised of three factors.

Factor A: Irrigation (2 levels)

i. I_0: No irrigation

ii. I_1: Supplemental irrigation

Factor B: Fertilizer (2 levels)

i. F_1: Recommended fertilizer dose-RFD

ii. F_2: 20% added with RFD

Factor C: Weed management (3 levels)

i. W_1: Hand weeding at 20 and 40 DAT

ii. W_2: Herbicide use pre emergence at 4 DAT

iii. W_3: Weeding by BRRI hand weeder at 20 and 40 DAT

Recommended fertilizer dose-RFD (150, 50, 75, 5.0, 2.0 and 1.0 kg ha^{-1} of N, P, K, S, Zn and B, respectively) as per BRRI, 2016.

As such there were 12 (2×2×3) treatments combinations viz. $I_0F_1W_1$, $I_0F_1W_2$, $I_0F_1W_3$, $I_0F_2W_1$, $I_0F_2W_2$, $I_0F_2W_3$, $I_1F_1W_1$, $I_1F_1W_2$, $I_1F_1W_3$, $I_1F_2W_1$, $I_1F_2W_2$ and $I_1F_2W_3$.

3.2.5.4 Experimental design and layout

The three factors experiment was laid out in split-split-plot design with three replications. An area of 408.50 m^2 (21.5 m × 19.0 m) was divided into 3 blocks. Each block was divided into 36 unit plots. Irrigation regime was placed along the main plot, fertilizer dose was placed in the sub plot and weeding methods were placed in the sub-sub plot. The size of the each unit plot was 2.0 m × 2.0 m. The space between two blocks, main and sub plots and two plots were 1.5 m, 1.5 m and 1.0 m, respectively. Each plot and sub-plot were separated by raised border.

3.2.5.5 Growing of crops

Seed collection and sprouting

Seeds were collected from BADC (Bangladesh Agricultural Development Corporation), BRRI (Bangladesh Rice Research Institute), Gazipur and local market just 20 days ahead of the sowing of seeds in seed bed. For seedling raising clean seeds were immersed in water in a bucket for 24 hours. The imbibed seeds were then taken out of water and kept in gunny bags. The seeds started sprouting after 48 hours which were suitable for sowing in 72 hours.

Raising of seedlings

The nursery bed was prepared by puddling with repeated ploughing followed by laddering. The sprouted seeds were sown on beds on 27 March, 2017 as uniformly as possible. Irrigation was gently provided to the bed as and when needed. No fertilizer was used in the nursery bed.

3.2.5.6 Land preparation

The plot selected for conducting the experiment was opened in the 03rd April 2017 with a power tiller, and left exposed to the sun for a week. After one week the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain good puddle condition. Weeds and stubbles were removed. The experimental plot was partitioned into unit plots in accordance with the experimental design. Organic and inorganic manures as indicated below were mixed with the soil of each unit plot.

3.2.5.7 Fertilizers and manure application

Fertilizers were applied as per the treatment of the experiment i.e., recommended fertilizer dose-RFD and 20% added with RFD. As recommended doses the fertilizers N, P, K, S, Zn and B in the form of urea, TSP (Triple Super Phosphate), MoP (Muriate of Potash), Gypsum, zinc sulphate and borax, respectively were applied @ @ 150 kg, 50 kg, 75 kg, 5.0 kg, 2.0 kg and 1.0 kg ha^{-1} (BRRI, 2016). The entire amount of TSP, MoP, gypsum, zinc sulphate and borax were applied during the final preparation of experimental plot. Urea was applied in two equal installments as top dressing at tillering and panicle initiation stages.

3.2.5.8 Transplanting of seedling

Twenty five days old seedlings were carefully uprooted from the seedling nursery and transplanted on 22 April, 2017 in well puddled plot with maintaining distance of 20 cm × 15 cm. One seedling was transplanted for each hill. After one week of transplanting all plots were checked for any missing hill, which was filled up with extra seedlings of the same source whenever required.

3.2.5.9 Intercultural operations

Intercultural operations were done to ensure normal growth of the crop. Plant protection measures were followed as and when necessary. The following intercultural operations were done:

Irrigation and drainage

Irrigation was provided as per treatment and in case of supplemental irrigation water saturation condition in the experimental field and irrigation was provided accordingly. The plot was finally dried out at 15 days before harvesting.

Weeding

Weedings were done as per treatment of the experiment. The newly emerged weeds were uprooted carefully at 20 DAT and 40 DAT by hand weeding and BARI hand weeder as per treatment and for pre emergence herbicide Amichlor 5G as active ingredient Butachlor @ 25 kg ha^{-1} was applied at 4 DAT (days after transpalnting.

Insect and pest control

There was no infection of diseases in the field but leaf roller (*Chaphalocrosis medinalis*) was found in the field and used Malathion @ 1.12 L ha^{-1} at 30 DAT with using a hand sprayer.

3.2.5.10 Harvesting, threshing and cleaning

The crop was harvested at full maturity when 80-90% of the grains were turned into straw colored. The harvested crop was bundled separately, properly tagged and brought to threshing floor. Enough care was taken during threshing and cleaning period of rice grain. Fresh weight of rice grain and straw were recorded plot wise from 1 m^2 area. The grains were dried up to moisture content 14%, then cleaned and weighed for individual plot. Yields of rice grain and straw were collected from 1 m^{-2} and recorded from each plot and then converted to hectare yield and expressed in t ha^{-1}.

3.2.5.11 Data recording

Weed population

From the 1m^2 area of every plot, the total weeds were uprooted and counted at Early Tillering Stage (ETS), Maximum Tillering Stage (MTS), Flowering Stage (FS) and Grain Filling Stage (GFS) and recorded.

Plant height

Plant height of rice was recorded in centimeter (cm) at ETS, MTS, FS, GFS and Maturity Stage (MS). Data were recorded as the average of 5 plants selected at random from the inner rows of each plot. The height was measured from the ground level to the tip of the panicle or flag leaf.

Number of tillers hill^{-1}

Number of tillers hill^1 was recorded at ETS, MTS, FS and GFS. Data were recorded as the average of 5 plants selected at random from the inner rows of each plot.

Leaf area index

Leaf area index (LAI) was measured in terms of total leaf area (cm^2) per square meter of the land area at the time of ETS, MTS, FS and GFS. Data were recorded as the average of 05 plants selected at random the inner rows of each plots and their area were measured with Portable Area Meter Model LI-3000, USA. The leaf area index (LAI) was worked out by using the formula of Yoshida (1981).

$$\text{Leaf area index} = \frac{\text{Total leaf area (cm}^2\text{)}}{\text{Unit land area (cm}^2\text{)}}$$

Total dry matter

Total dry matter (TDM) m^{-2} was recorded at ETS, MTS, FS and GFS by drying plant sample. Data were recorded as the average of 5 sample hill^{-1} collected at random from the inner rows of each plot and converted in m^{-2} and TDM were expressed in gram (g).

Crop Growth Rate (CGR)

CGR was calculated using the following formula (Hunt, 1978):

$$CGR = \frac{1}{A} \times \frac{W_2-W_1}{T_2-T_1} \quad g\ m^{-2}\ day^{-1}$$

Where,

A = Ground area (m^2)

W_1 = Total dry weight at time T_1 (g)

W_2 = Total dry weight at time T_2 (g)

T_1 = Initial time (day)

T_2 = Final time (day)

Relative Growth Rate (RGR)

RGR was calculated using the following formula (Hunt, 1978):

$$RGR = \frac{L_nW_2-L_nW_1}{T_2-T_1} \quad mg\ g^{-1}\ day^{-1}$$

Where,

W_1 = Total dry weight at time T_1 (g)

W_2 = Total dry weight at time T_2 (g)

T_1 = Initial time (day)

T_2 = Final time (day)

L_n = Natural logarithm

Net Assimilation Rate (NAR)

NAR was calculated using the following formula (Hunt, 1978):

$$NAR = \frac{W_2-W_1}{T_2-T_1} \times \frac{L_nLA_2-L_nLA_1}{LA_2-LA_1} \quad g\ m^{-2}\ day^{-1}$$

Where,

W_1 = Total dry weight at time T_1 (g)

W_2 = Total dry weight at time T_2 (g)

T_1 = Initial time (day)

T_2 = Final time (day)

LA_1 = Leaf area at time T_1 (m^2)

LA_2 = Leaf area at time T_2 (m^2)

L_n = Natural logarithm

Crop duration

Crop duration was recorded by counting the number of days required to harvest.

Effective tillers hill^{-1}

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

Non-effective tillers hill^{-1}

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

Total tillers hill^{-1}

The total number of tiller hill^{-1} was counted by adding the number of effective tillers hill^{-1} and non-effective tillers hill^{-1}. Data on total tillers hill^{-1} were counted from 5 selected hills and average value was recorded.

Panicle length

The length of panicle was measured with a meter scale from 5 selected panicle and the average length was recorded as per panicle in cm.

Filled grains panicle^{-1}

The total numbers of filled grain were collected randomly from selected 5 panicle of a plot on the basis of grain in the spikelet and then average numbers of filled grains panicle^{-1} was recorded.

Unfilled grains panicle^{-1}

The total numbers of unfilled grain was collected randomly from selected 5 plants of a plot on the basis of empty grain in the spikelet and then average numbers of unfilled grains panicle^{-1} was recorded.

Total grains panicle^{-1}

The total numbers of grain was collected randomly from selected 5 plants of a plot by adding filled and unfilled grain and then average numbers was recorded.

Weight of 1000-grain

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

Grain yield

Grains obtained from each unit plot were sun-dried and weighed carefully. The dry weight of grains of central 1 m^2 area in each plot were taken the final grain yield $plot^{-1}$ and finally converted to ton $hectare^{-1}$ (t ha^{-1}).

Straw yield

Straw obtained from each unit plot were sun-dried and weighed carefully. The dry weight of straw of central 1 m^2 area was taken from each plot and finally converted to ton $hectare^{-1}$ (t ha^{-1}).

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.

Harvest index

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

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

3.3 Statistical Analysis

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

Chapter 4

Results and Discussion

CHAPTER 4

RESULTS AND DISCUSSION

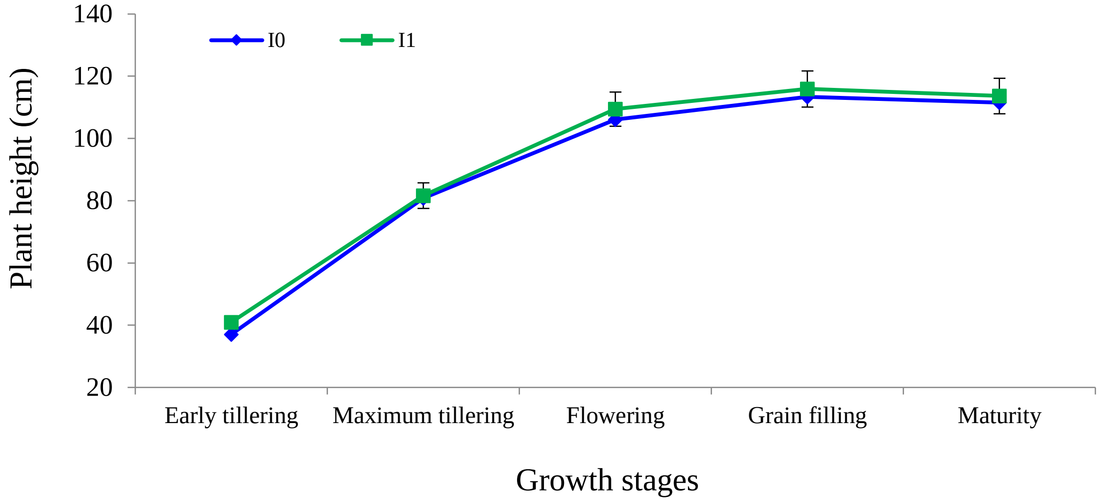
Field experiments were conducted to evaluate the performance of Aus rice varieties as influenced by varying irrigation, fertilizer and weed managements. The analysis of variance (ANOVA) of the data on different growth characters, yield components and yield are presented in Appendices IV-XXXVII. The experiment-wise results have been presented with the help of table and graphs and possible interpretations given as follows:

4.1 Experiment-1: Growth and Yield Performance of Different Aus Rice Varieties under Irrigated and Non-irrigated Condition

4.1.1 Plant height

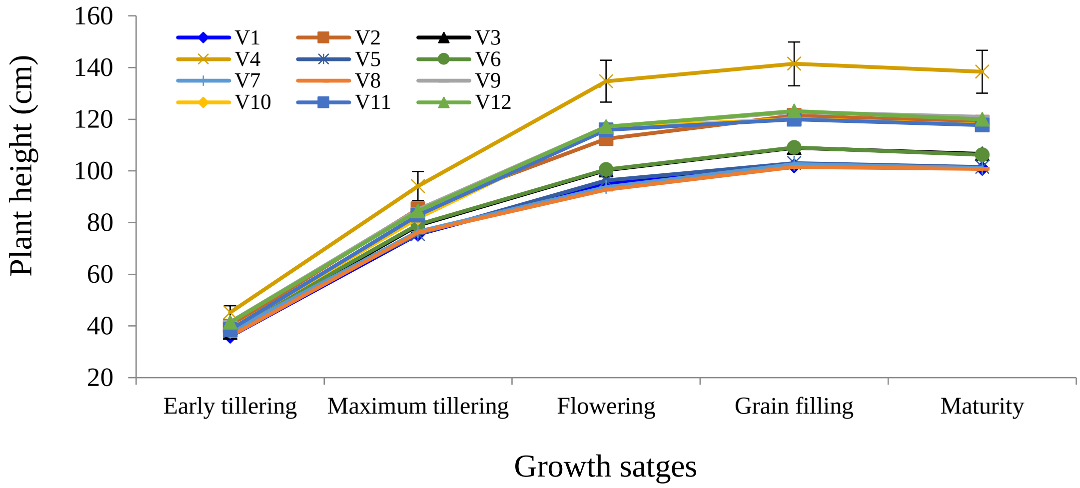
Plant height of rice at early tillering stage (ETS), maximum tillering stage (MTS), flowering stage (FS), grain filling stage (GFS) and maturity stage (MS) varied significantly due to different levels of irrigation (Figure 4.1.1). At ETS, MTS, FS, GFS and MS, the taller plants (41.00, 81.66, 109.44, 115.91 and 113.65 cm, respectively) were recorded from I_1 (supplemental irrigation) and the shorter plants (37.10, 80.85, 106.05, 113.41 and 111.47 cm, respectively) were found from I_0 (no irrigation). Generally, plant height is a genetical character and it is controlled by the genetic make up of the varieties. Ghosh *et al.* (2014) reported that water management practices exerted significant influence on plant height. Similar findings also stated by Ibraheem (2015) in earlier.

Different rice varieties showed significant differences on plant height of rice at ETS, MTS, FS, GFS and MS (Figure 4.1.2). At ETS, MTS, FS, GFS and MS, the tallest plant (45.16, 94.13, 134.72, 141.44 and 138.35 cm, respectively) were observed from V_4 (BRRI dhan27) which was followed (41.46, 85.05, 117.10, 122.83 and 120.98 cm, respectively) by V_9 (China-Muladi local), (41.38, 84.43, 117.14, 123.12 and 119.97 cm, respectively) by V_{12} (Abdul Hye-Jhalkathi local) and (39.93, 85.25, 112.36, 121.40 and 118.79 cm, respectively) by V_2 (BR-14),



I_0: No irrigation I_1: Supplemental irrigation

Figure 4.1.1. Effect of different levels of irrigation on plant height of rice at different growth stages in Aus season (Sx = 0.623, 0.096, 0.542, 0.360 and 0.338 at ETS, MTS, FS, GFS and MS, respectively).



V_1: BR-3; V_2: BR-14; V_3: BR-16; V_4: BRRI dhan27;
V_5: BRRI dhan42; V_6: BRRI dhan48; V_7: BRRI dhan55; V_8: BRRI dhan65;
V_9: China (Muladi local); V_{10}: Kali Shait-ta (Muladi local);
V_{11}: Benamuri (Muladi local) V_{12}: Abdul Hye (Jhalkathi local)

Figure 4.1.2. Effect of different rice varieties on plant height at different growth stages in aus season (Sx = 1.291, 1.092, 1.737, 1.756 and 1.693 at ETS, MTS, FS, GFS and MS, respectively).

whereas the shortest plant (35.95, 75.40, 95.14, 101.93 and 100.85 cm, respectively) was recorded from V_1 (BR-3) which was statistically similar (36.09, 76.11, 92.76, 101.54 and 100.76 cm, respectively) to V_8 (BRRI dhan65). Varieties showed different plant height on the basis of their varietal characters. Variety is the key component to produce plant height of rice depending upon their differences in genotypic characters, input requirements and response, growth process and off course the prevailing environmental conditions during the growing season. Different researchers recorded different plant height in earlier experiment due to different rice cultivars (Jisan *et al.*, 2014; Haque and Biswash, 2014; Khalifa, 2009; Masum *et al*., 2008).

Combined effect of different levels of irrigation and rice varieties showed statistically significant differences in terms of plant height of rice at ETS, MTS, FS, GFS and MS (Table 4.1.1). At ETS, MTS, FS, GFS and MS, the tallest plant (47.75, 96.44, 139.26, 145.94 and 142.83 cm, respectively) was recorded from the combination of I_1V_4 (supplemental irrigation and BRRI dhan27), while the shortest plant (33.36, 75.12, 92.18, 100.88 and 100.27 cm, respectively) was found from the combination of I_0V_1 (no irrigation and BR-3).

4.1.2 Number of tillers hill^{-1}

Different levels of irrigation showed statistically significant differences in terms of number of tillers hill^{-1} of rice at early tillering stage (ETS), maximum tillering stage (MTS), flowering stage (FS), grain filling stage (GFS) and maturity stage (MS) (Figure 4.1.3). At ETS, MTS, FS and GFS, the maximum number of tillers hill^{-1} (5.75, 12.78, 14.66 and 14.25, respectively) was found from I_1, whereas the minimum number (5.39, 12.04, 14.09 and 13.86, respectively) was recorded from I_0. Tilahun-Tadesse *et al.* (2013) reported that with continuous flooding number of tillers, were highly depressed but improved when drainage and aeration was practiced. Wang *et al.* (2010) found that tiller number hill^{-1} increased as the irrigation water depth increased.

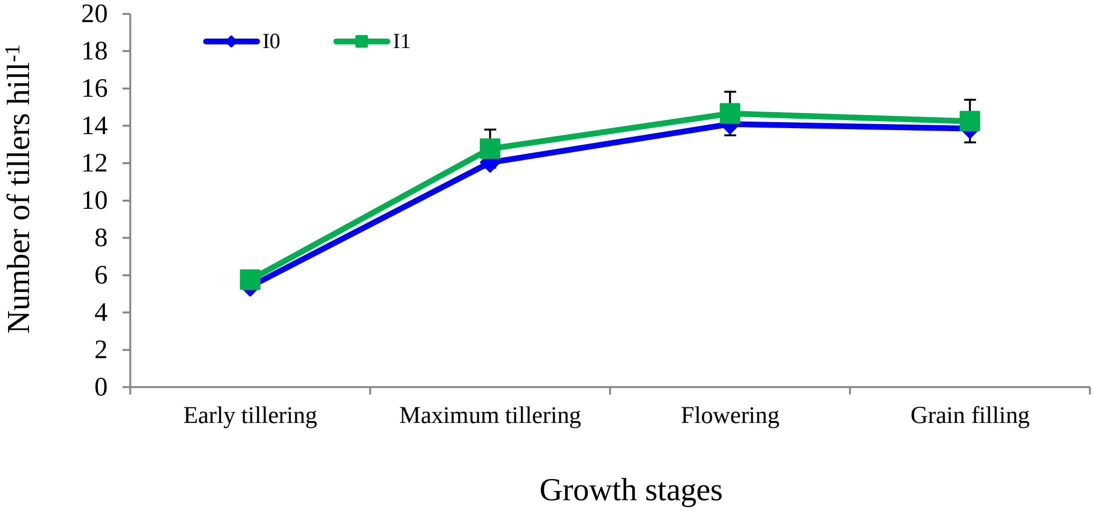
Table 4.1.1. Combined effect of different levels of irrigation and rice varieties on plant height (cm) at different growth stages in Aus season

Treatments combinations	Growth stage				
	Early tillering (ETS)	Maximum tillering (MTS)	Flowering (FS)	Grain filling (GFS)	Maturity (MS)
I_0V_1	33.36 g	75.12 j	92.18 h	100.88 i	100.27 h
I_0V_2	35.29 e-g	82.47 d-h	106.74 de	116.17 d-f	113.29 de
I_0V_3	35.55 e-g	77.65 h-j	96.94 f-h	106.19 g-i	103.94 f-h
I_0V_4	42.57 a-d	91.83 b	130.17 b	136.94 b	133.86 b
I_0V_5	41.33 b-e	75.85 ij	96.30 f-h	103.71 g-i	101.83 f-h
I_0V_6	36.28 e-g	78.02 h-j	98.17 f-h	107.25 g-i	103.78 f-h
I_0V_7	35.60 e-g	76.09 ij	93.79 h	101.41 i	100.58 h
I_0V_8	34.51 fg	76.21 ij	93.35 h	101.84 i	100.98 gh
I_0V_9	38.99 b-g	85.70 cd	115.68 c	122.74 cd	121.27 c
I_0V_{10}	37.87 c-g	85.32 c-e	120.65 c	124.51 c	122.77 c
I_0V_{11}	34.49 fg	82.50 d-h	114.29 cd	118.82 c-e	117.19 cd
I_0V_{12}	39.38 b-g	83.46 c-f	114.00 cd	120.50 cd	117.90 cd
I_1V_1	37.40 d-g	75.69 ij	96.50 f-h	102.98 hi	101.44 f-h
I_1V_2	44.57 ab	88.04 bc	117.97 c	126.63 c	124.29 c
I_1V_3	39.40 b-g	80.16 f-j	103.56 ef	111.65 e-g	109.24 ef
I_1V_4	47.75 a	96.44 a	139.26 a	145.94 a	142.83 a
I_1V_5	34.47 fg	75.15 j	96.43 f-h	102.21 i	101.09 gh
I_1V_6	40.14 b-f	80.41 e-i	102.83 e-g	110.92 f-h	108.56 e-g
I_1V_7	39.83 b-f	76.99 ij	94.98 gh	103.82 g-i	101.71 f-h
I_1V_8	38.82 b-g	76.01 ij	92.49 h	101.24 i	100.55 h
I_1V_9	43.93 a-c	84.39 c-f	118.52 c	122.91 cd	120.69 cd
I_1V_{10}	39.74 b-f	78.16 g-j	113.16 cd	115.65 d-f	113.02 de
I_1V_{11}	42.53 a-d	83.05 c-g	117.57 c	121.19 cd	118.37 cd
I_1V_{12}	43.38 a-d	85.40 c-e	120.28 c	125.74 c	122.03 c
Sx value	1.826	1.545	2.456	2.484	2.394
Level of significance	0.05	0.05	0.05	0.05	0.05
CV (%)	8.10	3.29	4.95	3.75	5.68

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

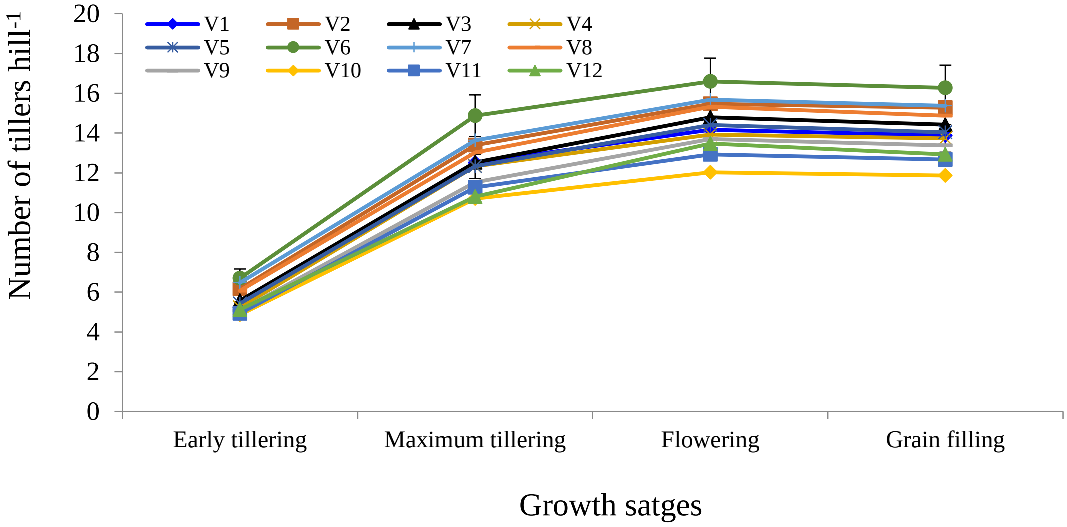
I_0: No irrigation; I_1: Supplemental irrigation

V_1: BR-3; V_2: BR-14; V_3: BR-16; V_4: BRRI dhan27;
V_5: BRRI dhan42; V_6: BRRI dhan48; V_7: BRRI dhan55; V_8: BRRI dhan65;
V_9: China (Muladi local); V_{10}: Kali Shait-ta (Muladi local); V_{11}: Benamuri (Muladi local);
V_{12}: Abdul Hye (Jhalkathi local)



I_0: No irrigation I_1: Supplementatal irrigation

Figure 4.1.3. Effect of different levels of irrigation on number of tillers hill^{-1} of rice at different growth stages in Aus season (Sx = 0.051, 0.102, 0.060 and 0.045 at ETS, MTS, FS and GFS, respectively).



V_1: BR-3; V_2: BR-14; V_3: BR-16; V_4: BRRI dhan27;
V_5: BRRI dhan42; V_6: BRRI dhan48; V_7: BRRI dhan55; V_8: BRRI dhan65;
V_9: China (Muladi local); V_{10}: Kali Shait-ta (Muladi local);
V_{11}: Benamuri (Muladi local) V_{12}: Abdul Hye (Jhalkathi local)

Figure 4.1.4. Effect of different rice varieties on number of tillers hill^{-1} at different growth stages in Aus season (Sx = 0.141, 0.237, 0.218 and 0.208 at ETS, MTS, FS and GFS, respectively).

Statistically significant variation was observed due to different rice varieties for number of tillers hill^{-1} of rice at ETS, MTS, FS and GFS (Figure 4.1.4). At ETS, MTS, FS and GFS, the maximum number of tillers hill^{-1} (6.70, 14.87, 16.60 and 16.27, respectively) was found from V_6, while the minimum number (4.93, 11.27, 12.93 and 12.67, respectively) was observed from V_{11}. Masum *et al*. (2008) reported maximum (25.63) tiller at 45 DAT, then with advancement to age it declined up to maturity, whereas, in the case of BRRI dhan44, maximum (18.92) tiller production was observed around panicle initiation stage at 60 DAT.

Due to the combined effect of different levels of irrigation and rice varieties statistically significant variation was recorded on number of tillers hill^{-1} of rice at ETS, MTS, FS and GFS (Table 4.1.2). At ETS, MTS, FS and GFS, the maximum number of tillers hill^{-1} (7.00, 15.13, 16.73 and 16.33, respectively) was observed from the combination of I_1V_6 and the minimum number (4.67, 10.33, 12.00 and 11.73, respectively) was found from the combination of I_0V_{10}.

4.1.3 Crop duration

Different levels of irrigation varied significantly in terms of crop duration of rice (Table 4.1.3). The highest crop duration (123.14 days) was recorded from I_1, while the lowest crop duration (118.33 days) was observed from I_0.

Crop duration of rice showed significant differences for different rice varieties (Table 4.1.3). The highest crop duration (132.83 days) was observed from V_1 which was statistically similar (131.67 days) to V_3 and closely followed (129.17 days, 128.67 days and 128.17 days, respectively) by V_9, V_{11} and V_{12}, whereas the lowest crop duration (106.50 days) was found from V_8 which was statistically similar (106.83 days and 106.83 days, respectively) to V_5 and V_7.

Combined effect of different levels of irrigation and rice varieties showed significant variation in terms of crop duration (Table 4.1.4). The highest crop duration (135.67 days) was observed from the combination of I_1V_1, while the lowest duration (102.33 days) was recorded from the combination of I_0V_8.

Table 4.1.2. Combined effect of different levels of irrigation and rice varieties on number of tillers hill^{-1} at different growth stages in Aus season

Treatments combinations	Growth stage			
	Early tillering (ETS)	Maximum tillering (MTS)	Flowering (FS)	Grain filling (GFS)
I_0V_1	5.07 fg	11.93 fg	13.73 i-l	13.53 f-i
I_0V_2	5.67 d-f	13.33 bc	15.20 c-f	15.13 cd
I_0V_3	5.27 e-g	11.93 fg	14.47 f-j	14.13 ef
I_0V_4	5.00 g	12.00 e-g	13.53 j-l	13.47 f-i
I_0V_5	5.73 d-f	12.53 c-f	14.87 e-h	14.53 de
I_0V_6	6.40 a-c	14.60 a	16.47 ab	16.20 ab
I_0V_7	6.27 b-d	13.13 b-d	15.27 c-f	15.13 cd
I_0V_8	5.73 d-f	12.87 c-f	14.53 f-j	14.20 ef
I_0V_9	4.87 g	10.47 h	13.27 lm	12.93 h-j
I_0V_{10}	4.67 g	10.33 h	12.00 n	11.73 l
I_0V_{11}	4.87 g	10.53 h	12.53 mn	12.33 j-l
I_0V_{12}	5.00 g	10.47 h	13.13 lm	12.73 i-k
I_1V_1	5.40 e-g	13.07 b-e	14.60 f-i	14.20 ef
I_1V_2	6.67 ab	13.47 bc	15.73 b-e	15.40 b-d
I_1V_3	5.87 c-e	13.13 b-d	15.13 d-g	14.73 c-e
I_1V_4	5.47 e-g	12.67 c-f	14.33 f-k	14.00 e-g
I_1V_5	5.13 fg	12.13 d-g	13.93 h-l	13.53 f-i
I_1V_6	7.00 a	15.13 a	16.73 a	16.33 a
I_1V_7	6.67 ab	14.13 ab	16.07 a-d	15.60 a-c
I_1V_8	6.40 a-c	13.20 b-d	16.13 a-c	15.53 a-c
I_1V_9	5.27 e-g	12.60 c-f	14.13 g-l	13.80 e-h
I_1V_{10}	4.87 g	10.73 h	12.00 n	12.00 kl
I_1V_{11}	5.00 g	12.00 e-g	13.33 k-m	13.00 h-j
I_1V_{12}	5.27 e-g	11.13 gh	13.80 i-l	13.13 g-j
Sx value	0.199	0.335	0.308	0.294
Level of significance	0.05	0.05	0.05	0.05
CV (%)	6.18	4.67	3.71	5.63

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

I_0: No irrigation; I_1: Supplemental irrigation

V_1: BR-3; V_2: BR-14; V_3: BR-16; V_4: BRRI dhan27;
V_5: BRRI dhan42; V_6: BRRI dhan48; V_7: BRRI dhan55; V_8: BRRI dhan65;
V_9: China (Muladi local); V_{10}: Kali Shait-ta (Muladi local); V_{11}: Benamuri (Muladi local);
V_{12}: Abdul Hye (Jhalkathi local)

Table 4.1.3. Effect of different levels of irrigation and rice varieties on crop duration, total, effective and non-effective tillers hill^{-1} in Aus season

Treatments	Crop duration (days)	Total tillers hill^{-1} (No.)	Effective tillers hill^{-1} (No.)	Non-effective tillers hill^{-1} (No.)
Levels of irrigation				
I_0	118.33 b	12.88 b	10.12 b	2.77 b
I_1	123.14 a	13.44 a	10.49 a	2.95 a
Sx value	0.691	0.061	0.063	0.030
Level of significance	0.05	0.05	0.05	0.05
CV (%)	3.43	2.80	3.68	6.16
Rice Varieties				
V_1	132.83 a	13.03 cd	10.50 d	2.53 ef
V_2	121.17 d	14.53 b	12.23 bc	2.30 fg
V_3	131.67 ab	13.63 c	10.50 d	3.13 bc
V_4	118.33 d	12.80 d	9.83 d	2.97 cd
V_5	106.83 f	13.07 cd	10.20 d	2.87 cd
V_6	111.00 e	16.00 a	13.97 a	2.03 g
V_7	106.83 f	14.73 b	12.60 b	2.13 g
V_8	106.50 f	14.33 b	11.67 c	2.67 de
V_9	129.17 bc	12.13 e	8.97 e	3.17 bc
V_{10}	127.67 c	10.47 g	6.80 g	3.67 a
V_{11}	128.67 bc	11.47 f	8.00 f	3.47 ab
V_{12}	128.17 bc	11.73 ef	8.37 ef	3.37 ab
Sx value	1.182	0.204	0.232	0.109
Level of significance	0.01	0.01	0.01	0.01
CV (%)	5.40	4.79	5.52	9.34

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

I_0: No irrigation; I_1: Supplemental irrigation

V_1: BR-3; V_2: BR-14; V_3: BR-16; V_4: BRRI dhan27;
V_5: BRRI dhan42; V_6: BRRI dhan48; V_7: BRRI dhan55; V_8: BRRI dhan65;
V_9: China (Muladi local); V_{10}: Kali Shait-ta (Muladi local); V_{11}: Benamuri (Muladi local);
V_{12}: Abdul Hye (Jhalkathi local)

Table 4.1.4. Combined effect of different levels of irrigation and rice varieties on crop duration, total, effective and non-effective tillers hill^{-1} in Aus season

Treatments combinations	Crop duration (days)	Total tillers hill^{-1} (No.)	Effective tillers hill^{-1} (No.)	Non-effective tillers hill^{-1} (No.)
I_0V_1	130.00 b-e	12.60 h-j	10.13 e-g	2.47 g-j
I_0V_2	121.00 g	14.33 c-f	12.20 bc	2.13 ij
I_0V_3	130.67 a-d	13.20 g-i	10.20 e-g	3.00 d-f
I_0V_4	112.67 h	12.40 i-k	9.47 f-h	2.93 e-g
I_0V_5	103.00 i	13.47 f-h	10.33 ef	3.13 c-e
I_0V_6	113.33 h	15.60 ab	13.93 a	1.67 k
I_0V_7	102.67 i	14.33 c-f	12.27 bc	2.07 jk
I_0V_8	102.33 i	13.87 e-g	11.47 cd	2.40 h-j
I_0V_9	126.67 c-f	11.60 k-m	8.73 hi	2.87 e-h
I_0V_{10}	125.00 e-g	10.73 mn	7.00 j	3.73 ab
I_0V_{11}	126.00 d-g	11.00 mn	7.13 j	3.87 a
I_0V_{12}	127.00 c-f	11.47 lm	8.53 hi	2.93 e-g
I_1V_1	135.67 a	13.47 f-h	10.87 de	2.60 f-i
I_1V_2	121.33 g	14.73 b-e	12.27 bc	2.47 g-j
I_1V_3	132.67 ab	14.07 d-g	10.80 de	3.27 b-e
I_1V_4	124.00 fg	13.20 g-i	10.20 e-g	3.00 d-f
I_1V_5	110.67 h	12.67 h-j	10.07 e-g	2.60 f-i
I_1V_6	108.67 h	16.40 a	14.00 a	2.40 h-j
I_1V_7	111.33 h	15.13 bc	12.93 b	2.20 ij
I_1V_8	110.67 h	14.80 b-d	11.87 c	2.93 e-g
I_1V_9	131.67 a-c	12.67 h-j	9.20 g-i	3.47 a-d
I_1V_{10}	130.33 a-e	10.20 n	6.60 j	3.60 a-c
I_1V_{11}	131.33 a-d	11.93 j-l	8.87 hi	3.07 d-f
I_1V_{12}	129.33 b-f	12.00 j-l	8.20 i	3.80 a
Sx value	1.672	0.288	0.329	0.154
Level of significance	0.01	0.05	0.05	0.01
CV (%)	5.40	4.79	5.52	9.34

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

I_0: No irrigation; I_1: Supplemental irrigation

V_1: BR-3; V_2: BR-14; V_3: BR-16; V_4: BRRI dhan27;
V_5: BRRI dhan42; V_6: BRRI dhan48; V_7: BRRI dhan55; V_8: BRRI dhan65;
V_9: China (Muladi local); V_{10}: Kali Shait-ta (Muladi local); V_{11}: Benamuri (Muladi local);
V_{12}: Abdul Hye (Jhalkathi local)

4.1.4 Number of effective tillers hill^{-1}

Different levels of irrigation showed statistically significant differences in terms of number of effective tillers hill^{-1} of rice (Table 4.1.3). The maximum number of effective tillers hill^{-1} (10.49) was found from I_1 and the minimum number (10.12) was observed from I_0. Nasir *et al.* (2014) recorded maximum number of effective tillers hill^{-1} (21.5) from irrigation management.

Different rice varieties showed significant differences on number of effective tillers hill^{-1} of rice (Table 4.1.3). The maximum number of effective tillers hill^{-1} (13.97) was observed from V_6 which was closely followed (12.60 and 12.23, respectively) by V_7 and V_2, while the minimum number (6.80) was found from V_{10} which was followed (8.00 and 8.37, respectively) by V_{11} and V_{12}. Jisan *et al.* (2014) reported that BRRI dhan52 produced the highest number of effective tillers hill^{-1} (11.28) and the lowest values were produced by BRRI dhan57.

Different levels of irrigation and rice varieties varied significantly due to their combined effect on number of effective tillers hill^{-1} of rice (Table 4.1.4). The maximum number of effective tillers hill^{-1} (14.00) was recorded from the combination of I_1V_6, whereas the minimum number (6.60) was recorded from the combination of I_1V_{10}.

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

Number of non-effective tillers hill^{-1} of rice varied significantly due to different levels of irrigation (Table 4.1.3). The minimum number of non-effective tillers hill^{-1} (2.77) was observed from I_0, while the maximum number (2.95) was recorded from I_1. Khairi *et al.* (2015) reported that AWD treatment produced minimum number of non-effective tillers hill^{-1} in rice.

Statistically significant variation was recorded for different rice varieties in terms of number of non-effective tillers hill^{-1} of rice (Table 4.1.3). The minimum number of non-effective tillers hill^{-1} (2.03) was observed from V_6 which was statistically similar (2.13 and 2.30, respectively) to V_7 and V_2 and closely followed (2.53) by

V_1, whereas the maximum number (3.67) was found from V_{10} which was statistically similar (3.47 and 3.37, respectively) to V_{11} and V_{12}.

Combined effect of different levels of irrigation and rice varieties showed significant variation on number of non-effective tillers hill^{-1} of rice (Table 4.1.4). The minimum number of non-effective tillers hill^{-1} (1.67) was recorded from the combination of I_0V_6 and the maximum number (3.87) was found from the combination of I_0V_{11}.

4.1.6 Number of total tillers hill^{-1}

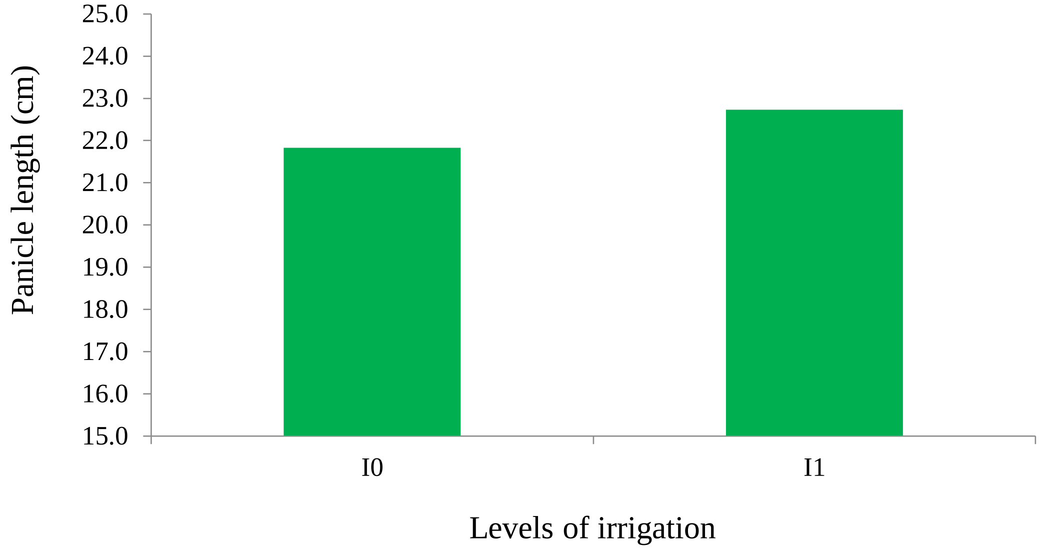
Statistically significant variation was recorded in terms of number of total tillers hill^{-1} of rice due to different levels of irrigation (Table 4.1.3). The maximum number of total tillers hill^{-1} (13.44) was observed from I_1, whereas the minimum number (12.88) was found from I_0.

Different rice varieties varied significantly on number of total tillers hill^{-1} of rice (Table 4.1.3). The maximum number of total tillers hill^{-1} (16.00) was observed from V_6 which was closely followed (14.73, 14.53 and 14.33, respectively) by V_7, V_2 and V_8 and they were statistically similar, while the minimum number (10.47) was recorded from V_{10} which was followed (11.47 and 11.73, respectively) by V_{11} and V_{12}. Khalifa (2009) reported that H_1 high yielding rice variety surpassed other varieties in consideration of total tillers hill^{-1}.

Combined effect of different levels of irrigation and rice varieties varied significantly in terms of number of total tillers hill^{-1} of rice (Table 4.1.4). The maximum number of total tillers hill^{-1} (16.40) was recorded from the combination of I_1V_6, whereas the minimum number (10.20) was observed from I_1V_{10}.

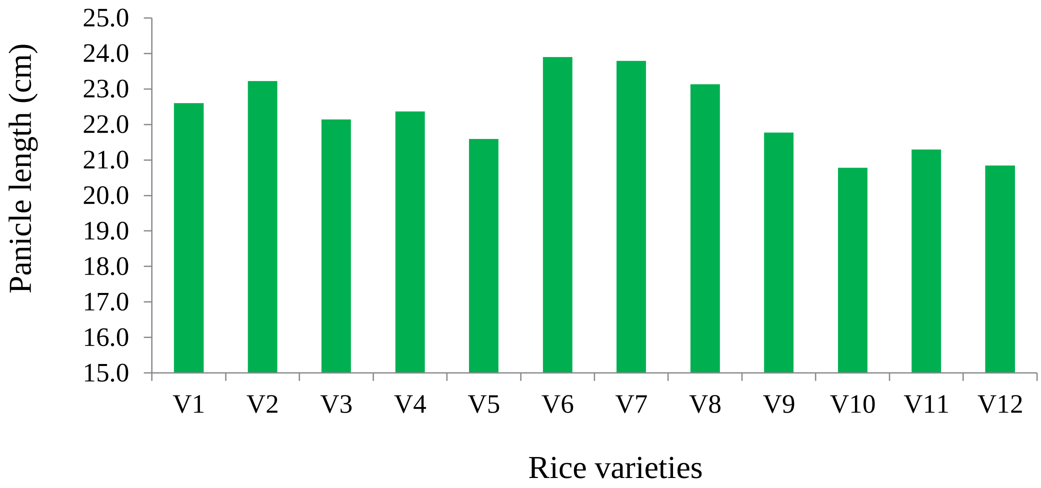
4.1.7 Panicle length

Different levels of irrigation showed significant differences in terms of panicle length of rice under the trial (Figure 4.1.5). The longer panicle (22.73 cm) was recorded from I_1 while the shorter panicle (21.83 cm) was found from I_0. Khairi *et al.* (2015) reported that AWD treatment produced longest panicle.



I_0: No irrigation; I_1: Supplemental irrigation

Figure 4.1.5. Effect of different levels of irrigation on panicle length of rice in Aus season (Sx = 0.053).



V_1: BR-3; V_2: BR-14; V_3: BR-16; V_4: BRRI dhan27;
V_5: BRRI dhan42; V_6: BRRI dhan48; V_7: BRRI dhan55; V_8: BRRI dhan65;
V_9: China (Muladi local); V_{10}: Kali Shait-ta (Muladi local);
V_{11}: Benamuri (Muladi local); V_{12}: Abdul Hye (Jhalkathi local)

Figure 4.1.6. Effect of different rice varieties on panicle length of rice in Aus season (Sx = 0.355)

Panicle length of rice varied significantly due to different rice varieties (Figure 4.1.6). The longest panicle (23.90 cm) was observed from V_6 which was statistically similar (23.79 cm, 23.22 cm and 23.13 cm, respectively) to V_7, V_2 and V_8, whereas the shortest panicle (20.78 cm) from V_{10} which was statistically similar (20.84 cm and 21.29 cm, respectively) to V_{12} and V_{11}. Wang *et al.* (2006) reported that high yielding varieties had larger panicles compared with conventional cultivars.

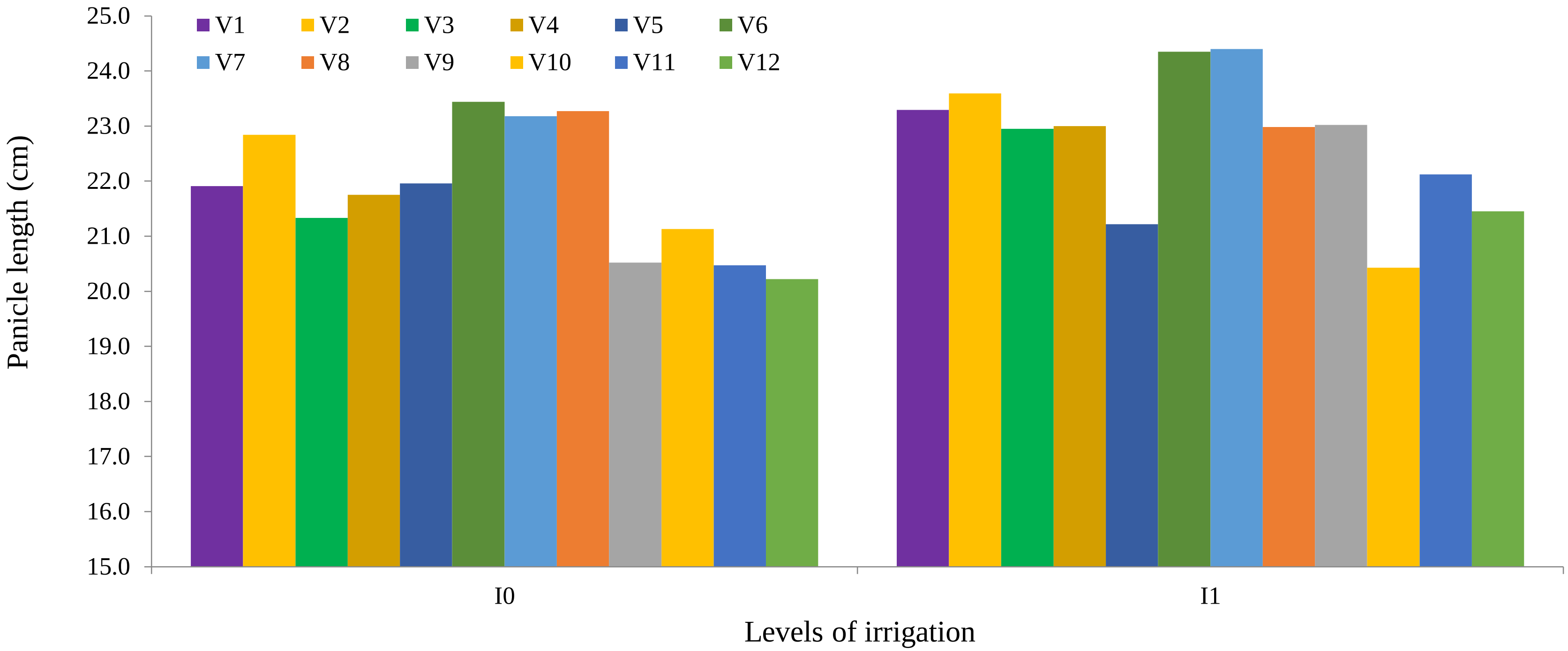
Statistically significant variation was recorded on panicle length of rice due to the combined effect of different levels of irrigation and rice varieties (Figure 4.1.7). The longest panicle (24.40 cm) was observed from the combination of I_1V_7 and the shortest panicle (20.22 cm) was found from I_0V_{12}.

4.1.8 Filled grains panicle^{-1}

Filled grains panicle^{-1} of rice showed statistically significant differences due to different levels of irrigation (Table 4.1.5). The maximum number of filled grains panicle^{-1} (108.20) was found from I_1 and the minimum number (101.63) was observed from I_0. Khairi *et al.* (2015) reported that AWD treatment gave the highest number of filled grains panicle^{-1}.

Different rice varieties showed significant differences in terms of filled grains panicle^{-1} of rice (Table 4.1.5). The maximum number of filled grains panicle^{-1} (122.56) was observed from V_6 which was statistically similar (119.89) to V_7 and closely followed (113.67 and 112.83, respectively) by V_8 and V_2, while the minimum number (85.78) was recorded from V_{10} which was statistically similar (87.83 and 92.83, respectively) to V_{12} and V_{11}. Obulamma *et al.* (2004) recorded highest number of filled grains panicle^{-1} in APHR 2 than DRRH 1 variety.

Filled grains panicle^{-1} of rice showed significant differences due to the combined effect of different levels of irrigation and rice varieties (Table 4.1.6). The maximum number of filled grains panicle^{-1} (124.89) was recorded from the combination of I_1V_7, whereas the minimum number (83.67) was observed from the combination of I_0V_{11}.



I_0: No irrigation

I_1: Supplemental irrigation;

V_1: BR-3; V_2: BR-14; V_3: BR-16; V_4: BRRI dhan27;

V_5: BRRI dhan42; V_6: BRRI dhan48; V_7: BRRI dhan55; V_8: BRRI dhan65;

V_9: China (Muladi local); V_{10}: Kali Shait-ta (Muladi local);

V_{11}: Benamuri (Muladi local); V_{12}: Abdul Hye (Jhalkathi local)

Figure 4.1.7. Combined effect of different levels of irrigation and rice varieties on panicle length in Aus season. (Sx = 0.502).

Table 4.1.5. Effect of different levels of irrigation and rice varieties on filled, unfilled and total grains panicle^{-1} and weight of 1000 grains in Aus season

Treatments	Filled grains panicle^{-1} (No.)	Unfilled grains panicle^{-1} (No.)	Total grains panicle^{-1} (No.)	Weights of 1000 grains (g)
Levels of irrigation				
I_0	101.63 b	9.45 b	111.08 b	25.69
I_1	108.20 a	9.95 a	118.16 a	25.87
Sx value	0.786	0.060	0.813	0.140
Level of significance	0.05	0.05	0.05	NS
CV (%)	4.50	3.73	4.26	3.26
Rice Varieties				
V_1	108.00 c	8.78 ef	116.78 bc	24.60 de
V_2	112.83 bc	8.94 ef	121.78 a-c	24.56 de
V_3	106.39 c	10.33 cd	116.72 bc	26.02 c
V_4	106.28 c	8.50 fg	114.78 cd	25.53 cd
V_5	106.11 c	9.61 de	115.72 bc	24.82 d
V_6	122.56 a	7.39 h	129.95 a	24.64 de
V_7	119.89 ab	7.78 gh	127.67 a	26.14 bc
V_8	113.67 bc	9.89 d	123.56 ab	23.68 e
V_9	96.83 d	10.33 cd	107.17 de	26.48 bc
V_{10}	85.78 e	12.89 a	98.67 f	27.10 ab
V_{11}	92.83 de	11.22 b	104.06 ef	27.68 a
V_{12}	87.83 e	10.78 bc	98.61 f	28.09 a
Sx value	2.672	0.283	2.729	0.346
Level of significance	0.01	0.01	0.01	0.01
CV (%)	6.24	7.15	5.83	3.29

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

I_0: No irrigation; I_1: Supplemental irrigation

V_1: BR-3; V_2: BR-14; V_3: BR-16; V_4: BRRI dhan27;
V_5: BRRI dhan42; V_6: BRRI dhan48; V_7: BRRI dhan55; V_8: BRRI dhan65;
V_9: China (Muladi local); V_{10}: Kali Shait-ta (Muladi local); V_{11}: Benamuri (Muladi local);
V_{12}: Abdul Hye (Jhalkathi local)

Table 4.1.6. Combined effect of different levels of irrigation and rice varieties on filled, unfilled and total grains panicle^{-1} and weight of 1000 grains in Aus season

Treatments combinations	Filled grains panicle^{-1} (No.)	Unfilled grains panicle^{-1} (No.)	Total grains panicle^{-1} (No.)	Weights of 1000 grains (g)
I_0V_1	102.56 cd	8.44 g-i	111.00 d-f	24.35 f-h
I_0V_2	112.44 a-d	8.78 f-i	121.22 a-d	24.22 f-h
I_0V_3	100.78 de	10.00 c-f	110.78 d-f	25.05 e-h
I_0V_4	104.67 cd	7.56 i	112.22 c-e	25.67 c-f
I_0V_5	107.56 cd	10.45 cd	118.00 b-d	24.74 f-h
I_0V_6	121.44 ab	6.33 j	127.78 ab	24.34 f-h
I_0V_7	114.89 a-c	7.67 i	122.55 a-d	25.58 d-f
I_0V_8	115.11 a-c	9.78 d-g	124.89 a-c	23.61 h
I_0V_9	86.11 f	9.55 d-g	95.66 g	26.47 b-e
I_0V_{10}	85.00 f	13.11 a	98.11 g	26.93 b-d
I_0V_{11}	83.67 f	12.11 ab	95.78 g	28.60 a
I_0V_{12}	85.33 f	9.67 d-g	95.00 g	28.69 a
I_1V_1	113.44 a-d	9.11 e-h	122.56 a-d	24.86 e-h
I_1V_2	113.22 a-d	9.11 e-h	122.33 a-d	24.90 e-h
I_1V_3	112.00 b-d	10.67 cd	122.67 a-d	26.99 b-d
I_1V_4	107.89 cd	9.45 d-g	117.33 b-d	25.39 d-g
I_1V_5	104.67 cd	8.78 f-i	113.44 c-e	24.90 e-h
I_1V_6	123.67 ab	8.45 g-i	132.11 a	24.93 e-h
I_1V_7	124.89 a	7.89 hi	132.78 a	26.69 b-d
I_1V_8	112.22 b-d	10.00 c-f	122.22 a-d	23.74 gh
I_1V_9	107.55 cd	11.11 bc	118.67 b-d	26.48 b-e
I_1V_{10}	86.55 f	12.67 a	99.22 fg	27.28 a-c
I_1V_{11}	102.00 d	10.33 c-e	112.34 c-e	26.76 b-d
I_1V_{12}	90.33 ef	11.89 ab	102.22 e-g	27.49 ab
Sx value	3.779	0.401	3.859	0.490
Level of significance	0.05	0.01	0.05	0.05
CV (%)	6.24	7.15	5.83	3.29

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

I_0: No irrigation; I_1: Supplemental irrigation

V_1: BR-3; V_2: BR-14; V_3: BR-16; V_4: BRRI dhan27;
V_5: BRRI dhan42; V_6: BRRI dhan48; V_7: BRRI dhan55; V_8: BRRI dhan65;
V_9: China (Muladi local); V_{10}: Kali Shait-ta (Muladi local); V_{11}: Benamuri (Muladi local);
V_{12}: Abdul Hye (Jhalkathi local)

4.1.9 Unfilled grains panicle^{-1}

Different levels of irrigation showed statistically significant differences in terms of unfilled grains panicle^{-1} of rice (Table 4.1.5). The minimum number of unfilled grains panicle^{-1} (9.45) was recorded from I_0, whereas the maximum number (9.95) was found from I_1.

Different rice varieties showed significant differences on unfilled grains panicle^{-1} of rice (Table 4.1.5). The minimum number of unfilled grains panicle^{-1} (7.39) was observed from V_6 which was statistically similar (7.78) to V_7 and closely followed (8.50) by V_4, whereas the maximum number (12.89) was recorded from V_{10}. Hosain *et al*. (2014) reported that varieties Heera2 and Aloron gave the higher spikelet sterility.

Statistically significant variation was recorded due to the combined effect of different levels of irrigation and rice varieties on unfilled grains panicle^{-1} of rice (Table 4.1.6). The minimum number of unfilled grains panicle^{-1} (6.33) was recorded from the combination of I_0V_6 and the maximum number (12.67) was found from the combination of I_1V_{10}.

4.1.10 Total grains panicle^{-1}

Statistically significant variation was recorded in terms of total grains panicle^{-1} of rice due to different levels of irrigation (Table 4.1.5). The maximum number of total grains panicle^{-1} (118.16) was observed from I_1 and the minimum number (111.08) was recorded from I_0.

Total grains panicle^{-1} of rice varied significantly due to different rice varieties (Table 4.1.5). The maximum number of total grains panicle^{-1} (129.95) was found from V_6 which was statistically similar (127.67, 123.56 and 121.78, respectively) to V_7, V_8 and V_2 and followed (116.78 and 115.72, respectively) by V_1 and V_5, while the minimum number (98.61) was recorded from V_{12} which was statistically similar (98.67 and 104.06, respectively) to V_{10} and V_{11}. Guilani *et al*. (2003) found that grains panicle^{-1} was not significantly different among cultivars.

Combined effect of different levels of irrigation and rice varieties showed statistically significant differences in terms of total grains panicle^{-1} of rice (Table 4.1.6). The maximum number of total grains panicle^{-1} (132.78) was recorded from the combination of I_1V_7, whereas the minimum number (85.33) was observed from the combination of I_0V_{12}.

4.1.11 Weight of 1000 grains

Weight of 1000 grains of rice showed statistically significant differences due to different levels of irrigation (Table 4.1.5). The highest weight of 1000 grains (25.87 g) was recorded from I_1, while the lowest weight (25.69 g) from I_0. Khairi *et al.* (2015) reported that AWD treatment affected weight of 1000-grains.

Statistically significant variation was recorded due to different rice varieties in terms of weight of 1000 grains of rice (Table 4.1.5). The highest weight of 1000 grains (28.09 g) was recorded from V_{12} which was statistically similar (27.68 g and 27.10 g, respectively) to V_{11} and V_{10} and followed (26.48 g and 26.14 g, respectively) by V_9 and V_7, whereas, the lowest weight (23.68 g) from V_8 which was statistically similar (24.64 g, 24.60 g and 24.56 g, respectively) to V_6, V_1 and V_2. Wang *et al.* (2006) reported that high yielding variety had heavier seeds compared with conventional cultivars.

Weight of 1000 grains of rice varied significantly due to the combined effect of different levels of irrigation and rice varieties under the present trial (Table 4.1.6). The highest weight of 1000 grains (28.69 g) was recorded from the combination of I_0V_{12}, whereas the lowest weight (23.61 g) was found from I_0V_8.

4.1.12 Grain yield

Different levels of irrigation showed statistically significant differences for grain yield of rice (Table 4.1.7). The highest grain yield (4.22 t ha^{-1}) was recorded from I_1, whereas the lowest grain yield (3.90 t ha^{-1}) was found from I_0. Karim *et al.* (2014) reported that grain yield was 7.62% higher in sprinkler and 4.72% higher in AWD irrigation method over flood irrigation method.

Table 4.1.7. Effect of different levels of irrigation and rice varieties on grain, straw, biological yield and harvest index in Aus season

Treatments	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
Levels of irrigation				
I_0	3.90 b	5.02 b	8.92 b	43.57 a
I_1	4.22 a	5.69 a	9.91 a	42.37 b
Sx value	0.038	0.094	0.133	0.167
Level of significance	0.05	0.05	0.05	0.05
CV (%)	5.67	10.58	8.46	2.33
V_1	4.10 c	5.51 bc	9.62 bc	42.74 c
V_2	5.01 ab	5.87 ab	10.87 a	46.06 ab
V_3	4.69 b	6.39 a	11.08 a	42.30 c
V_4	4.04 c	5.68 bc	9.73 b	41.70 c
V_5	3.91 cd	5.41 bc	9.32 b-d	41.97 c
V_6	5.22 a	5.60 bc	10.82 a	48.19 a
V_7	4.89 ab	5.70 bc	10.59 a	46.18 ab
V_8	3.85 c-e	5.10 c	8.96 cd	43.05 bc
V_9	3.51 e	5.11 c	8.62 d	40.64 c
V_{10}	2.90 f	4.07 d	6.97 e	41.72 c
V_{11}	3.03 f	4.52 d	7.55 e	40.22 c
V_{12}	3.61 de	5.26 bc	8.87 cd	40.81 c
Sx value	0.083	0.134	0.175	0.740
Level of significance	0.01	0.01	0.01	0.01
CV (%)	5.01	6.11	4.56	4.22

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

I_0: No irrigation; I_1: Supplemental irrigation

V_1: BR-3; V_2: BR-14; V_3: BR-16; V_4: BRRI dhan27;
V_5: BRRI dhan42; V_6: BRRI dhan48; V_7: BRRI dhan55; V_8: BRRI dhan65;
V_9: China (Muladi local); V_{10}: Kali Shait-ta (Muladi local); V_{11}: Benamuri (Muladi local);
V_{12}: Abdul Hye (Jhalkathi local)

Grain yield of rice varied significantly due to different rice varieties (Table 4.1.7). The highest grain yield (5.22 t ha^{-1}) was observed from V_6 which was statistically similar (5.01 t ha^{-1} and 4.89 t ha^{-1}, respectively) to V_2 and V_7 and closely followed (4.69 t ha^{-1}) by V_3, while the lowest grain yield (2.90 t ha^{-1}) was found from V_{10} which was statistically similar (3.03 t ha^{-1}) to V_{11}. Kanfany *et al*. (2014) reported that grain yield of rice high yielding varieties was not significantly higher than that of the check cultivar.

Statistically significant variation was recorded due to the combined effect of different levels of irrigation and rice varieties in terms of grain yield of rice (Table 4.1.8). The highest grain yield was recorded (5.45 t ha^{-1}) from the combination of I_1V_6, whereas the lowest grain yield (2.84 t ha^{-1}) was found from the combination of I_0V_{10}.

4.1.13 Straw yield

Straw yield of rice varied significantly due to different levels of irrigation (Table 4.1.7). The highest straw yield (5.69 t ha^{-1}) was observed from I_1 and the lowest straw yield (5.02 t ha^{-1}) was recorded from I_0.

Different rice varieties showed significant differences on straw yield of rice (Table 4.1.7). Data revealed that the highest straw yield (6.39 t ha^{-1}) was observed from V_3 which was statistically similar (5.87 t ha^{-1}) to V_2 and closely followed (5.70 t ha^{-1}, 5.68 t ha^{-1}, 5.60 t ha^{-1}, 5.51 t ha^{-1} and 5.41 t ha^{-1}, respectively) by V_7, V_4, V_6, V_1 and V_5. On the other hand, the lowest straw yield (4.07 t ha^{-1}) was found from V_{10} which was statistically similar (4.52 t ha^{-1}) to V_{11}. Patel (2000) observed significantly higher grain and straw yield from Kranti than IR36.

Combined effect of different levels of irrigation and rice varieties varied significantly in terms of straw yield of rice (Table 4.1.8). The highest straw yield (6.68 t ha^{-1}) was recorded from the combination of I_1V_3, while the lowest straw yield (3.72 t ha^{-1}) was observed from the combination of I_0V_{10}.

Table 4.1.8. Combined effect of different levels of irrigation and rice varieties on grain, straw and biological yield and harvest index in Aus season

Treatments combinations	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
I_0V_1	3.91 hi	5.11 f-i	9.02 f-h	43.37 b-e
I_0V_2	4.77 c-e	5.57 c-g	10.34 c	46.11 a-c
I_0V_3	4.50 ef	6.10 a-c	10.60 bc	42.41 e-h
I_0V_4	3.78 h-j	5.04 g-i	8.83 f-i	42.83 c-g
I_0V_5	3.87 hi	5.24 e-i	9.11 e-h	42.52 e-h
I_0V_6	4.98 bc	5.42 d-h	10.41 c	47.87 a
I_0V_7	4.53 d-f	5.30 d-i	9.83 c-e	46.07 a-d
I_0V_8	3.65 i-k	4.76 ij	8.41 hi	43.44 b-e
I_0V_9	3.64 i-k	5.01 g-j	8.65 g-i	42.07 e-h
I_0V_{10}	2.84 m	3.72 l	6.56 l	43.29 b-f
I_0V_{11}	2.86 m	4.15 l	7.01 kl	40.90 e-h
I_0V_{12}	3.48 j-l	4.84 h-j	8.33 hi	41.90 e-h
I_1V_1	4.30 fg	5.92 b-d	10.21 cd	42.10 e-h
I_1V_2	5.24 ab	6.16 a-c	11.41 a	46.01 a-d
I_1V_3	4.88 cd	6.68 a	11.56 a	42.19 e-h
I_1V_4	4.30 fg	6.32 ab	10.63 bc	40.57 e-h
I_1V_5	3.94 g-i	5.58 c-g	9.53 d-f	41.42 e-h
I_1V_6	5.45 a	5.78 b-e	11.23 ab	48.51 a
I_1V_7	5.25 ab	6.10 a-c	11.35 ab	46.30 ab
I_1V_8	4.05 gh	5.45 d-h	9.50 d-f	42.66 d-h
I_1V_9	3.37 kl	5.22 e-i	8.58 hi	39.20 h
I_1V_{10}	2.97 m	4.42 jk	7.38 jk	40.14 e-h
I_1V_{11}	3.19 lm	4.89 h-j	8.09 ij	39.55 gh
I_1V_{12}	3.73 h-k	5.68 c-f	9.42 e-g	39.73 f-h
Sx value	0.118	0.189	0.248	1.046
Level of significance	0.05	0.01	0.05	0.05
CV (%)	5.01	6.11	4.56	4.22

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

I_0: No irrigation; I_1: Supplemental irrigation

V_1: BR-3; V_2: BR-14; V_3: BR-16; V_4: BRRI dhan27;
V_5: BRRI dhan42; V_6: BRRI dhan48; V_7: BRRI dhan55; V_8: BRRI dhan65;
V_9: China (Muladi local); V_{10}: Kali Shait-ta (Muladi local); V_{11}: Benamuri (Muladi local);
V_{12}: Abdul Hye (Jhalkathi local)

4.1.14 Biological yield

Biological yield of rice showed statistically significant differences due to different levels of irrigation under this trial (Table 4.1.7). The highest biological yield was recorded from I_1 (9.91 t ha^{-1}), whereas the lowest biological yield was observed from I_0 (8.92 t ha^{-1}).

Different rice varieties showed significant differences on biological yield of rice (Table 4.1.7). The highest biological yield was recorded from V_3 (11.08 t ha^{-1}) which was statistically similar to V_2 (10.87 t ha^{-1}), V_6 (10.82 t ha^{-1}) and V_7 (10.59 t ha^{-1}) and closely followed by V_4 (9.73 t ha^{-1}), V_1 (9.62 t ha^{-1}) and V_5 (9.32 t ha^{-1}), whereas the lowest biological yield was found from V_{10} (6.97 t ha^{-1}) which was statistically similar to V_{11} (7.55 t ha^{-1}).

Different levels of irrigation and rice varieties showed statistically significant differences due to their combined effect on biological yield of rice (Table 4.1.8). The highest biological yield was recorded from the combination of I_1V_3 (11.56 t ha^{-1}) and the lowest biological yield was observed from I_0V_{10} (6.56 t ha^{-1}).

4.1.15 Harvest index

Harvest index of rice varied significantly due to different levels of irrigation (Table 4.1.7). The highest harvest index was found from I_0 (43.57%) and the lowest harvest index was observed from I_1 (42.37%).

Statistically significant variation was recorded due to different rice varieties in terms of harvest index of rice (Table 4.1.7). The highest harvest index was found from V_6 (48.19%) which was statistically similar to V_7 (46.18%) and V_2 (46.06%) and followed by V_8 (43.05%), while the lowest was observed from V_{11} (40.22%) which was statistically similar with other rice varieties except V_6, V_2 and V_8.

Due to the combined effect of different levels of irrigation and rice varieties showed statistically significant differences in terms of harvest index of rice (Table 4.1.8). The highest harvest index was recorded from the combination of I_1V_6 (48.51%), whereas the lowest harvest index from I_1V_9 (39.20%).

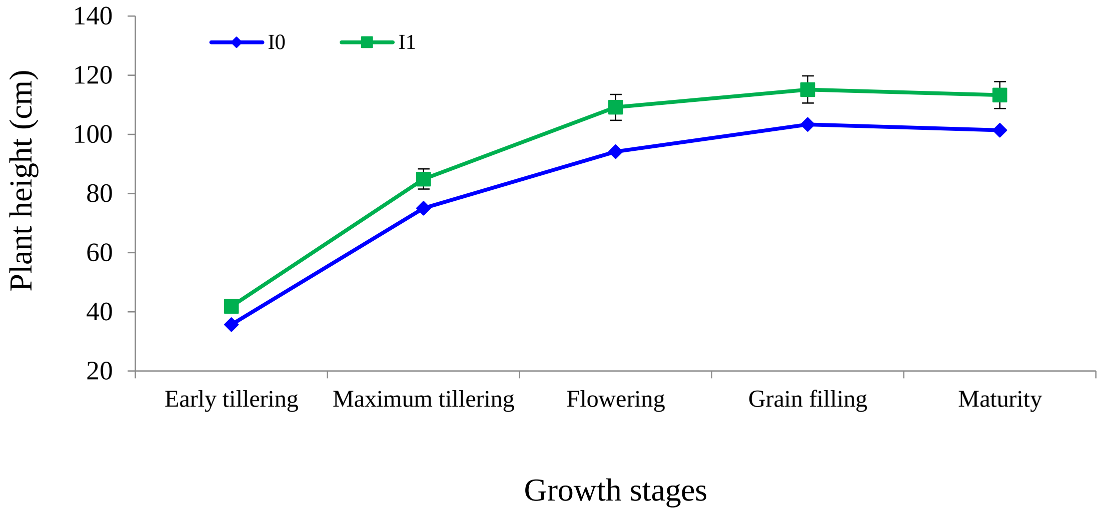
4.2 Experiment-2: Yield Performance of Selected Aus Rice Varieties under Irrigated and Non-irrigated Condition

In the first year (2015) twelve different Aus varieties were tested. Out of them four good performing varieties were selected to be tested again in the second year Aus season (2016). This second experiment was conducted to find out the yield performance of selected Aus rice varieties under irrigated and non-irrigated condition.

4.2.1 Plant height

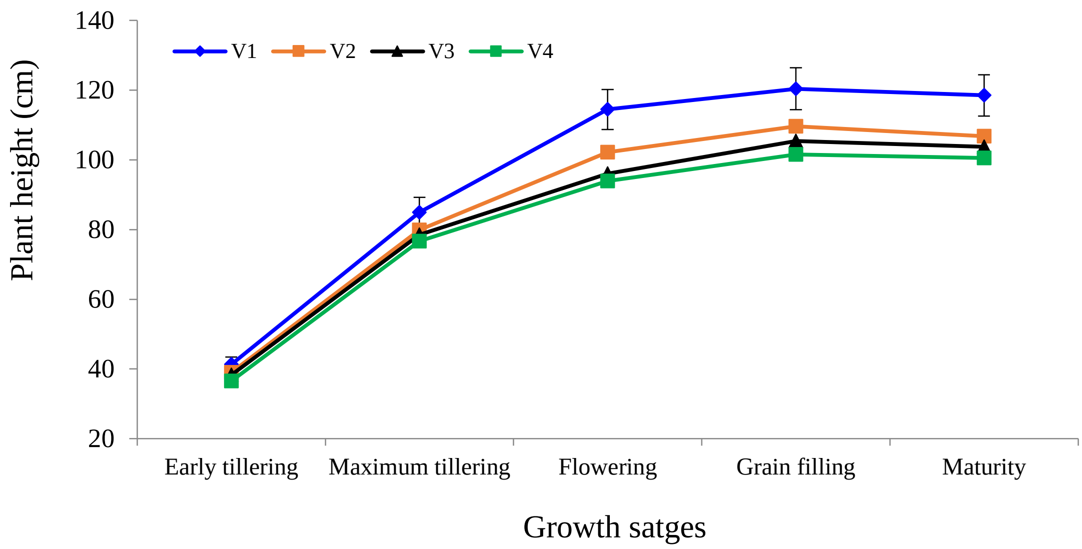
Different levels of irrigation showed statistically significant differences in terms of plant height of rice at early tillering stage (ETS), maximum tillering stage (MTS), flowering stage (FS), grain filling stage (GFS) and maturity stage (MS) (Figure 4.2.1). At ETS, MTS, FS, GFS and MS, the taller plant (41.85, 84.94, 109.20, 115.18 and 113.31 cm, respectively) was observed from I_1 (supplemental irrigation), whereas the shorter plants (35.76, 75.08, 94.14, 103.36 and 101.46 cm, respectively) was recorded from I_0 (no irrigation). Plant height is a genetical character and specific variety produced more or less similar size of plant but it may differ due to prevailing different biotic and abiotic factors. Data revealed that supplemental irrigation produced significantly taller plant compared to the no irrigation condition. Timon *et al.* (2015) showed that there were significant differences in terms of plant height in irrigated and non-irrigated rice cultivation.

Plant height of rice at ETS, MTS, FS, GFS and MS varied significantly due to different rice varieties (Figure 4.2.2). At ETS, MTS, FS, GFS and MS, the tallest plant (41.36, 84.97, 114.47, 120.41 and 118.51 cm, respectively) was found from V_1 (BR-14) which was followed (39.02, 79.90, 102.20, 109.67 and 106.76 cm, respectively) by V_2 (BRRI dhan48) and also (38.33, 78.51, 96.03, 105.43 and 103.75 cm, respectively) by V_3 (BRRI dhan55), while the shortest plant (36.51, 76.64, 93.97, 101.58 and 100.51 cm, respectively) was observed from V_4 (BRRI dhan65). Generally different varieties produced different size of plant because plant height is a genetical character and it is controlled by the genetic make up of



I_0: No irrigation; I_1: Supplemental irrigation

Figure 4.2.1. Effect of different levels of irrigation on plant height of rice at different growth stages in Aus season (Sx = 0.464, 1.528, 2.163, 0.999 and 2.703 at ETS, MTS, FS, GFS and MS, respectively).



V_1: BR-14 V_2: BRRI dhan48

V_3: BRRI dhan55 V_4: BRRI dhan65

Figure 4.2.2. Effect of different selected rice varieties on plant height at different growth stages in Aus season (Sx = 0.956, 1.340, 2.257, 2.381 and 2.703 at ETS, MTS, FS, GFS and MS, respectively).

the specific variety. Variety is the key component to produce plant height of rice depending upon their differences in genotypic characters, input requirements and response, growth process and off course the prevailing environmental conditions during the growing season. Munoz *et al.* (1996) noted that IR8025A rice cultivar produced 16% longer plant than the commercial variety Oryzica Yacu-9. Khalifa (2009) reported that H_1 high yielding rice variety surpassed other varieties in terms of plant height. Bhuiyan *et al*. (2014) reported that the different rice varieties had significant effects on plant height at maturity.

Statistically significant variation was recorded in terms of plant height of rice at ETS, MTS, FS, GFS and MS due to the combined effect of different levels of irrigation and rice varieties (Table 4.2.1). At ETS, MTS, FS, GFS and MS, the tallest plant (46.84, 92.75, 126.73, 130.82 and 128.36 cm, respectively) was observed from the combination of I_1V_1 (supplemental irrigation and BR-14), whereas the shortest plant (34.97, 72.21, 89.49, 100.29 and 97.59 cm, respectively) was recorded from the combination of I_0V_4 (no irrigation and BRRI dhan65).

4.2.2 Number of tillers hill^{-1}

Number of tillers hill^{-1} of rice at early tillering stage (ETS), maximum tillering stage (MTS), flowering stage (FS), grain filling stage (GFS) and maturity stage (MS) varied significantly due to different levels of irrigation (Table 4.2.2). At ETS, MTS, FS and GFS, the maximum number of tiller hill^{-1} (6.52, 14.72, 16.62 and 16.25, respectively) was observed from I_1, while the minimum number (5.65, 13.82, 14.40 and 14.03, respectively) was recorded from I_0.

Different rice varieties showed significant differences in terms of number of tiller hill^{-1} of rice at ETS, MTS, FS and GFS (Table 4.2.2). At ETS, MTS, FS and GFS, the maximum number of tiller hill^{-1} (6.53, 15.17, 16.50 and 16.27, respectively) was found from V_2 which was followed (6.17, 14.27, 15.97 and 15.57, respectively) by V_3 and also (6.00, 14.23, 14.93 and 14.60, respectively) by V_1 and the minimum number (5.63, 13.40, 14.63 and 14.13, respectively) was found

Table 4.2.1. Combined effect of different levels of irrigation and selected rice varieties on plant height (cm) at different growth stages in Aus season

Treatments combinations	Growth stage				
	Early tillering (ETS)	Maximum tillering (MTS)	Flowering (FS)	Grain filling (GFS)	Maturity (MS)
I_0V_1	35.88 cd	77.20 bc	102.20 bc	110.00 bc	108.65 bc
I_0V_2	35.13 cd	74.04 bc	92.73 cd	101.90 c	100.55 c
I_0V_3	37.06 cd	76.86 bc	92.15 cd	101.26 c	99.03 c
I_0V_4	34.97 d	72.21 c	89.49 d	100.29 c	97.59 c
I_1V_1	46.84 a	92.75 a	126.73 a	130.82 a	128.36 a
I_1V_2	42.92 ab	87.60 a	111.68 b	119.05 b	115.93 b
I_1V_3	39.60 bc	80.16 b	102.58 bc	109.60 bc	108.48 bc
I_1V_4	38.05 cd	79.25 b	95.80 cd	101.27 c	100.48 c
Sx value	1.352	1.895	3.191	3.367	3.822
Level of significance	0.05	0.01	0.05	0.05	0.05
CV (%)	6.03	4.10	5.44	5.34	6.16

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

I_0: No irrigation I_1: Supplemental irrigation

V_1: BR-14 V_2: BRRI dhan48

V_3: BRRI dhan55 V_4: BRRI dhan65

Table 4.2.2. Effect of different levels of irrigation and selected rice varieties on number of total tillers hill^{-1} at different growth stages in Aus season

Treatments	Growth stage			
	Early tillering (ETS)	Maximum tillering (MTS)	Flowering (FS)	Grain filling (GFS)
Levels of irrigation				
I_0	5.65 b	13.82 b	14.40 b	14.03 b
I_1	6.52 a	14.72 a	16.62 a	16.25 a
Sx value	0.043	0.108	0.293	0.254
Level of significance	0.01	0.05	0.05	0.05
CV(%)	2.44	2.62	6.65	5.80
Selected rice varieties				
V_1	6.00 b	14.23 b	14.93 bc	14.60 bc
V_2	6.53 a	15.17 a	16.50 a	16.27 a
V_3	6.17 b	14.27 b	15.97 ab	15.57 ab
V_4	5.63 c	13.40 c	14.63 c	14.13 c
Sx value	0.107	0.213	0.339	0.324
Level of significance	0.01	0.01	0.01	0.01
CV(%)	4.33	3.66	5.35	5.24

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

I_0: No irrigation I_1: Supplemental irrigation

V_1: BR-14 V_2: BRRI dhan48

V_3: BRRI dhan55 V_4: BRRI dhan65

from V_4. Masum *et al*. (2008) reported maximum (25.63) tillers hill^{-1} at 45 DAT, then with advancement to age it declined up to maturity, whereas, in the case of BRRI dhan44, maximum (18.92) tiller production was observed around panicle initiation stage at 60 DAT. Khalifa (2009) reported that H_1 high yielding rice variety surpassed other varieties in consideration of tillers hill^{-1}.

Combined effect of different levels of irrigation and rice varieties varied significantly in terms of number of tiller hill^{-1} of rice at ETS, MTS, FS and GFS (Table 4.2.3). At ETS, MTS, FS and GFS, the maximum number of tiller hill^{-1} (6.67, 15.20, 18.47 and 18.33, respectively) was observed from the combination of I_1V_2 and the minimum number (5.07, 12.40, 14.13 and 13.67, respectively) was recorded from the combination of I_0V_4.

4.2.3 Leaf area index

Leaf area index of rice at early tillering stage (ETS), maximum tillering stage (MTS), flowering stage (FS), grain filling stage (GFS) and maturity stage (MS) varied significantly due to different levels of irrigation (Figure 4.2.3). At ETS, MTS, FS and GFS, the highest leaf area index (1.49, 3.05, 5.05 and 4.07, respectively) was observed from I_1, while the lowest (1.29, 2.52, 4.36 and 3.43, respectively) was recorded from I_0.

Different rice varieties showed significant differences in terms of leaf area index of rice at ETS, MTS, FS and GFS (Figure 4.2.4). At ETS, MTS, FS and GFS, the highest leaf area index (1.52, 3.24, 4.92 and 4.25, respectively) was found from V_2 which was followed (1.48, 2.96, 4.82 and 3.82, respectively) by V_3 and also (1.32, 2.68, 4.75 and 3.75, respectively) by V_1, whereas the lowest (1.25, 2.29, 4.32 and 3.19, respectively) was observed from V_4.

Combined effect of different levels of irrigation and rice varieties varied significantly in terms of leaf area index of rice at ETS, MTS, FS and GFS under the present trial (Table 4.2.4). At ETS, MTS, FS and GFS, the highest leaf area index (1.68, 3.58, 5.39 and 4.55, respectively) was found from the combination of I_1V_2 and the lowest (1.20, 2.21, 4.32 and 3.10, respectively) from I_0V_4.

Table 4.2.3. Combined effect of different levels of irrigation and selected rice varieties on number of total tillers hill^{-1} at different growth stages in Aus season

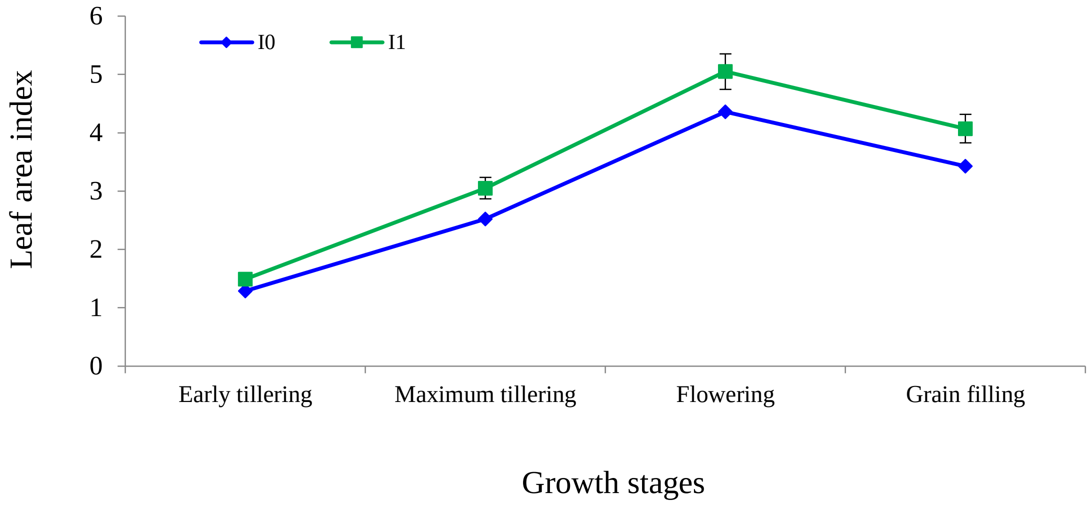
Treatments combinations	Growth stage			
	Early tillering (ETS)	Maximum tillering (MTS)	Flowering (FS)	Grain filling (GFS)
I_0V_1	5.40 bc	14.00 bc	14.20 b	13.87 cd
I_0V_2	6.40 a	15.13 a	14.53 b	14.20 cd
I_0V_3	5.73 b	13.73 c	14.73 b	14.40 cd
I_0V_4	5.07 c	12.40 d	14.13 b	13.67 d
I_1V_1	6.60 a	14.47 a-c	15.67 b	15.33 bc
I_1V_2	6.67 a	15.20 a	18.47 a	18.33 a
I_1V_3	6.60 a	14.80 ab	17.20 a	16.73 b
I_1V_4	6.20 a	14.40 a-c	15.13 b	14.60 cd
Sx value	0.152	0.301	0.479	0.459
Level of significance	0.05	0.05	0.05	0.05
CV (%)	4.33	3.66	5.35	5.24

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

I_0: No irrigation I_1: Supplemental irrigation

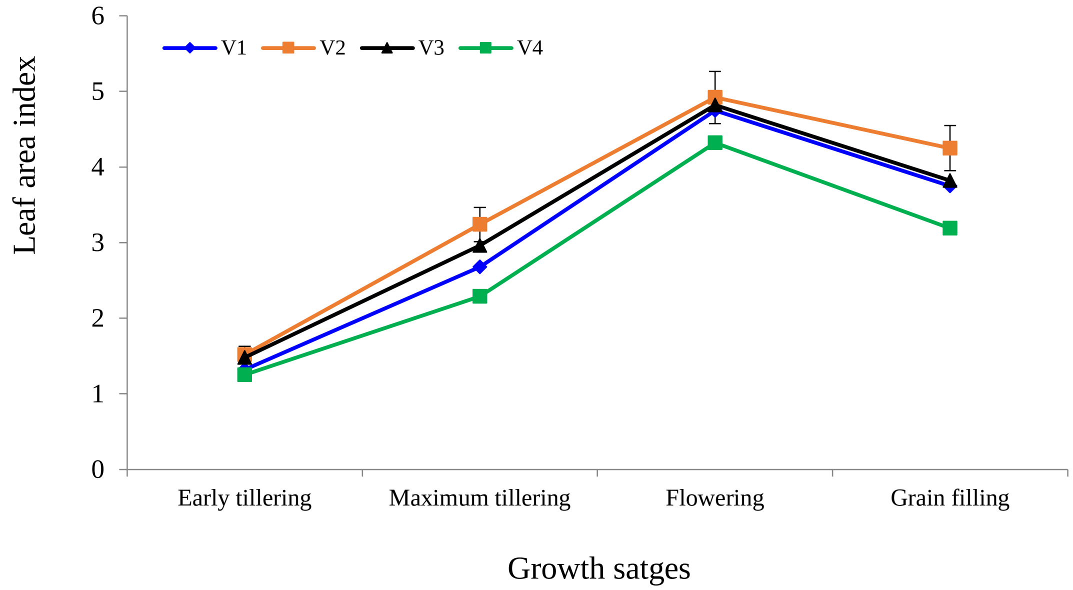
V_1: BR-14 V_2: BRRI dhan48

V_3: BRRI dhan55 V_4: BRRI dhan65



I_0: No irrigation; I_1: Supplemental irrigation

Figure 4.2.3. Effect of different levels of irrigation on leaf area index of rice at different growth stages in Aus season (Sx = 0.016, 0.031, 0.298 and 0.351 at ETS, MTS, FS and GFS, respectively).



V_1: BR-14 V_2: BRRI dhan48

V_3: BRRI dhan55 V_4: BRRI dhan65

Figure 4.2.4. Effect of different selected rice varieties on leaf area index at different growth stages in Aus season (Sx = 0.022, 0.089, 0.339 and 0.376 at ETS, MTS, FS and GFS, respectively).

Table 4.2.4. Combined effect of different levels of irrigation and selected rice varieties on leaf area index at different growth stages in Aus season

Treatments combinations	Growth stage			
	Early tillering (ETS)	Maximum tillering (MTS)	Flowering (FS)	Grain filling (GFS)
I_0V_1	1.24 c	2.25 e	4.28 b	3.32 b
I_0V_2	1.36 b	2.89 bc	4.45 b	3.95 a
I_0V_3	1.37 b	2.74 cd	4.37 b	3.36 b
I_0V_4	1.20 c	2.21 e	4.12 b	3.10 c
I_1V_1	1.39 b	3.10 bc	5.22 a	4.18 a
I_1V_2	1.68 a	3.58 a	5.39 a	4.55 a
I_1V_3	1.59 a	3.17 b	5.26 a	4.27 a
I_1V_4	1.30 bc	2.36 de	4.31 b	3.28 b
Sx value	0.032	0.125	0.480	0.532
Level of significance	0.05	0.05	0.05	0.05
CV (%)	4.18	3.19	5.54/9	6.59/8

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

I_0: No irrigation　　I_1: Supplemental irrigation

V_1: BR-14　　V_2: BRRI dhan48

V_3: BRRI dhan55　　V_4: BRRI dhan65

4.2.4 Crop duration

Crop duration of rice varied significantly due to different levels of irrigation (Table 4.2.5). The maximum crop duration (116.67 days) was observed from I_1, while the minimum crop duration (103.50 days) was recorded from I_0.

Different rice varieties showed significant differences in terms of crop duration of rice (Table 4.2.5). The maximum crop duration (120.33 days) was found from V_1 which was followed (110.67 days and 106.33 days) by V_2 and V_3, respectively and they were statistically similar, whereas the minimum crop duration (103.00 days) was observed from V_4.

Combined effect of different levels of irrigation and rice varieties varied significantly in terms of crop duration of rice (Table 4.2.6). The maximum crop duration (131.67 days) was observed from the combination of I_1V_1 and the minimum crop duration (101.67 days) was recorded from the combination of I_0V_4.

4.2.5 Number of effective tillers hill^{-1}

Number of effective tillers hill^{-1} of rice varied significantly due to different levels of irrigation (Table 4.2.5). The maximum number of effective tillers hill^{-1} (15.05) was observed from I_1, while the minimum number (12.10) was recorded from I_0. Haque *et al.* (2015) reported that stagnation of water and continuous 2-5 cm standing water in the field had no significant effect on number of effective tillers hill^{-1}.

Different rice varieties showed significant differences in terms of number of effective tillers hill^{-1} of rice (Table 4.2.5). The maximum number of effective tillers hill^{-1} (14.80) was found from V_2 which was statistically similar (14.03) to V_3 and closely followed (13.20) by V_1, whereas the minimum number (12.27) was observed from V_4. Khalifa (2009) reported that high yielding rice variety surpassed other varieties in consideration of effective tillers hill^{-1}.

Table 4.2.5. Effect of different levels of irrigation and selected rice varieties on crop duration, effective and non-effective tillers $hill^{-1}$ and panicle length in Aus season

Treatments	Crop duration (days)	Effective tillers $hill^{-1}$ (No.)	Non-effective tillers $hill^{-1}$ (No.)	Panicle length (cm)
Levels of irrigation				
I_0	103.50 b	12.10 b	2.75 a	21.93 b
I_1	116.67 a	15.05 a	2.03 b	24.58 a
Sx value	1.910	0.248	0.085	0.416
Level of significance	0.05	0.01	0.05	0.05
CV(%)	6.01	6.34	12.33	6.20
Selected rice varieties				
V_1	120.33 a	13.20 b	2.47 ab	23.20 ab
V_2	110.67 b	14.80 a	2.07 c	24.35 a
V_3	106.33 bc	14.03 ab	2.37 b	23.46 a
V_4	103.00 c	12.27 c	2.67 a	22.00 b
Sx value	1.950	0.303	0.082	0.400
Level of significance	0.01	0.01	0.01	0.01
CV(%)	4.34	5.47	8.36	4.22

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

I_0: No irrigation I_1: Supplemental irrigation

V_1: BR-14 V_2: BRRI dhan48

V_3: BRRI dhan55 V_4: BRRI dhan65

Table 4.2.6. Combined effect of different levels of irrigation and selected rice varieties on crop duration, effective and non-effective tillers hill^{-1} and panicle length in Aus season

Treatments combinations	Crop duration (days)	Effective tillers hill^{-1} (No.)	Non-effective tillers hill^{-1} (No.)	Panicle length (cm)
I_0V_1	109.00 c	12.00 cd	3.00 a	21.28 c
I_0V_2	101.33 c	12.67 cd	2.20 cd	23.00 bc
I_0V_3	102.00 c	12.27 cd	3.00 a	22.27 c
I_0V_4	101.67 c	11.47 d	2.80 ab	21.17 c
I_1V_1	131.67 a	14.40 b	1.93 de	25.13 a
I_1V_2	120.00 b	16.93 a	1.93 de	25.70 a
I_1V_3	110.67 c	15.80 a	1.73 e	24.65 ab
I_1V_4	104.33 c	13.07 c	2.53 bc	22.83 bc
Sx value	2.757	0.429	0.116	0.566
Level of significance	0.01	0.05	0.01	0.05
CV (%)	4.34	5.47	8.36	4.22

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

I_0: No irrigation I_1: Supplemental irrigation

V_1: BR-14 V_2: BRRI dhan48

V_3: BRRI dhan55 V_4: BRRI dhan65

Combined effect of different levels of irrigation and rice varieties varied significantly in terms of number of effective tillers hill^{-1} of rice (Table 4.2.6). The maximum number of effective tillers hill^{-1} (16.93) was observed from the combination of I_1V_2 and the minimum number (11.47) was recorded from the combination of I_0V_4.

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

Number of non-effective tillers hill^{-1} of rice varied significantly due to different levels of irrigation (Table 4.2.5). The minimum number of non-effective tillers hill^{-1} (2.75) was observed from I_0, while the maximum number (2.03) was recorded from I_1.

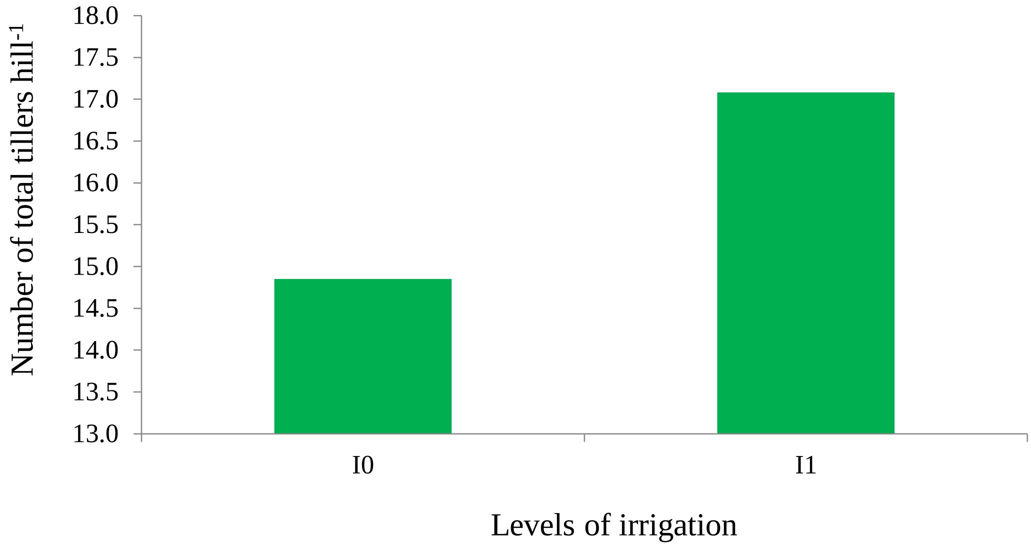
Different rice varieties showed significant differences in terms of number of non-effective tillers hill^{-1} of rice (Table 4.2.5). The minimum number of non-effective tillers hill^{-1} (2.07) was found from V_2 which was followed (2.37) by V_3, whereas the maximum number (2.67) was observed from V_4 which was statistically similar (2.47) to V_1.

Combined effect of different levels of irrigation and rice varieties varied significantly in terms of number of non-effective tillers hill^{-1} of rice (Table 4.2.6). The minimum number of non-effective tillers hill^{-1} (1.73) was found from the combination of I_1V_3 and the maximum number (3.00) was observed from the combination of I_0V_1 and I_0V_3.

4.2.7 Number of total tillers hill^{-1}

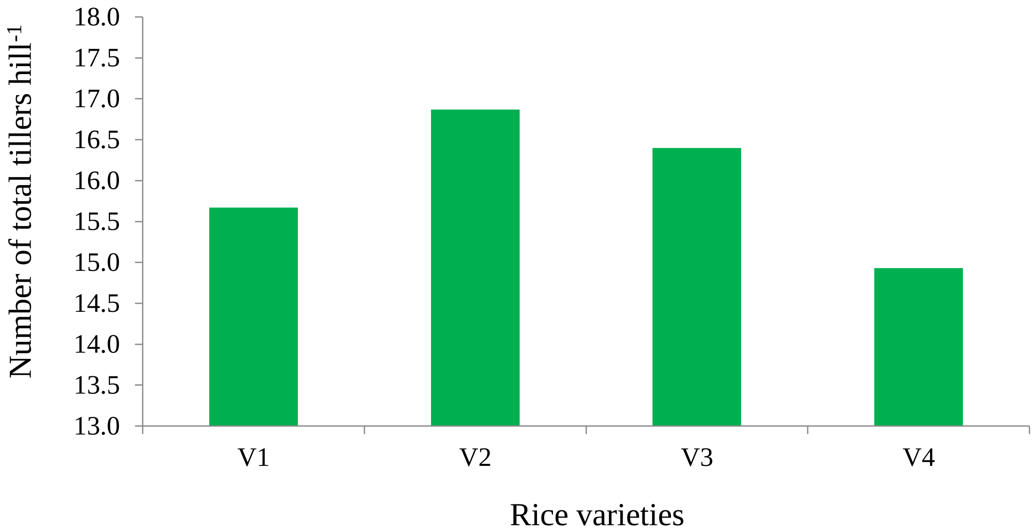
Number of total tillers hill^{-1} of rice varied significantly due to different levels of irrigation (Figure 4.2.5). The maximum number of total tillers hill^{-1} (17.08) was found from I_1, whereas the minimum number (14.85) was recorded from I_0.

Different rice varieties showed significant differences in terms of number of total tillers hill^{-1} of rice (Figure 4.2.6). The maximum number of total tillers hill^{-1} (16.87) was recorded from V_2 which was statistically similar (16.40) to V_3 and followed (15.67) by V_1, while the minimum number (14.93) was found from V_4.



I_0: No irrigation I_1: Supplemental irrigation

Figure 4.2.5. Effect of different levels of irrigation on number of total tillers hill^{-1} of rice in Aus season (Sx = 0.292).



V_1: BR-14 V_2: BRRI dhan48

V_3: BRRI dhan55 V_4: BRRI dhan65

Figure 4.2.6. Effect of different selected rice varieties on number of total tillers hill^{-1} in Aus season (Sx = 0.266).

Combined effect of different levels of irrigation and rice varieties varied significantly in terms of number of total tillers hill^{-1} of rice (Figure 4.2.7). The maximum number of total tillers hill^{-1} (18.87) was recorded from the combination of I_1V_2 and the minimum number (14.27) from I_0V_4.

4.2.8 Panicle length

Panicle length of rice varied significantly due to different levels of irrigation (Table 4.2.5). The longest panicle (24.58 cm) was recorded from I_1 and the shortest panicle (21.93 cm) was found from I_0. Haque *et al.* (2015) reported that stagnation of water and continuous 2-5 cm standing water in the field had no significant effect on panicle length.

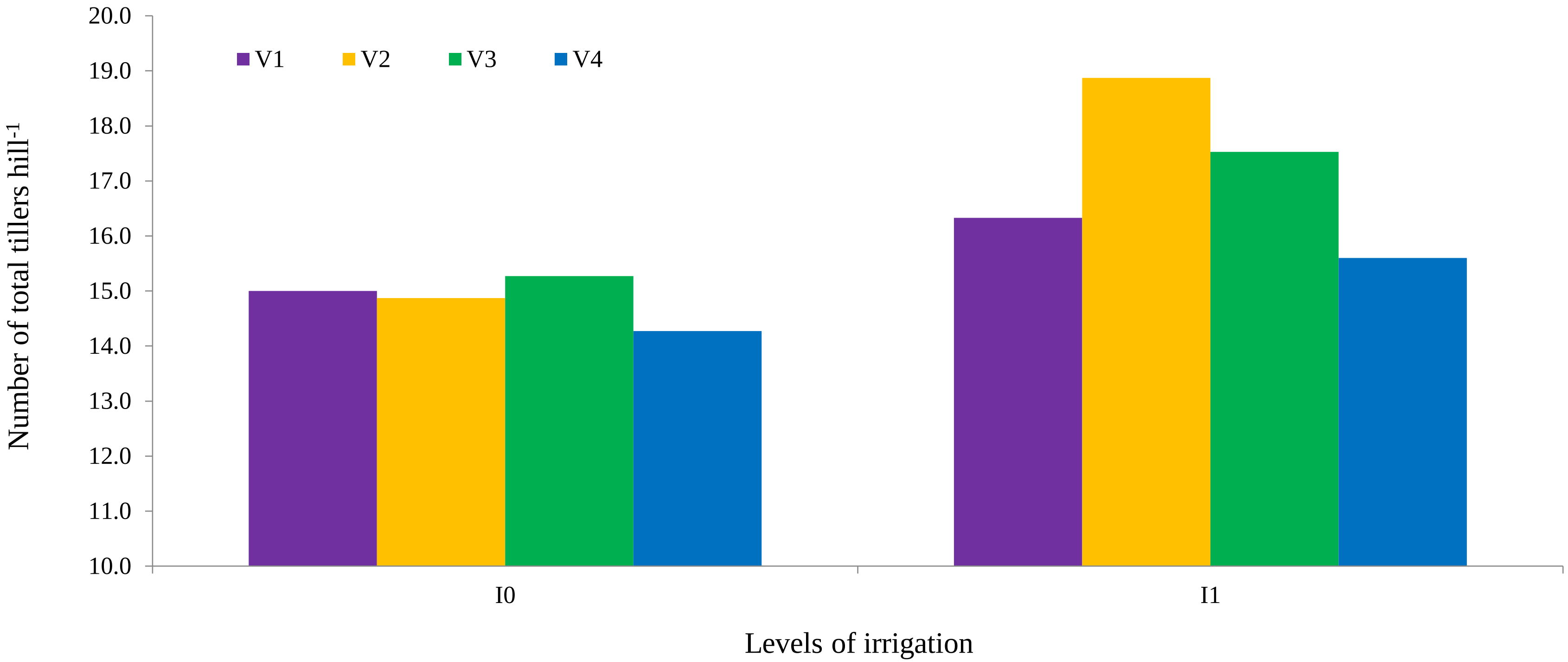
Different rice varieties showed significant differences in terms of panicle length of rice (Table 4.2.5). The longest panicle (24.35 cm) was recorded from V_2 which was statistically similar (23.46 cm and 23.20 cm) to V_3 and V_1, whereas the shortest panicle (22.00 cm) was observed from V_4.

Combined effect of different levels of irrigation and rice varieties varied significantly in terms of panicle length of rice (Table 4.2.6). The longest panicle (25.70 cm) was observed from the combination of I_1V_2, while the shortest panicle (21.17 cm) was found from the combination of I_0V_4.

4.2.9 Filled grains panicle^{-1}

Number of filled grains panicle^{-1} of rice varied significantly due to different levels of irrigation (Table 4.2.7). The maximum number of filled grains panicle^{-1} (120.72) was observed from I_1, whereas the minimum number (107.32) from I_0.

Different rice varieties showed significant differences in terms of number of filled grains panicle^{-1} of rice (Table 4.2.7). The maximum number of filled grains panicle^{-1} (119.90) was found from V_2 which was statistically similar (116.10) to V_3 and closely followed (112.57) by V_1, while the minimum number (107.50) was found from V_4. Obulamma *et al.* (2004) recorded highest number of filled grain panicle^{-1} in APHR 2 than DRRH 1 variety.



I_0: No irrigation

I_1: Supplemental irrigation

V_1: BR-14

V_2: BRRI dhan48

V_3: BRRI dhan55

V_4: BRRI dhan65

Figure 4.2.7. Combined effect of different levels of irrigation and selected rice varieties on number of total tillers hill^{-1} in Aus season (Sx = 0.376)

Table 4.2.7. Effect of different levels of irrigation and selected rice varieties on filled, unfilled and total grains panicle^{-1} and weight of 1000 grains in Aus season

Treatments	Filled grains panicle^{-1} (No.)	Unfilled grains panicle^{-1} (No.)	Total grains panicle^{-1} (No.)	Weights of 1000 grains (g)
Levels of irrigation				
I_0	107.32 b	8.43 a	115.75 b	23.81 b
I_1	120.72 a	7.40 b	128.12 a	25.32 a
Sx value	1.805	0.144	1.946	0.210
Level of significance	0.05	0.05	0.05	0.05
CV(%)	5.48	6.28	5.53	2.97
Selected rice varieties				
V_1	112.57 bc	8.17 b	120.73 ab	24.65 b
V_2	119.90 a	7.10 c	127.00 a	24.76 b
V_3	116.10 ab	7.40 c	123.50 a	25.82 a
V_4	107.50 c	9.00 a	116.50 b	23.05 c
Sx value	2.126	0.158	2.076	0.234
Level of significance	0.01	0.01	0.05	0.01
CV(%)	4.57	4.87	4.17	2.33

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

I_0: No irrigation I_1: Supplemental irrigation

V_1: BR-14 V_2: BRRI dhan48

V_3: BRRI dhan55 V_4: BRRI dhan65

Combined effect of different levels of irrigation and rice varieties varied significantly in terms of filled grains panicle^{-1} of rice (Table 4.2.8). The maximum number of filled grains panicle^{-1} (129.80) was found from the combination of I_1V_2 and the minimum number (101.00) was attained from the combination of I_0V_4.

4.2.10 Unfilled grains panicle^{-1}

Number of unfilled grains panicle^{-1} of rice varied significantly due to different levels of irrigation under the present trial (Table 4.2.7). The minimum number of unfilled grains panicle^{-1} (7.40) was recorded from I_1 and the maximum number (8.43) was found from I_0. Haque *et al.* (2015) reported that stagnation of water and continuous 2-5 cm standing water in the field had no significant effect on number of unfilled grains panicle^{-1}.

Different rice varieties showed significant differences in terms of number of unfilled grains panicle^{-1} of rice (Table 4.2.7). The minimum number of unfilled grains panicle^{-1} (7.10) was found from V_2 which was statistically similar (7.40) to V_3, whereas the maximum number (9.00) was observed from V_4 which was closely followed (8.17) by V_1. Hosain *et al.* (2014) reported that varieties Heera2 and Aloron gave the higher spikelet sterility.

Combined effect of different levels of irrigation and rice varieties varied significantly in terms of unfilled grains panicle^{-1} of rice (Table 4.2.8). The minimum number of unfilled grains panicle^{-1} (6.13) was found from the combination of I_1V_2, while the maximum number (9.93) was recorded from the combination of I_0V_4.

4.2.11 Total grains panicle^{-1}

Number of total grains panicle^{-1} of rice varied significantly due to different levels of irrigation (Table 4.2.7). The maximum number of total grains panicle^{-1} (128.12) was observed from I_1, while the minimum number (115.75) was recorded from I_0.

Table 4.2.8. Combined effect of different levels of irrigation and selected rice varieties on filled, unfilled and total grains panicle^{-1} and weight of 1000 grains in Aus season

Treatments combinations	Filled grains panicle^{-1} (No.)	Unfilled grains panicle^{-1} (No.)	Total grains panicle^{-1} (No.)	Weights of 1000 grains (g)
I_0V_1	112.07 b	8.07 b	120.13 bc	23.44 d
I_0V_2	110.00 bc	8.07 b	118.07 bc	23.94 cd
I_0V_3	106.20 bc	7.67 bc	113.87 bc	24.87 bc
I_0V_4	101.00 c	9.93 a	110.93 c	23.00 d
I_1V_1	113.07 b	8.27 b	121.33 b	25.85 ab
I_1V_2	129.80 a	6.13 d	135.93 a	25.58 b
I_1V_3	126.00 a	7.13 c	133.13 a	26.77 a
I_1V_4	114.00 b	8.07 b	122.07 b	23.10 d
Sx value	3.006	0.223	2.935	0.331
Level of significance	0.05	0.01	0.05	0.05
CV (%)	4.57	4.87	4.17	2.33

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

I_0: No irrigation I_1: Supplemental irrigation

V_1: BR-14 V_2: BRRI dhan48

V_3: BRRI dhan55 V_4: BRRI dhan65

Different rice varieties varied significantly in terms of number of total grains panicle^{-1} (Table 4.2.7). The maximum number of total grains panicle^{-1} (127.00) was recorded from V_2 which was statistically similar (123.50 and 120.73) to V_3 and V_1, respectively, whereas the minimum number (116.50) from V_4. Guilani *et al*. (2003) observed that grain number panicle^{-1} was not differ significantly.

Combined effect of different levels of irrigation and rice varieties varied significantly in terms of total grains panicle^{-1} of rice (Table 4.2.8). The maximum number of total grains panicle^{-1} (135.93) was found from the combination of I_1V_2 and the minimum number (110.93) was recorded from the combination of I_0V_4.

4.2.12 Weight of 1000 grains

Weight of 1000 grains of rice varied significantly due to different levels of irrigation (Table 4.2.7). The highest weight of 1000 grains (25.32 g) was recorded from I_1, while the lowest weight (23.81 g) was found from I_0. Haque *et al.* (2015) reported that stagnation water had no significant effect on 1000-grain weight.

Different rice varieties varied significantly in terms of weight of 1000 grains of rice (Table 4.2.7). The highest weight of 1000 grains (25.82 g) was found from V_3 which was followed (24.76 g and 24.65 g) by V_2 and V_1, respectively and they were statistically similar and the lowest weight (23.05 g) from V_4. Wang *et al*. (2006) reported that HYV had heavier seeds compared with conventional.

Combined effect of different levels of irrigation and rice varieties varied significantly in terms of weight of 1000 grains of rice (Table 4.2.8). The highest weight of 1000 grains (26.77 g) was observed from the combination of I_1V_3, whereas the lowest weight (23.00 g) was recorded from the combination of I_0V_4.

4.2.13 Grain yield

Grain yield of rice varied significantly due to different levels of irrigation (Table 4.2.9). The highest grain yield (5.17 t ha^{-1}) was recorded from I_1, while the lowest grain yield (4.44 t ha^{-1}) was found from I_0. Afroja (2004) observed that treatment with 1-7 cm continuous standing water gave the highest yield of 7.39 t ha^{-1}, whereas, treatment with no irrigation gave the lowest yield of 3.98 t ha^{-1}.

Table 4.2.9. Effect of different levels of irrigation and selected rice varieties on grain, straw and biological yield and harvest index in Aus season

Treatments	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
Levels of irrigation				
I_0	4.44 b	5.24 b	9.68 b	45.75
I_1	5.17 a	5.97 a	11.14 a	46.25
Sx value	0.081	0.062	0.129	0.242
Level of significance	0.05	0.01	0.01	NS
CV(%)	5.81	3.14	4.28	1.83
Selected rice varieties				
V_1	5.07 ab	5.89 a	10.97 a	46.19 b
V_2	5.30 a	5.66 a	10.96 a	48.31 a
V_3	4.95 b	5.75 a	10.70 a	46.23 b
V_4	3.90 c	5.13 b	9.02 b	43.26 c
Sx value	0.076	0.091	0.130	0.468
Level of significance	0.01	0.01	0.01	0.01
CV(%)	3.86	3.97	3.05	2.49

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

I_0: No irrigation I_1: Supplemental irrigation

V_1: BR-14 V_2: BRRI dhan48

V_3: BRRI dhan55 V_4: BRRI dhan65

Different rice varieties showed significant differences in terms of grain yield of rice (Table 4.2.9). The highest grain yield (5.30 t ha^{-1}) was observed from V_2 which was statistically similar (5.07 t ha^{-1}) to V_1 and followed (4.95 t ha^{-1}) by V_3, whereas the lowest grain yield (3.90 t ha^{-1}) was found from V_4. Probably the highest grain yield of BRRI dhan48 were attained due to the production of highest number of total tillers plant^{-1}, total dry matter, crop growth rate, number of effective tillers plant^{-1}, panicle length, number of grans panicle^{-1}, 1000 grain weight by this rice variety. Jisan *et al*. (2014) reported that the highest grain yield (5.69 t ha^{-1}) was obtained from BRRI dhan52 followed by BRRI dhan49 (5.15 t ha^{-1}) and the lowest one (4.25 t ha^{-1}) was obtained from BRRI dhan57.

Combined effect of different levels of irrigation and rice varieties varied significantly in terms of grain yield of rice (Table 4.2.10). The highest grain yield (5.69 t ha^{-1}) was recorded from the combination of I_1V_2 and the lowest grain yield (3.59 t ha^{-1}) was found from the combination of I_0V_4.

4.2.14 Straw yield

Straw yield of rice varied significantly due to different levels of irrigation (Table 4.2.9). The highest straw yield (5.97 t ha^{-1}) was observed from I_1, while the lowest straw yield (5.24 t ha^{-1}) was recorded from I_0.

Different rice varieties showed significant differences in terms of straw yield of rice (Table 4.2.9). The highest straw yield (5.89 t ha^{-1}) was found from V_1 which was statistically similar (5.75 t ha^{-1} and 5.66 t ha^{-1}) to V_3 and V_2, respectively, whereas the lowest straw yield (5.13 t ha^{-1}) was observed from V_4. Patel (2000) observed significantly higher grain and straw yield from Kranti than IR36.

Combined effect of different levels of irrigation and rice varieties varied significantly in terms of straw yield of rice (Table 4.2.10). The highest straw yield (6.34 t ha^{-1}) was observed from the combination of I_1V_1 and the lowest straw yield (4.58 t ha^{-1}) was recorded from the combination of I_0V_4.

Table 4.2.10. Combined effect of different levels of irrigation and selected rice varieties on grain, straw and biological yield and harvest index in Aus season

Treatments combinations	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
I_0V_1	4.52 de	5.45 d	9.96 c	45.33 cd
I_0V_2	4.91 bc	5.41 d	10.32 c	47.60 ab
I_0V_3	4.74 cd	5.52 cd	10.26 c	46.16 bc
I_0V_4	3.59 f	4.58 e	8.17 d	43.92 de
I_1V_1	5.63 a	6.34 a	11.97 a	47.05 a-c
I_1V_2	5.69 a	5.91 bc	11.60 ab	49.03 a
I_1V_3	5.16 b	5.98 ab	11.14 b	46.30 bc
I_1V_4	4.21 e	5.67 b-d	9.87 c	42.61 e
Sx value	0.107	0.129	0.183	0.662
Level of significance	0.05	0.01	0.05	0.05
CV (%)	3.86	3.97	3.05	2.49

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

I_0: No irrigation　　I_1: Supplemental irrigation

V_1: BR-14　　V_2: BRRI dhan48

V_3: BRRI dhan55　　V_4: BRRI dhan65

4.2.15 Biological yield

Biological yield of rice varied significantly due to different levels of irrigation (Table 4.2.9). The highest biological yield (11.14 t ha^{-1}) was recorded from I_1 and the lowest biological yield (9.68 t ha^{-1}) was found from I_0.

Different rice varieties showed significant differences in terms of biological yield of rice (Table 4.2.9). The highest biological yield (10.97 t ha^{-1}) was observed from V_1 which was statistically similar (10.96 t ha^{-1} and 10.70 t ha^{-1}) by V_2 and V_3, respectively, while the lowest biological yield (9.02 t ha^{-1}) was found from V_4. Haque *et al*. (2015) reported that greater remobilization of shoot reserves to the grain rendered also higher biological yield of high yielding rice varieties.

Combined effect of different levels of irrigation and rice varieties varied significantly in terms of biological yield of rice (Table 4.2.10). The highest biological yield (11.97 t ha^{-1}) was recorded from the combination of I_1V_1, whereas the lowest biological yield (8.17 t ha^{-1}) was found from the combination of I_0V_1.

4.2.16 Harvest index

Harvest index of rice varied non-significantly due to different levels of irrigation (Table 4.2.9). The highest harvest index (46.25%) was found from I_1, while the lowest harvest index (45.75%) was observed from I_0.

Different rice varieties showed significant differences in terms of harvest index of rice (Table 4.2.9). The highest harvest index (48.31%) was found from V_2 which was followed (46.23% and 46.19%) by V_3 and V_1, respectively and they were statistically similar, whereas the lowest harvest index (43.26%) was observed from V_4. Patel (2000) observed significantly higher harvest index from rice variety Kranti than IR36.

Combined effect of different levels of irrigation and rice varieties varied significantly in terms of harvest index of rice (Table 4.2.10). The highest harvest index (49.03%) was found from the combination of I_1V_2 and the lowest harvest index (42.61%) was observed from the combination of I_1V_4.

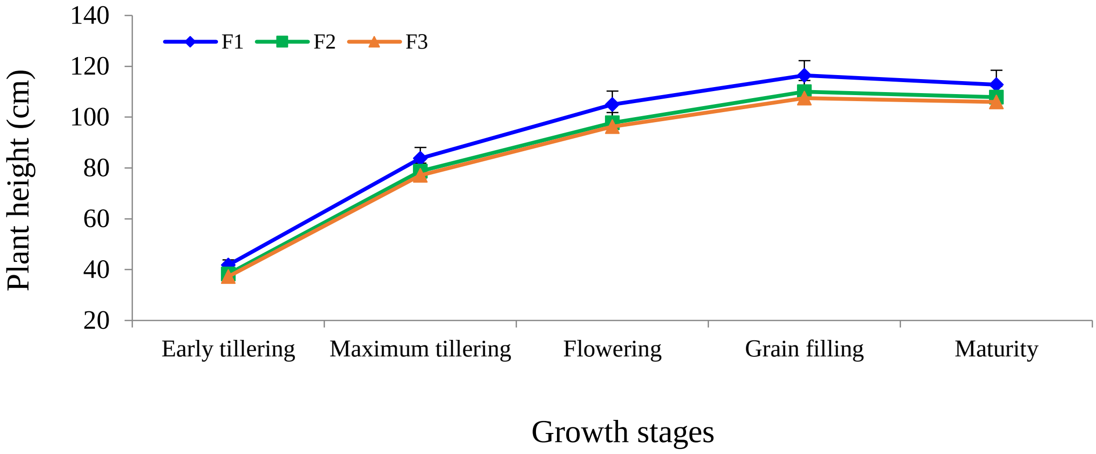
4.3 Experiment-3: Productivity of Aus Rice Varieties Under Different Fertility Regime

The experiment was conducted to find out the productivity of Aus rice varieties under different fertility regime. The analyses of variance (ANOVA) of the data on different parameters are presented in Appendix XV-XX. The results have been presented on tables and graphs and possible interpretations given under the following headings:

4.3.1 Plant height

Different fertility regime showed statistically significant differences in terms of plant height of rice at early tillering stage (ETS), maximum tillering stage (MTS), flowering stage (FS), grain filling stage (GFS) and maturity stage (MS) (Figure 4.3.1). At ETS, MTS, FS, GFS and MS, the tallest plant (41.78, 83.84, 104.95, 116.40 and 112.80 cm, respectively) was recorded from F_1 (Recommended fertilizer dose-RFD), whereas the shortest plants (37.30, 77.04, 96.29, 107.49 and 106.02 cm, respectively) was observed from F_3 (20% less with RFD) which was statistically similar (38.21, 78.79, 97.83, 109.96 and 107.84 cm, respectively) with F_2 (20% added with RFD). It was revealed from the recorded data that recommended fertilizer doses-RFD produced significantly taller plants compared to 20% less and 20% added with RFD. Hossaen *et al*. (2011) reported that recommended fertilizer significantly influence plant height of rice.

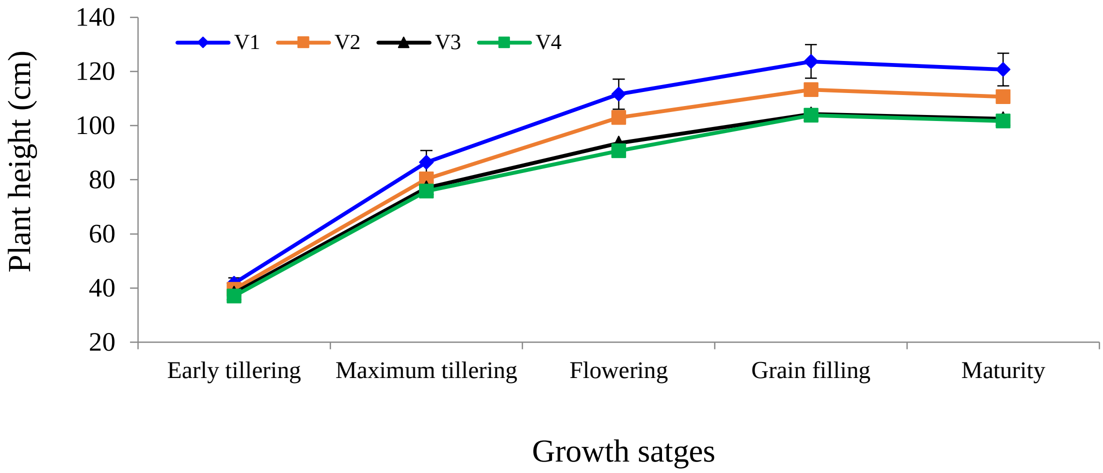
Plant height of rice at ETS, MTS, FS, GFS and MS varied significantly due to different rice varieties (Figure 4.3.2). At ETS, MTS, FS, GFS and MS, the tallest plant (41.73, 86.49, 111.64, 123.72 and 120.71 cm, respectively) was observed from V_1 (BR-14) which was followed (39.56, 80.25, 102.95, 113.28 and 110.66 cm, respectively) by V_2 (BRRI dhan48), while the shortest plant (37.00, 75.84, 90.69, 103.78 and 101.68 cm, respectively) was found from V_4 (BRRI dhan65) which was statistically similar (38.10, 76.99, 93.49, 104.34 and 102.50 cm, respectively) to V_3 (BRRI dhan55). Generally different rice varieties produced different size of plant because plant height is a genetical character and it is



F_1: Recommended fertilizer dose-RFD F_2: 20% added with RFD

F_3: 20% less with RFD

Figure 4.3.1. Effect of different fertilizer regime on plant height of rice at different growth stages in Aus season (Sx = 0.680, 0.839, 1.452, 1.593 and 1.286 at ETS, MTS, FS, GFS and MS, respectively).



V_1: BR-14 V_2: BRRI dhan48

V_3: BRRI dhan55 V_4: BRRI dhan65

Figure 4.3.2. Effect of different selected rice varieties on plant height at different growth stages in Aus season (Sx = 0.626, 1.335, 1.349, 1.857 and 1.633 at ETS, MTS, FS, GFS and MS, respectively).

controlled by the genetic make up of the specific varieties. Jisan *et al*. (2014) BRRI dhan52 produced the tallest plant (117.20 cm), whereas the lowest plant height by BRRI dhan57.

Statistically significant variation was recorded in terms of plant height of rice at ETS, MTS, FS, GFS and MS due to the combined effect of different fertility regime and rice varieties (Table 4.3.1). At ETS, MTS, FS, GFS and MS, the tallest plant (44.02, 89.59, 113.39, 129.05 and 124.49 cm, respectively) was found from the combination of F_1V_1 (Recommended dose of fertilizers-RFD and BR-14), whereas the shortest plant (33.86, 71.11, 84.44, 100.48 and 100.03 cm, respectively) was found from the combination of F_3V_4 (20% less with RFD and BRRI dhan65).

4.3.2 Number of tillers hill^{-1}

Number of tillers hill^{-1} of rice at early tillering stage (ETS), maximum tillering stage (MTS), flowering stage (FS), grain filling stage (GFS) and maturity stage (MS) varied significantly due to different fertility regime (Table 4.3.2). At ETS, MTS, FS and GFS, the maximum number of tiller hill^{-1} (6.70, 14.98, 16.67 and 16.37, respectively) was found from F_1, while the minimum number (6.02, 13.05, 13.75 and 13.47, respectively) was recorded from F_3 which was statistically similar (6.18, 13.42, 14.73 and 14.32 cm, respectively) to F_2. Hossain (2013) reported that number of tillers hill^{-1} varied for different fertility regime.

Different rice varieties showed significant differences in terms of number of tiller hill^{-1} of rice at ETS, MTS, FS and GFS (Table 4.3.2). At ETS, MTS, FS and GFS, the maximum number of tiller hill^{-1} (6.71, 14.76, 16.02 and 15.60, respectively) was recorded from V_2 which was statistically similar (6.47, 13.73, 15.20 and 14.87, respectively) to V_3, whereas the minimum number (5.69, 13.24, 14.31 and 14.09, respectively) was observed from V_4 which was statistically similar (6.33, 13.53, 14.67 and 14.31, respectively) to V_1.

Table 4.3.1. Combined effect of different fertility regime and selected rice varieties on plant height (cm) at different growth stages in Aus season

Treatments combinations	Growth stage				
	Early tillering (ETS)	Maximum tillering (MTS)	Flowering (FS)	Grain filling (GFS)	Maturity (MS)
F_1V_1	44.02 a	89.59 a	113.39 a	129.05 a	124.49 a
F_1V_2	42.88 ab	87.75 ab	110.57 a	126.41 a	122.81 a
F_1V_3	39.49 b-e	81.05 b-d	98.69 b	105.98 b	102.87 b
F_1V_4	40.74 a-d	76.97 d-f	97.15 bc	104.15 b	101.04 b
F_2V_1	38.96 c-f	83.12 a-d	109.92 a	119.63 a	117.43 a
F_2V_2	38.17 d-f	75.87 d-f	96.64 bc	107.59 b	105.53 b
F_2V_3	39.31 c-e	76.72 d-f	94.31 b-d	105.91 b	104.45 b
F_2V_4	36.39 f-g	79.43 c-e	90.47 c-e	106.71 b	103.96 b
F_3V_1	42.22 a-c	86.76 a-c	111.61 a	122.49 a	120.21 a
F_3V_2	37.63 d-f	77.12 d-f	101.64 b	105.85 b	103.65 b
F_3V_3	35.50 fg	73.19 ef	87.47 de	101.12 b	100.18 b
F_3V_4	33.86 g	71.11 f	84.44 e	100.48 b	100.03 b
Sx value	1.084	2.313	2.336	3.217	2.829
Level of significance	0.05	0.05	0.05	0.05	0.05
CV(%)	4.80	5.01	4.06	5.01	4.50

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

F_1: Recommended fertilizer dose-RFD

F_2: 20% added with RFD

F_3: 20% less with RFD

V_1: BR-14

V_2: BRRI dhan48

V_3: BRRI dhan55

V_4: BRRI dhan65

Table 4.3.2. Effect of different fertility regime and selected rice varieties on number of total tillers hill^{-1} at different growth stages in Aus season

Treatments	Growth stage			
	Early tillering (ETS)	Maximum tillering (MTS)	Flowering (FS)	Grain filling (GFS)
Fertility regime				
F_1	6.70 a	14.98 a	16.67 a	16.37 a
F_2	6.18 b	13.42 b	14.73 b	14.32 ab
F_3	6.02 b	13.05 b	13.75 b	13.47 b
Sx value	0.120	0.356	0.448	0.533
Level of significance	0.05	0.05	0.05	0.05
CV(%)	6.60	8.91	10.32	12.53
Selected rice varieties				
V_1	6.33 b	13.53 b	14.67 b	14.31 b
V_2	6.71 a	14.76 a	16.02 a	15.60 a
V_3	6.47 a	13.73 a	15.20 ab	14.87 ab
V_4	5.69 b	13.24 b	14.31 b	14.09 b
Sx value	0.140	0.253	0.292	0.311
Level of significance	0.01	0.01	0.01	0.01
CV(%)	6.69	5.49	5.82	6.35

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

F_1: Recommended fertilizer dose-RFD

F_2: 20% added with RFD

F_3: 20% less with RFD

V_1: BR-14

V_2: BRRI dhan48

V_3: BRRI dhan55

V_4: BRRI dhan65

Combined effect of different fertility regime and rice varieties varied significantly in terms of number of tiller hill^{-1} of rice at ETS, MTS, FS and GFS (Table 4.3.3). At ETS, MTS, FS and GFS, the maximum number of tiller hill^{-1} (7.47, 15.80, 17.53 and 17.20, respectively) was observed from the combination of F_1V_2 and the minimum number (5.60, 12.00, 12.33 and 12.13, respectively) was found from the combination of F_3V_4.

4.3.3 Total dry matter

Total dry matter of rice at early tillering stage (ETS), maximum tillering stage (MTS), flowering stage (FS), grain filling stage (GFS) and maturity stage (MS) varied significantly due to different fertility regime (Figure 4.3.3). At ETS, MTS, FS and GFS, the highest total dry matter (169.48, 526.06, 668.71 and 819.09 g m^{-2}, respectively) was observed from F_1, which was statistically similar (162.43, 516.67, 659.02 and 808.09 g m^{-2}) to F_2, while the lowest (150.31, 462.79, 530.72 and 676.65 g m^{-2}, respectively) was recorded from F_3.

Different rice varieties showed significant differences in terms of total dry matter of rice at ETS, MTS, FS and GFS (Figure 4.3.4). At ETS, MTS, FS and GFS, the highest total dry matter (168.61, 533.68, 696.65 and 805.66 g m^{-2}, respectively) was found from V_2 which was statistically similar (164.23, 507.28, 619.53 and 773.11 g m^{-2}, respectively) to V_3, whereas the lowest (149.98, 462.30, 557.53 and 731.17 g m^{-2}, respectively) was observed from V_4 which was followed (160.14, 504.09, 604.21 and 761.84 g m^{-2}, respectively) by V_1. Xie *et al.* (2007) found that total dry matter of BRRI dhan44 significantly varied at different sampling dates.

Combined effect of different fertility regime and rice varieties varied significantly in terms of total dry matter of rice at ETS, MTS, FS and GFS (Table 4.3.4). At ETS, MTS, FS and GFS, the highest total dry matter (185.02, 552.38, 746.27 and 878.23 g m^{-2}, respectively) was observed from the combination of F_1V_2 and the lowest (133.86, 422.69, 453.87 and 568.75 g m^{-2}, respectively) was recorded from the combination of F_2V_4.

Table 4.3.3. Combined effect of different fertility regime and selected rice varieties on number of total tillers hill^{-1} at different growth stages in Aus season

Treatments combinations	Growth stage			
	Early tillering (ETS)	Maximum tillering (MTS)	Flowering (FS)	Grain filling (GFS)
F_1V_1	6.27 bc	14.87 ab	16.60 a-c	16.13 ab
F_1V_2	7.47 a	15.80 a	17.53 a	17.20 a
F_1V_3	7.33 a	15.73 a	17.07 ab	16.93 a
F_1V_4	5.73 bc	13.53 b-d	15.47 b-d	15.20 b
F_2V_1	6.27 bc	12.07 e	12.80 f	12.47 d
F_2V_2	6.40 bc	14.27 bc	15.60 b-d	15.07 b
F_2V_3	6.33 bc	13.13 c-e	15.40 cd	14.80 b
F_2V_4	5.73 bc	14.20 bc	15.13 cd	14.93 b
F_3V_1	6.47 b	13.67 b-d	14.60 de	14.33 bc
F_3V_2	6.27 bc	14.20 bc	14.93 cd	14.53 bc
F_3V_3	5.73 bc	12.33 de	13.13 ef	12.87 cd
F_3V_4	5.60 c	12.00 e	12.33 f	12.13 d
Sx value	0.243	0.438	0.506	0.539
Level of significance	0.05	0.01	0.01	0.01
CV(%)	6.69	5.49	5.82	6.35

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

F_1: Recommended fertilizer dose-RFD

F_2: 20% added with RFD

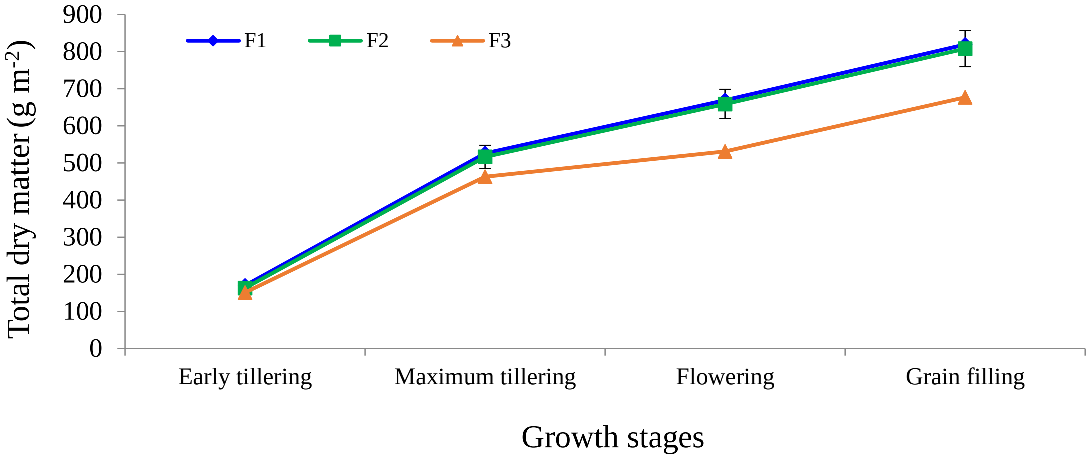
F_3: 20% less with RFD

V_1: BR-14

V_2: BRRI dhan48

V_3: BRRI dhan55

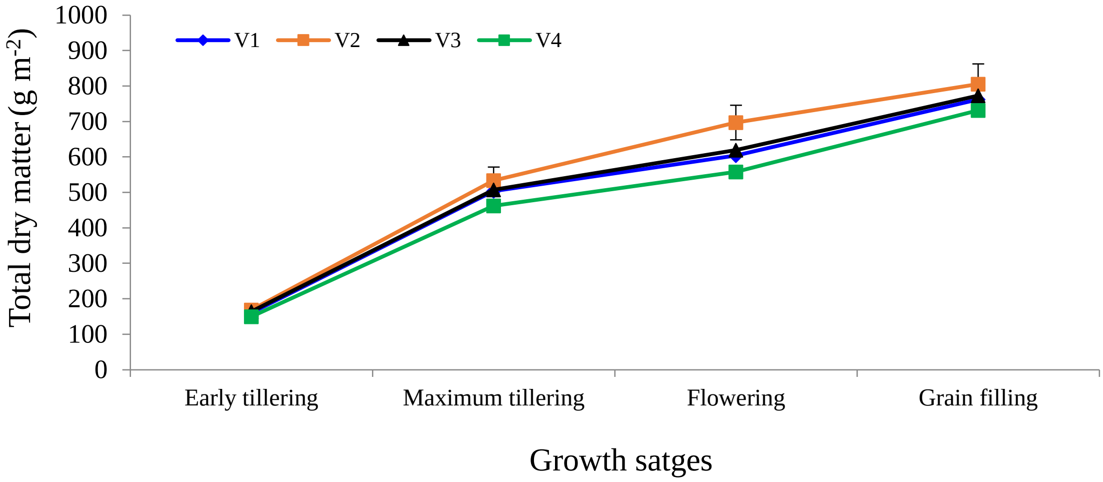
V_4: BRRI dhan65



F_1: Recommended fertilizer dose-RFD F_2: 20% added with RFD

F_3: 20% less with RFD

Figure 4.3.3. Effect of different fertilizer regime on total dry matter of rice at different growth stages in Aus season (Sx = 2.999, 11.89, 9.383 and 15.97 at ETS, MTS, FS and GFS, respectively).



V_1: BR-14; V_2: BRRI dhan48;

V_3: BRRI dhan55; V_4: BRRI dhan65;

Figure 4.3.4. Effect of different selected rice varieties on total dry matter at different growth stages in Aus season (Sx = 3.329, 7.692, 12.95 and 14.57 at ETS, MTS, FS and GFS, respectively).

Table 4.3.4. Combined effect of different fertility regime and selected rice varieties on total dry matter-TDM (g m^{-2}) at different growth stages in Aus season

Treatments combinations	Growth stage			
	Early tillering (ETS)	Maximum tillering (MTS)	Flowering (FS)	Grain filling (GFS)
F_1V_1	167.13 ab	537.20 ab	648.28 b-d	733.57 c
F_1V_2	182.54 a	552.38 a	746.27 a	878.23 a
F_1V_3	185.02 a	549.83 a	715.33 ab	864.10 ab
F_1V_4	143.25 c	464.82 cd	564.94 e	800.45 b
F_2V_1	138.60 c	483.74 c	573.23 de	722.34 c
F_2V_2	171.74 a	548.26 a	738.70 a	850.13 ab
F_2V_3	166.55 ab	535.27 ab	670.34 a-c	835.60 ab
F_2V_4	172.82 a	499.40 bc	653.79 b-d	824.31 ab
F_3V_1	174.70 a	491.33 c	591.12 c-e	829.60 ab
F_3V_2	151.56 bc	500.39 bc	604.99 c-e	688.61 c
F_3V_3	141.13 c	436.73 de	472.92 f	619.63 d
F_3V_4	133.86 c	422.69 e	453.87 f	568.75 d
Sx value	5.766	13.32	25.23	22.43
Level of significance	0.01	0.01	0.01	0.01
CV(%)	6.21	4.60	7.06	5.06

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

F_1: Recommended fertilizer dose-RFD

F_2: 20% added with RFD

F_3: 20% less with RFD

V_1: BR-14

V_2: BRRI dhan48

V_3: BRRI dhan55

V_4: BRRI dhan65

4.3.4 Crop duration

Crop duration of rice varied significantly due to different fertility regime (Figure 4.3.5). The maximum crop duration (116.92 days) was observed from F_2 and the minimum crop duration (106.50 days) was recorded from F_1 which was statistically similar (107.17 days) to F_3.

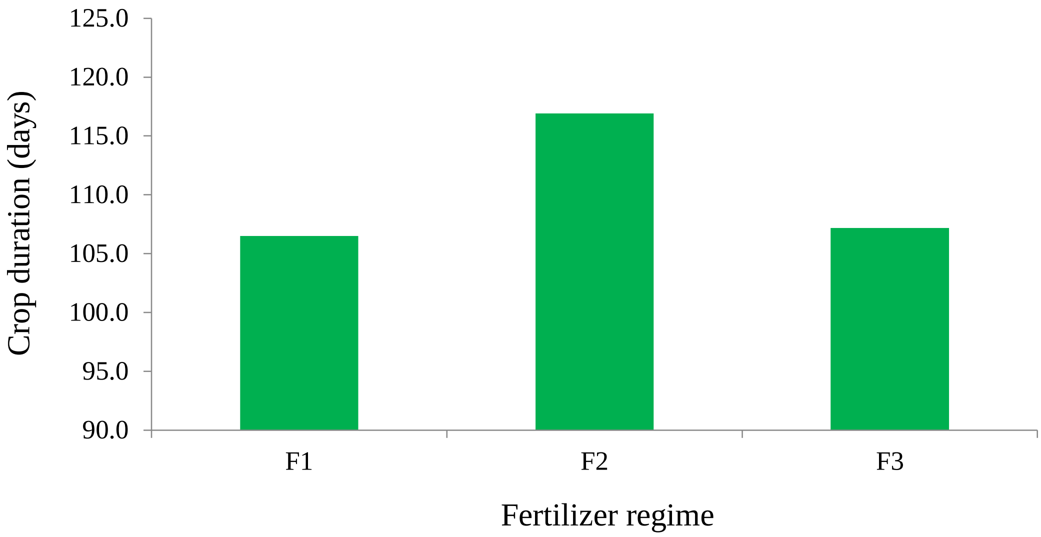
Different rice varieties showed significant differences in terms of crop duration of rice (Figure 4.3.6). Data revealed that the maximum crop duration (121.00 days) was found from V_1 which was followed (110.44 days) by V_2, whereas the minimum crop duration (103.78 days) was observed from V_4 which was statistically similar (105.56 days) to V_3.

Combined effect of different fertility regime and rice varieties varied significantly in terms of crop duration of rice (Figure 4.3.7). The maximum crop duration (124.67 days) was observed from the combination of F_2V_1 and the minimum crop duration (100.67 days) was recorded from the combination of F_2V_3.

4.3.5 Number of effective tillers hill^{-1}

Number of effective tillers hill^{-1} of rice varied significantly due to different fertility regime (Table 4.3.5). The maximum number of effective tillers hill^{-1} (14.42) was found from F_1, while the minimum number (11.55) was observed from F_3 which was statistically similar (11.85) to F_2.

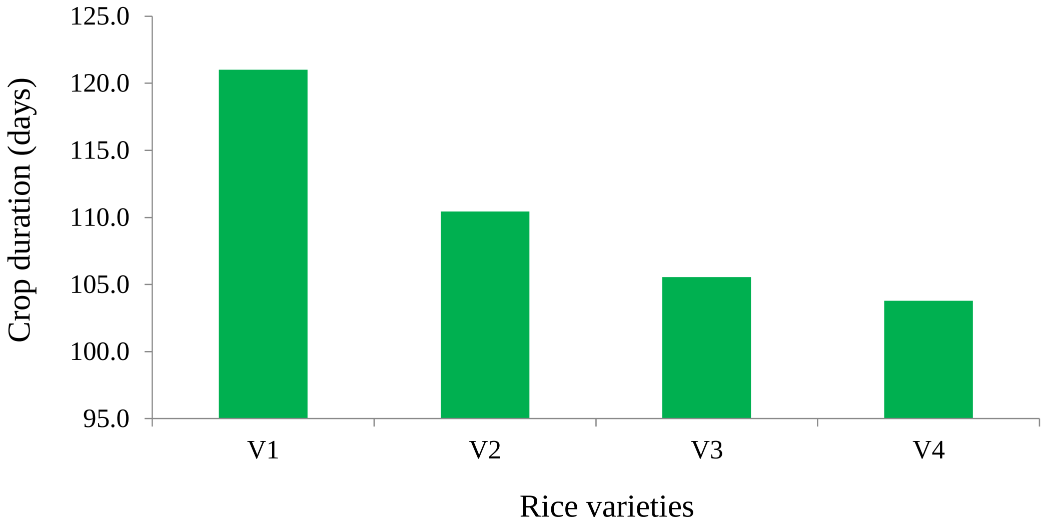
Different rice varieties showed significant differences in terms of number of effective tillers hill^{-1} of rice (Table 4.3.5). The maximum number of effective tillers hill^{-1} (13.62) was observed from V_2 which was followed (12.82 and 12.16) by V_3 and V_1, respectively and they were statistically similar, whereas the minimum number (11.82) was recorded from V_4. Masum *et al*. (2008) reported that BRRI dhan52 produced the highest number of effective tillers hill^{-1} (11.28), while the lowest values of these parameters were produced by BRRI dhan57.



F_1: Recommended fertilizer dose-RFD F_2: 20% added with RFD

F_3: 20% less with RFD

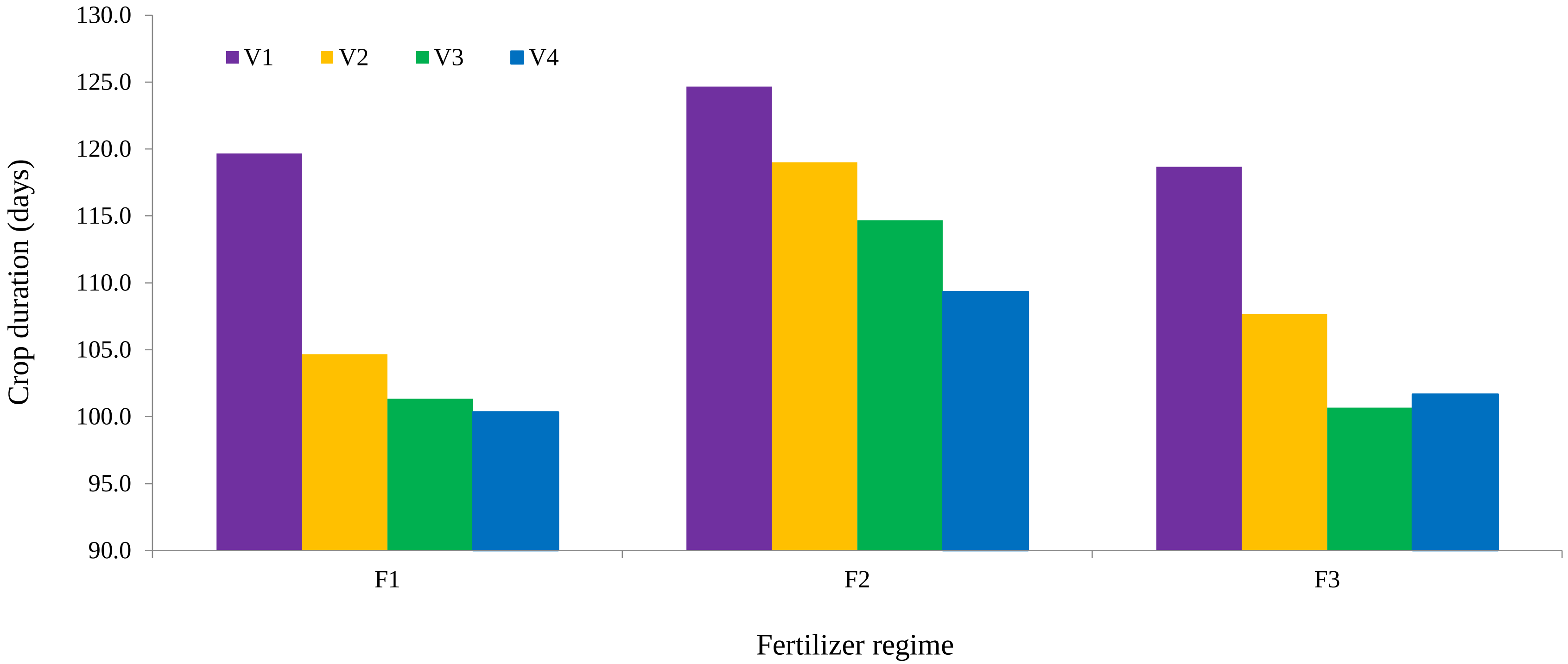
Figure 4.3.5. Effect of different fertilizer regime on crop duration in Aus season (Sx = 1.111).



V_1: BR-14 V_2: BRRI dhan48

V_3: BRRI dhan55 V_4: BRRI dhan65

Figure 4.3.6. Effect of different selected rice varieties on crop duration in Aus season (Sx = 0.923).



F_1: Recommended fertilizer dose-RFD F_2: 20% added with RFD V_1: BR-14 V_2: BRRI dhan48

F_3: 20% less with RFD V_3: BRRI dhan55 V_4: BRRI dhan65

Figure 4.3.7. Combined effect of different fertilizer regime and selected rice varieties on crop duration in Aus season (Sx = 1.599).

Combined effect of different fertility regime and rice varieties varied significantly in terms of number of effective tillers hill^{-1} of rice (Table 4.3.6). The maximum number of effective tillers hill^{-1} (15.33) was recorded from the combination of F_1V_2 and the minimum number (10.27) was found from the combination of F_3V_4.

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

Number of non-effective tillers hill^{-1} of rice varied significantly due to different fertility regime (Table 4.3.5). The minimum number of non-effective tillers hill^{-1} (1.90) was observed from F_1 which was statistically similar (2.13) to F_3, whereas the maximum number (2.50) was recorded from F_2.

Different rice varieties showed significant differences in terms of number of non-effective tillers hill^{-1} of rice (Table 4.3.5). The minimum number of non-effective tillers hill^{-1} (2.00) was found from V_2 which was similar (2.13) to V_3, while the maximum number (2.33) was observed from V_4 which was statistically similar (2.24) to V_1.

Combined effect of different fertility regime and rice varieties varied significantly in terms of number of non-effective tillers hill^{-1} of rice (Table 4.3.6). The minimum number of non-effective tillers hill^{-1} (1.67) was found from the combination of F_1V_2, whereas the maximum number (3.20) was recorded from the combination of F_2V_4.

4.3.7 Number of total tillers hill^{-1}

Number of total tillers hill^{-1} of rice varied significantly due to different fertility regime (Table 4.3.5). The maximum number of total tillers hill^{-1} (16.32) was observed from F_1 and the minimum number (13.68) was recorded from F_3 which was statistically similar (14.35) to F_2. Vetayasuporn (2012) reported that maximum number of total panicle hill^{-1} (14.82) from RFD-chemical fertilizer.

Table 4.3.5. Effect of different fertility regime and selected rice varieties on effective, non-effective and total tillers hill^{-1} and panicle length in Aus season

Treatments	Effective tillers hill^{-1} (No.)	Non-effective tillers hill^{-1} (No.)	Total tillers hill^{-1} (No.)	Panicle length (cm)
Fertility regime				
F_1	14.42 a	1.90 b	16.32 a	24.44 a
F_2	11.85 b	2.50 a	14.35 b	23.50 ab
F_3	11.55 b	2.13 b	13.68 b	22.70 b
Sx value	0.532	0.067	0.497	0.282
Level of significance	0.05	0.01	0.05	0.05
CV(%)	14.61	10.57	11.65	4.14
Selected rice varieties				
V_1	12.16 bc	2.24 a	14.40 bc	23.75 ab
V_2	13.62 a	2.00 b	15.62 a	24.33 a
V_3	12.82 b	2.13 ab	14.96 ab	23.55 ab
V_4	11.82 c	2.33 a	14.16 c	22.56 b
Sx value	0.258	0.075	0.244	0.394
Level of significance	0.01	0.05	0.01	0.05
CV(%)	6.13	10.31	4.95	5.02

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

F_1: Recommended fertilizer dose-RFD

F_2: 20% added with RFD

F_3: 20% less with RFD

V_1: BR-14

V_2: BRRI dhan48

V_3: BRRI dhan55

V_4: BRRI dhan65

Table 4.3.6. Effect of different fertility regime and selected rice varieties on effective, non-effective and total tillers hill^{-1} and panicle length in Aus season

Treatments combinations	Effective tillers hill^{-1} (No.)	Non-effective tillers hill^{-1} (No.)	Total tillers hill^{-1} (No.)	Panicle length (cm)
F_1V_1	14.00 ab	2.20 b-e	16.20 ab	24.65 a-c
F_1V_2	15.33 a	1.67 f	17.00 a	25.78 a
F_1V_3	15.00 a	1.87 ef	16.87 a	24.92 ab
F_1V_4	13.33 bc	1.87 ef	15.20 bc	22.43 c-e
F_2V_1	10.33 e	2.07 b-f	12.40 d	22.21 de
F_2V_2	12.87 bc	2.33 b-d	15.20 bc	24.28 a-d
F_2V_3	12.33 cd	2.40 bc	14.73 c	23.97 a-e
F_2V_4	11.87 cd	3.20 a	15.07 bc	23.54 a-e
F_3V_1	12.13 cd	2.47 b	14.60 c	24.39 a-d
F_3V_2	12.67 bc	2.00 c-f	14.67 c	22.94 b-e
F_3V_3	11.13 de	2.13 b-e	13.27 d	21.75 e
F_3V_4	10.27 e	1.93 d-f	12.20 d	21.71 e
Sx value	0.447	0.129	0.422	0.683
Level of significance	0.05	0.01	0.01	0.05
CV(%)	6.13	10.31	4.95	5.02

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

F_1: Recommended fertilizer dose-RFD

F_2: 20% added with RFD

F_3: 20% less with RFD

V_1: BR-14

V_2: BRRI dhan48

V_3: BRRI dhan55

V_4: BRRI dhan65

Different rice varieties showed significant differences in terms of number of total tillers hill^{-1} of rice (Table 4.3.5). The maximum number of total tillers hill^{-1} (15.62) was found from V_2 which was statistically similar (14.96) to V_3. On the other hand, the minimum number (14.16) was observed from V_4 which was statistically similar (14.40) to V_1. Masum *et al*. (2008) reported that in the case of BRRI dhan44, maximum (18.92) tiller production was observed around panicle initiation stage at 60 DAT.

Combined effect of different fertility regime and rice varieties varied significantly in terms of number of total tillers hill^{-1} of rice (Table 4.3.6). The maximum number of total tillers hill^{-1} (17.00) was observed from the combination of F_1V_2 and the minimum number (12.20) was recorded from the combination of F_3V_4.

4.3.8 Panicle length

Panicle length of rice varied significantly due to different fertility regime (Table 4.3.5). The longest panicle (24.44 cm) was recorded from F_1 which was statistically similar (23.50 cm) to F_2, while the shortest panicle (22.70 cm) was found from F_3.

Different rice varieties showed significant differences in terms of panicle length of rice (Table 4.3.5). The longest panicle (24.33 cm) was observed from V_2 which was statistically similar (23.75 cm and 23.55 cm) to V_1 and V_3, respectively, whereas the shortest panicle (22.56 cm) was recorded from V_4. Shaloie *et al*. (2014) reported that traits was significantly affected in terms of panicle length.

Combined effect of different fertility regime and rice varieties varied significantly in terms of panicle length of rice (Table 4.3.6). The longest panicle (25.78 cm) was observed from the combination of F_1V_2, while the shortest panicle (21.71 cm) was recorded from the combination of F_3V_4.

4.3.9 Filled grains panicle^{-1}

Number of filled grains panicle^{-1} of rice varied significantly due to different fertility regime (Table 4.3.7). The maximum number of filled grains panicle^{-1} (122.33) was observed from F_1 which was followed (116.98) by F_2, whereas the minimum number (110.78) was recorded from F_3.

Different rice varieties showed significant differences in terms of number of filled grains panicle^{-1} of rice (Table 4.3.7). The maximum number of filled grains panicle^{-1} (123.09) was found from V_2 which was statistically similar (118.89) to V_3, while the minimum number (111.00) was observed from V_4 which was statistically similar (113.82) to V_1. Haque and Biswash (2014) reported that number of filled grains panicle^{-1} was the highest for BRRI dhan29 (163.3), whereas, Jagoron only 118.

Combined effect of different fertility regime and rice varieties varied significantly in terms of filled grains panicle^{-1} of rice (Table 4.3.8). The maximum number of filled grains panicle^{-1} (129.40) was observed from the combination of F_1V_2, whereas the minimum number (101.53) was recorded from the combination of F_3V_4.

4.3.10 Unfilled grains panicle^{-1}

Number of unfilled grains panicle^{-1} of rice varied significantly due to different fertility regime (Table 4.3.7). The minimum number of unfilled grains panicle^{-1} (7.52) was observed from F_1 which was followed (8.40) by F_2, while the maximum number (9.03) was recorded from F_3.

Different rice varieties showed significant differences in terms of number of unfilled grains panicle^{-1} of rice (Table 4.3.7). The minimum number of unfilled grains panicle^{-1} (7.89) was found from V_4, whereas the maximum number (8.60) was observed from V_2 which was statistically similar (8.42 and 8.36) by V_3 and V_1, respectively.

Table 4.3.7. Effect of different fertility regime and selected rice varieties on filled, unfilled and total grains panicle^{-1} and weight of 1000 grains in Aus season

Treatments	Filled grains panicle^{-1} (No.)	Unfilled grains panicle^{-1} (No.)	Total grains panicle^{-1} (No.)	Weights of 1000 grains (g)
Fertility regime				
F_1	122.33 a	7.52 c	129.85 a	25.27
F_2	116.98 b	8.40 b	125.38 b	24.60
F_3	110.78 c	9.03 a	119.82 c	24.34
Sx value	0.799	0.101	0.770	0.583
Level of significance	0.01	0.01	0.01	NS
CV(%)	2.37	4.20	2.17	8.17
Selected rice varieties				
V_1	113.82 b	8.36 ab	122.18 b	24.49 b
V_2	123.09 a	8.60 a	131.69 a	24.66 ab
V_3	118.89 a	8.42 a	127.31 a	26.10 a
V_4	111.00 b	7.89 b	118.89 b	23.68 b
Sx value	1.615	0.158	1.575	0.486
Level of significance	0.01	0.05	0.01	0.05
CV(%)	4.15	5.70	3.78	5.90

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

F_1: Recommended fertilizer dose-RFD

F_2: 20% added with RFD

F_3: 20% less with RFD

V_1: BR-14

V_2: BRRI dhan48

V_3: BRRI dhan55

V_4: BRRI dhan65

Table 4.3.8. Combined effect of different fertility regime and selected rice varieties on filled, unfilled and total grains panicle^{-1} and weight of 1000 grains in Aus season

Treatments combinations	Filled grains panicle^{-1} (No.)	Unfilled grains panicle^{-1} (No.)	Total grains panicle^{-1} (No.)	Weights of 1000 grains (g)
F_1V_1	116.80 c-e	7.60 e	124.40 cd	26.32 a
F_1V_2	129.40 a	8.07 c-e	137.47 a	24.11 a-c
F_1V_3	126.40 ab	7.87 de	134.27 ab	26.40 a
F_1V_4	116.73 c-e	6.53 f	123.27 cd	24.24 a-c
F_2V_1	110.87 de	8.00 c-e	118.87 d	22.56 bc
F_2V_2	119.93 b-d	8.47 b-e	128.40 bc	24.77 ab
F_2V_3	122.40 a-c	8.60 a-d	131.00 a-c	26.04 a
F_2V_4	114.73 c-e	8.53 b-d	123.27 cd	25.02 ab
F_3V_1	113.80 c-e	9.47 a	123.27 cd	24.57 ab
F_3V_2	119.93 b-d	9.27 ab	129.20 a-c	25.11 ab
F_3V_3	107.87 ef	8.80 a-c	116.67 de	25.87 a
F_3V_4	101.53 f	8.60 a-d	110.13 e	21.79 c
Sx value	2.797	0.274	2.727	0.842
Level of significance	0.05	0.05	0.05	0.05
CV(%)	4.15	5.70	3.78	5.90

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

F_1: Recommended fertilizer dose-RFD

F_2: 20% added with RFD

F_3: 20% less with RFD

V_1: BR-14

V_2: BRRI dhan48

V_3: BRRI dhan55

V_4: BRRI dhan65

Combined effect of different fertility regime and rice varieties varied significantly in terms of unfilled grains panicle^{-1} of rice (Table 4.3.8). The minimum number of unfilled grains panicle^{-1} (6.53) was found from the combination of F_1V_4 and the maximum number (9.47) was recorded from the combination of F_2V_1.

4.3.11 Total grains panicle^{-1}

Number of total grains panicle^{-1} of rice varied significantly due to different fertility regime (Table 4.3.7). The maximum number of total grains panicle^{-1} (129.85) was recorded from F_1 which was closely followed (125.38) by F_2 and the minimum number (119.82) was found from F_3. Vetayasuporn (2012) reported that maximum number of grain per panicle (108.20) from RFD-chemical fertilizer.

Different rice varieties showed significant differences in terms of number of total grains panicle^{-1} of rice (Table 4.3.7). The maximum number of total grains panicle^{-1} (131.69) was found from V_2 which was statistically similar (127.31) to V_3, while the minimum number (118.89) was observed from V_4 which was statistically similar (122.18) to V_1. Haque and Biswash (2014) reported from earlier that number of total grains was highest in BRRI dhan29 (201.7) and for Jagoron it was 133.7 only.

Combined effect of different fertility regime and rice varieties showed statistically significant differences in terms of total grains panicle^{-1} of rice (Table 4.3.8). The maximum number of total grains panicle^{-1} (137.47) was observed from the combination of F_1V_2, whereas the minimum number (110.13) was recorded from the combination of F_3V_4.

4.3.12 Weight of 1000 grains

Weight of 1000 grains of rice varied non-significantly due to different fertility regime (Table 4.3.7). The highest weight of 1000 grains (25.27 g) was observed from F_1, while the lowest weight (24.34 g) was recorded from F_3.

Different rice varieties showed significant differences in terms of weight of 1000 grains of rice (Table 4.3.7). The highest weight of 1000 grains (26.10 g) was found from V_3 which was statistically similar (24.66 g) to V_2, whereas the lowest weight (23.68 g) was observed from V_4 which was statistically similar (24.49 g) to V_1. Jisan *et al*. (2014) reported that among the varieties, BRRI dhan52 produced the highest 1000-grain weight (23.65 g), whereas the lowest values of these parameters was produced by BRRI dhan57.

Combined effect of different fertility regime and rice varieties varied significantly in terms of weight of 1000 grains of rice (Table 4.3.8). The highest weight of 1000 grains (26.40 g) was observed from the combination of F_1V_3 and the lowest weight (21.79 g) was recorded from the combination of F_3V_4.

4.3.13 Grain yield

Grain yield of rice varied significantly due to different fertility regime (Table 4.3.9). The highest grain yield (5.23 t ha^{-1}) was recorded from F_1 which was statistically similar (4.95 t ha^{-1}) to F_2, while the lowest grain yield (4.41 t ha^{-1}) was observed from F_3. Vetayasuporn (2012) reported that maximum grain yield (5.57 t ha^{-1}) was obtained from RFD-chemical fertilizer which also gave the highest all yield parameters such as number of grain $panicle^{-1}$, total number panicle per hill, plant height and percentage of filled grain. Basu *et al*. (2012) reported that the highest grain yield was observed in treatment containing the full recommended dose of chemical fertilizers along with the double dose of cowdung (F_1M_3) and it was the lowest in without chemical fertilizers and recommended dose of cowdung (F_0M_1).

Different rice varieties showed significant differences in terms of grain yield of rice (Table 4.3.9). The highest grain yield (5.40 t ha^{-1}) was observed from V_2 which was followed (5.10 t ha^{-1} and 5.01 t ha^{-1}) by V_1 and V_3, respectively and they were statistically similar, whereas the lowest grain yield (3.95 t ha^{-1}) was found from V_4. Hosain *et al*. (2014) reported that BRRI dhan48 produced the highest grain yield (5.51 t ha^{-1}).

Table 4.3.9. Effect of different fertility regime and selected rice varieties on grain, straw and biological yield and harvest index in Aus season

Treatments	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
<u>Fertility regime</u>				
F_1	5.23 a	6.09 a	11.32 a	46.05
F_2	4.95 a	5.82 b	10.77 b	45.86
F_3	4.41 b	5.04 c	9.46 c	46.56
Sx value	0.074	0.040	0.104	0.305
Level of significance	0.01	0.01	0.01	NS
CV(%)	5.24	2.44	3.42	2.29
<u>Selected rice varieties</u>				
V_1	5.10 b	5.91 a	11.01 a	46.33 b
V_2	5.40 a	5.70 a	11.10 a	48.59 a
V_3	5.01 b	5.82 a	10.83 a	46.28 b
V_4	3.95 c	5.16 b	9.11 b	43.43 c
Sx value	0.099	0.104	0.193	0.307
Level of significance	0.01	0.01	0.01	0.01
CV(%)	6.08	5.52	5.52	1.99

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

F_1: Recommended fertilizer dose-RFD

F_2: 20% added with RFD

F_3: 20% less with RFD

V_1: BR-14

V_2: BRRI dhan48

V_3: BRRI dhan55

V_4: BRRI dhan65

Combined effect of different fertility regime and rice varieties varied significantly in terms of grain yield of rice (Table 4.3.10). The highest grain yield (5.85 t ha^{-1}) was found from the combination of F_1V_2 and the lowest grain yield (3.49 t ha^{-1}) was observed from the combination of F_3V_4.

4.3.14 Straw yield

Straw yield of rice varied significantly due to different fertility regime (Table 4.3.9). The highest straw yield (6.09 t ha^{-1}) was observed from F_1 which was followed (5.82 t ha^{-1}) to F_2, while the lowest straw yield (5.04 t ha^{-1}) was recorded from F_3.

Different rice varieties showed significant differences in terms of straw yield of rice (Table 4.3.9). The highest straw yield (5.91 t ha^{-1}) was found from V_1 which was statistically similar (5.82 t ha^{-1} and 5.70 t ha^{-1}) to V_3 and V_2, whereas the lowest straw yield (5.16 t ha^{-1}) was observed from V_4.

Combined effect of different fertility regime and rice varieties varied significantly in terms of straw yield of rice (Table 4.3.10). The highest straw yield (6.71 t ha^{-1}) was observed from the combination of F_1V_3 and the lowest straw yield (4.34 t ha^{-1}) was recorded from the combination of F_3V_4.

4.3.15 Biological yield

Biological yield of rice varied significantly due to different fertility regime (Table 4.3.9). The highest biological yield (11.32 t ha^{-1}) was found from F_1 which was followed (10.77 t ha^{-1}) by F_2 and the lowest biological yield (9.46 t ha^{-1}) was recorded from F_3.

Different rice varieties showed significant differences in terms of biological yield of rice (Table 4.3.9). The highest biological yield (11.10 t ha^{-1}) was observed from V_2 which was statistically similar (11.01 t ha^{-1} and 10.83 t ha^{-1}) by V_1 and V_3, respectively, whereas the lowest biological yield (9.11 t ha^{-1}) was recorded from V_4. Haque and Biswash (2014) reported that In case of biological yield (g), BRRI dhan29 showed highest yield (49.6 g) and Hira only 18 g.

Table 4.3.10. Combined effect of different fertility regime and selected rice varieties on grain, straw and biological yield and harvest index in Aus season

Treatments combinations	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
F_1V_1	5.52 ab	6.41 ab	11.92 ab	46.26 cd
F_1V_2	5.85 a	6.02 bc	11.87 ab	49.26 a
F_1V_3	5.49 ab	6.71 a	12.20 a	45.01 de
F_1V_4	4.06 e	5.22 de	9.29 de	43.67 e
F_2V_1	4.79 cd	5.89 bc	10.69 c	44.82 de
F_2V_2	5.38 ab	5.58 cd	10.96 bc	49.06 ab
F_2V_3	5.33 a-c	5.87 bc	11.19 a-c	47.57 a-c
F_2V_4	4.30 de	5.93 bc	10.23 cd	42.01 f
F_3V_1	4.99 bc	5.43 c-e	10.42 c	47.93 a-c
F_3V_2	4.96 bc	5.51 cd	10.47 c	47.44 bc
F_3V_3	4.21 e	4.89 e	9.11 e	46.25 cd
F_3V_4	3.49 f	4.34 f	7.83 f	44.61 de
Sx value	0.171	0.180	0.335	0.531
Level of significance	0.05	0.01	0.01	0.01
CV(%)	6.08	5.52	5.5.2	1.99

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

F_1: Recommended fertilizer dose-RFD

F_2: 20% added with RFD

F_3: 20% less with RFD

V_1: BR-14

V_2: BRRI dhan48

V_3: BRRI dhan55

V_4: BRRI dhan65

Combined effect of different fertility regime and rice varieties varied significantly in terms of biological yield of rice (Table 4.3.10). The highest biological yield (12.20 t ha^{-1}) was found from the combination of F_1V_3 and the lowest biological yield (7.34 t ha^{-1}) was observed from the combination of F_3V_4.

4.3.16 Harvest index

Harvest index of rice varied non-significantly due to different fertility regime (Table 4.3.9). The highest harvest index (46.56%) was observed from F_3 and the lowest harvest index (45.86%) was recorded from F_2.

Different rice varieties showed significant differences in terms of harvest index of rice (Table 4.3.9). The highest harvest index (48.59%) was recorded from V_2 which was followed (46.33% and 46.28%) by V_1 and V_3, respectively and they were statistically similar. On the other hand, the lowest harvest index (43.43%) was observed from V_4.

Combined effect of different fertility regime and rice varieties varied significantly in terms of harvest index of rice (Table 4.3.10). The highest harvest index (49.26%) was observed from the combination of F_1V_2, whereas the lowest harvest index (42.01%) was recorded from the combination of F_2V_4.

4.4 Experiment-4: Effect of Weed Management on the Yield Attributes and Yield of Different Aus Rice Varieties

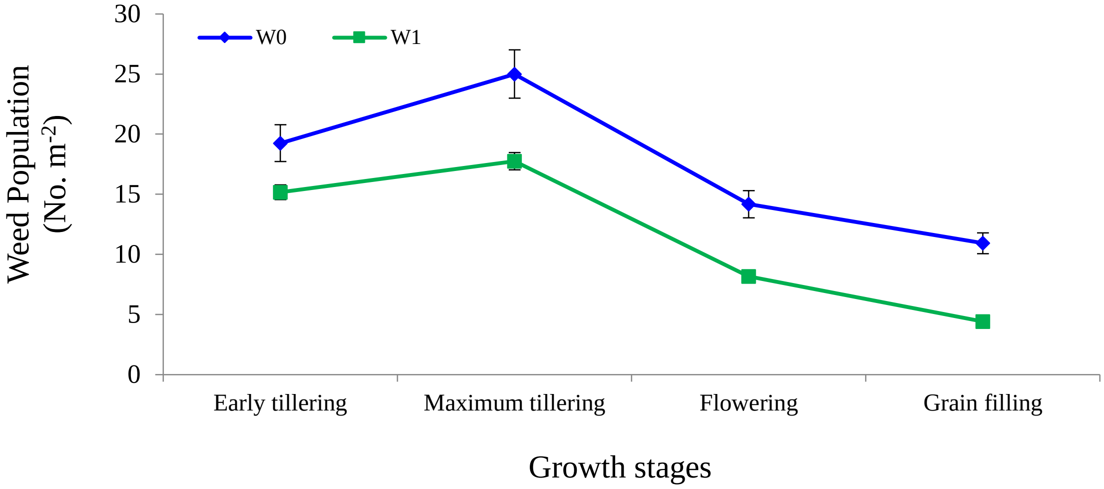
The experiment was conducted to find out the effect of weed management on the yield attributes and yield of different Aus rice varieties. The analyses of variance (ANOVA) of the data on different parameters are presented in Appendix XXI-XXVI. The results have been presented on tables and graphs and possible interpretations given under the following headings:

4.4.1 Weed population

Weed population showed statistically significant differences due to different weed management at early tillering stage (ETS), maximum tillering stage (MTS), flowering stage (FS) and grain filling stage (Figure 4.4.1). At ETS, MTS, FS and GFS, the higher weed population (19.25, 25.00, 14.17 and 10.92, respectively) was found from W_0 (no weeding i.e. control condition), whereas the lower weed population (15.17, 17.75, 8.16 and 4.42, respectively) was recorded from W_1 (hand weeding at 20 and 40 DAT). Kishore *et al.* (2016) reported the lowest weed density with two hand weeding.

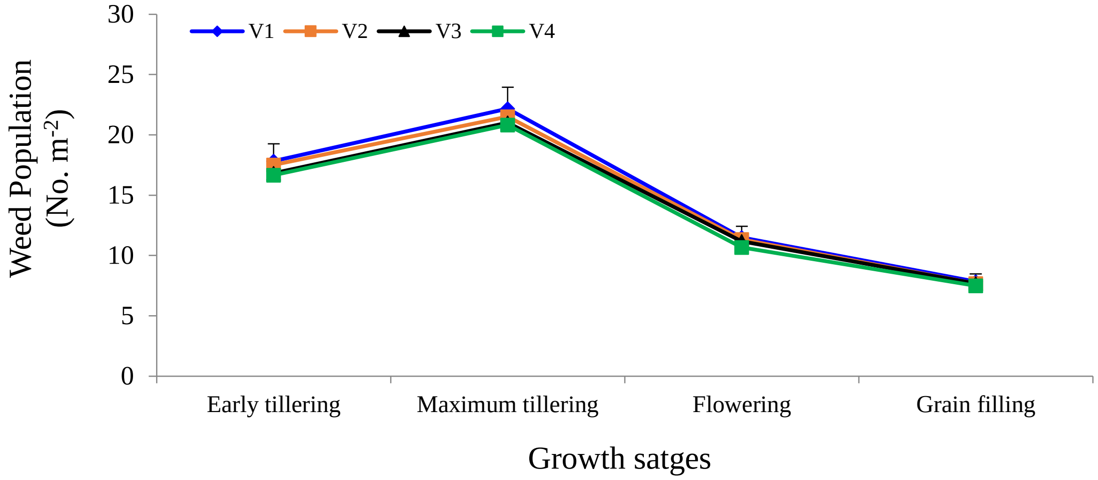
Statistically non-significant variation was observed in terms of weed population at ETS, MTS, FS and GFS for different rice varieties (Figure 4.4.2). At ETS, MTS, FS and GFS, the highest weed population (17.83, 22.17, 11.50 and 7.83, respectively) was found from V_1 (BR-14), while the lowest weed population (16.67, 20.83, 10.67 and 7.50, respectively) was observed from V_4 (BRRI dhan65).

Combined effect of different weed management and rice varieties varied significantly in terms of weed population at ETS, MTS, FS and GFS (Table 4.4.1). At ETS, MTS, FS and GFS, the highest weed population (21.33, 26.00, 15.00 and 11.33, respectively) was observed from the combination of W_0V_2 (no weeding i.e. control condition and BRRI dhan48), whereas the lowest weed population (13.67, 15.67, 7.67 and 4.00, respectively) was recorded from the combination of W_1V_2 (hand weeding at 20 and 40 DAT BRRI dhan48).



W_0: No weeding (control condition) W_1: Hand weeding at 20 and 40 DAT

Figure 4.4.1. Effect of different weed management on weed population of rice at different growth stages in Aus season (Sx = 0.385, 0.406, 0.107 and 0.168 at ETS, MTS, FS and GFS, respectively).



V_1: BR-14 V_2: BRRI dhan48

V_3: BRRI dhan55 V_4: BRRI dhan65

Figure 4.4.2. Effect of different selected rice varieties on weed population at different growth stages in Aus season (Sx = 0.545, 0.575, 0.151 and 0.238 at ETS, MTS, FS and GFS, respectively).

Table 4.4.1. Combined effect of different weed management and selected rice varieties on weed population (m^{-2}) at different growth stages in Aus season

Treatments combinations	Growth stage			
	Early tillering (ETS)	Maximum tillering (MTS)	Flowering (FS)	Grain filling (GFS)
W_0V_1	20.33 a	23.67 a	14.33 a	11.00 a
W_0V_2	21.33 a	26.00 a	15.00 a	11.33 a
W_0V_3	19.33 ab	24.33 a	14.33 a	10.67 a
W_0V_4	16.00 cd	26.00 a	13.00 b	11.00 a
W_1V_1	15.33 cd	19.33 b	8.67 c	4.33 c
W_1V_2	13.67 d	15.67 c	7.67 c	4.00 c
W_1V_3	14.00 d	17.67 bc	8.00 c	5.00 b
W_1V_4	17.67 bc	18.33 b	8.33 c	4.33 c
Sx value	0.770	0.813	0.336	0.214
Level of significance	0.01	0.05	0.01	0.05
CV(%)	7.75	6.59	5.22	4.83

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

W_0: No weeding (control condition)

W_1: Hand weeding at 20 and 40 DAT

V_1: BR-14

V_2: BRRI dhan48

V_3: BRRI dhan55

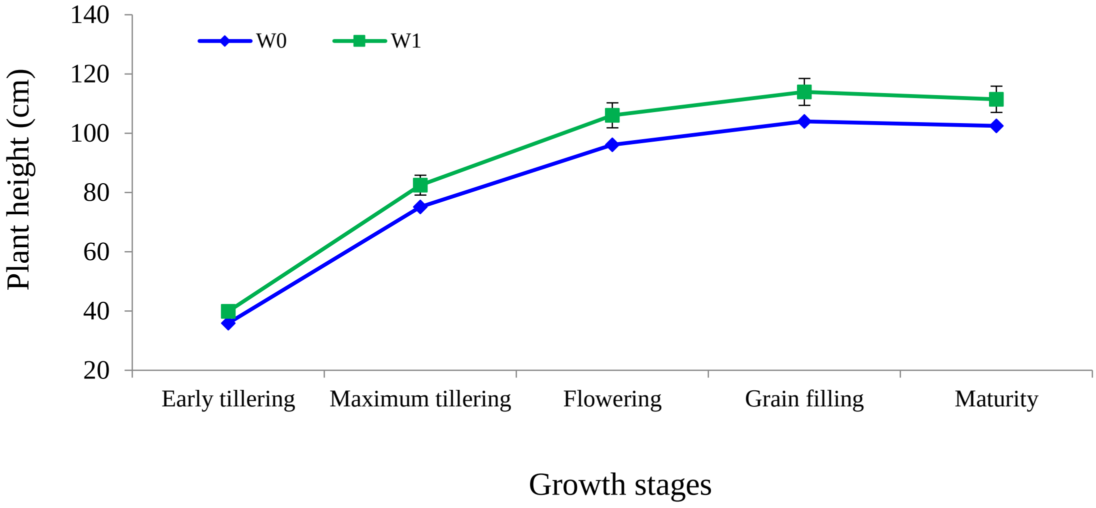
V_4: BRRI dhan65

4.4.2 Plant height

Plant height of rice varied significantly due to different weed management at early tillering stage (ETS), maximum tillering stage (MTS), flowering stage (FS), grain filling stage (GFS) and maturity stage (MS) (Figure 4.4.3). At ETS, MTS, FS, GFS and MS, the taller plant (39.92, 82.51, 106.06, 113.99 and 111.50 cm, respectively) was recorded from W_1, while the shorter plants (35.96, 75.12, 96.10, 104.06 and 102.50 cm, respectively) was observed from W_0. Data reveled that hand weeding at 20 and 40 DAT produced tallest plant than the control condition. Hasanuzz*aman et al.* (2007) stated that plant height was significantly affected by different weeding treatments. Bhuiyan *et al*. (2014) reported that that the different rice varieties significant effects the plant height at maturity.

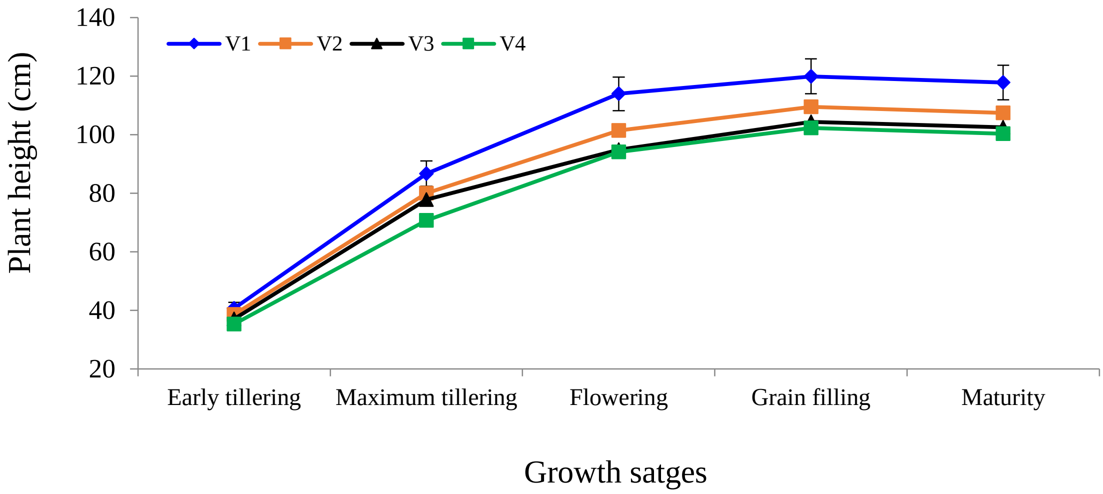
Different rice varieties showed statistically significant differences in terms of plant height of rice at ETS, MTS, FS, GFS and MS (Figure 4.4.4). At ETS, MTS, FS, GFS and MS, the tallest plant (40.68, 86.72, 113.93, 119.93 and 117.83 cm, respectively) was found from V_1 which was followed (38.63, 79.97, 101.46, 109.54 and 107.40 cm, respectively) by V_2 and also (37.10, 77.86, 94.85, 104.35 and 102.46 cm, respectively) by V_3, whereas the shortest plant (35.36, 70.71, 94.09, 102.28 and 100.31 cm, respectively) was observed from V_4. Haque and Biswash (2014) reported that the highest plant height was 101.5 cm from BRRI dhan28 and the lowest plant height from Richer (82.5 cm).

Statistically significant variation was recorded in terms of plant height of rice at ETS, MTS, FS, GFS and MS due to the combined effect of different weed management and rice varieties (Table 4.4.2). At ETS, MTS, FS, GFS and MS, the tallest plant (41.27, 87.93, 116.44, 121.13 and 118.78 cm, respectively) was found from the combination of W_1V_1 and the shortest plant (32.26, 64.86, 80.33, 88.42 and 90.12 cm, respectively) was observed from the combination of W_0V_4.



W_0: No weeding (control condition) W_1: Hand weeding at 20 and 40 DAT

Figure 4.4.3. Effect of different weed management on plant height of rice at different growth stages in Aus season (Sx = 0.452, 1.143, 2.213, 1.811 and 1.922 at ETS, MTS, FS, GFS and MS, respectively).



V_1: BR-14 V_2: BRRI dhan48

V_3: BRRI dhan55 V_4: BRRI dhan65

Figure 4.4.4. Effect of different selected rice varieties on plant height at different growth stages in Aus season (Sx = 0.639, 1.616, 3.129, 2.561 and 2.719 at ETS, MTS, FS, GFS and MS, respectively).

Table 4.4.2. Combined effect of different weed management and selected rice varieties on plant height (cm) at different growth stages in Aus season

Treatments combinations	Growth stage				
	Early tillering (ETS)	Maximum tillering (MTS)	Flowering (FS)	Grain filling (GFS)	Maturity (MS)
W_0V_1	40.09 ab	85.50 ab	111.41 ab	118.73 ab	116.88 ab
W_0V_2	37.37 b	78.98 bc	101.99 a-c	106.13 cd	104.52 bc
W_0V_3	34.12 c	71.14 de	90.69 cd	101.26 d	100.17 c
W_0V_4	32.26 c	64.86 e	80.33 d	90.12 e	88.42 d
W_1V_1	41.27 a	87.93 a	116.44 a	121.13 a	118.78 a
W_1V_2	39.88 ab	80.96 a-c	100.93 bc	112.95 a-d	110.28 a-c
W_1V_3	40.09 ab	84.58 ab	99.00 bc	107.43 b-d	104.74 bc
W_1V_4	38.45 ab	76.56 cd	107.85 ab	114.45 a-c	112.20 a-c
Sx value	0.903	2.286	4.425	3.621	3.845
Level of significance	0.05	0.05	0.05	0.05	0.05
CV(%)	4.12	5.02	7.58	5.75	6.22

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

W_0: No weeding (control condition)

W_1: Hand weeding at 20 and 40 DAT

V_1: BR-14

V_2: BRRI dhan48

V_3: BRRI dhan55

V_4: BRRI dhan65

4.4.3 Number of tillers hill^{-1}

Number of tillers hill^{-1} of rice at early tillering stage (ETS), maximum tillering stage (MTS), flowering stage (FS), grain filling stage (GFS) and maturity stage (MS) varied significantly due to different weed management (Table 4.4.3). At ETS, MTS, FS and GFS, the maximum number of tiller hill^{-1} (6.65, 14.47, 16.60 and 16.15, respectively) was observed from W_1, while the minimum number (6.05, 13.25, 14.57 and 14.08, respectively) was recorded from W_0. Kishore *et al.* (2016) reported the maximum number of panicle (m^{-2}) with two hand weeding.

Different rice varieties showed significant differences in terms of number of tiller hill^{-1} of rice at ETS, MTS, FS and GFS (Table 4.4.3). At ETS, MTS, FS and GFS, the maximum number of tiller hill^{-1} (6.87, 14.97, 16.87 and 16.33, respectively) was recorded from V_2 which was followed (6.40, 13.83, 15.67 and 15.13, respectively) by V_3 and also (6.10, 13.57, 15.37 and 15.00, respectively) by V_1, whereas the minimum number (6.03, 13.07, 14.43 and 14.00, respectively) was found from V_4. Masum *et al.* (2008) reported that number of total tillers hill^{-1} was significantly influenced by cultivars at all stages of crop growth. Nizersail was achieved maximum (25.63) tiller at 45 DAT, whereas in the case of BRRI dhan44, maximum (18.92) tiller production was observed around panicle initiation stage at 60 DAT.

Combined effect of different weed management and rice varieties varied significantly in terms of number of tiller hill^{-1} of rice at ETS, MTS, FS and GFS (Table 4.4.4). At ETS, MTS, FS and GFS, the maximum number of tiller hill^{-1} (7.13, 15.40, 17.73 and 17.40, respectively) was recorded from the combination of W_1V_2 and the minimum number (5.40, 11.73, 12.73 and 12.27, respectively) was observed from the combination of W_0V_4.

4.4.4 Crop duration

Crop duration of rice varied significantly due to different weed management (Table 4.4.5). The maximum crop duration (113.58 days) was found from W_1 and the minimum crop duration (109.17 days) was recorded from W_0.

Table 4.4.3. Effect of different weed management and selected rice varieties on number of total tillers hill^{-1} at different growth stages in Aus season

Treatments	Growth stage			
	Early tillering (ETS)	Maximum tillering (MTS)	Flowering (FS)	Grain filling (GFS)
Weed management				
W_0	6.05 b	13.25 b	14.57 b	14.08 b
W_1	6.65 a	14.47 a	16.60 a	16.15 a
Sx value	0.093	0.182	0.175	0.176
Level of significance	0.01	0.01	0.01	0.01
CV(%)	5.07	4.55	3.90	4.02
Selected rice varieties				
V_1	6.10 b	13.57 b	15.37 b	15.00 b
V_2	6.87 a	14.97 a	16.87 a	16.33 a
V_3	6.40 b	13.83 b	15.67 b	15.13 b
V_4	6.03 b	13.07 b	14.43 c	14.00 c
Sx value	0.132	0.258	0.248	0.248
Level of significance	0.01	0.01	0.01	0.01
CV(%)	5.07	4.55	3.90	4.02

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

W_0: No weeding (control condition)

W_1: Hand weeding at 20 and 40 DAT

V_1: BR-14

V_2: BRRI dhan48

V_3: BRRI dhan55

V_4: BRRI dhan65

Table 4.4.4. Combined effect of different weed management and selected rice varieties on number of total tillers hill^{-1} at different growth stages in Aus season

Treatments combinations	Growth stage			
	Early tillering (ETS)	Maximum tillering (MTS)	Flowering (FS)	Grain filling (GFS)
W_0V_1	6.00 c	13.40 b	14.67 c	14.33 c
W_0V_2	6.60 a-c	14.53 ab	16.00 b	15.27 bc
W_0V_3	6.20 bc	13.33 b	14.87 c	14.47 c
W_0V_4	5.40 d	11.73 c	12.73 d	12.27 d
W_1V_1	6.20 bc	13.73 b	16.07 b	15.67 b
W_1V_2	7.13 a	15.40 a	17.73 a	17.40 a
W_1V_3	6.60 a-c	14.33 ab	16.47 b	15.80 b
W_1V_4	6.67 ab	14.40 ab	16.13 b	15.73 b
Sx value	0.186	0.364	0.351	0.351
Level of significance	0.05	0.05	0.05	0.05
CV(%)	5.07	4.55	3.90	4.02

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

W_0: No weeding (control condition)

W_1: Hand weeding at 20 and 40 DAT

V_1: BR-14

V_2: BRRI dhan48

V_3: BRRI dhan55

V_4: BRRI dhan65

Table 4.4.5. Effect of different weed management and selected rice varieties on crop duration, non-effective and total tillers hill^{-1} and panicle length in Aus season

Treatments	Crop duration (days)	Non-effective tillers hill^{-1} (No.)	Total tillers hill^{-1} (No.)	Panicle length (cm)
Weed management				
W_0	109.17 b	2.90 a	14.62 b	22.64 b
W_1	113.58 a	1.78 b	15.42 a	24.04 a
Sx value	1.242	0.062	0.221	0.257
Level of significance	0.05	0.01	0.05	0.01
CV(%)	3.86	9.23	5.10	3.82
Selected rice varieties				
V_1	120.67 a	2.49 ab	14.59 b	23.27 ab
V_2	113.50 b	2.03 c	16.10 a	23.93 a
V_3	109.17 b	2.20 bc	14.83 b	23.80 a
V_4	102.17 c	2.67 a	14.57 b	22.35 b
Sx value	1.756	0.088	0.312	0.364
Level of significance	0.01	0.01	0.01	0.05
CV(%)	3.86	9.23	5.10	3.82

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

W_0: No weeding (control condition)

W_1: Hand weeding at 20 and 40 DAT

V_1: BR-14

V_2: BRRI dhan48

V_3: BRRI dhan55

V_4: BRRI dhan65

Different rice varieties showed significant differences in terms of crop duration of rice (Table 4.4.5). The maximum crop duration (120.67 days) was found from V_1 which was followed (113.50 days and 109.17 days) by V_2 and V_3, respectively and they were statistically similar, whereas the minimum crop duration (102.17 days) was observed from V_4.

Combined effect of different weed management and rice varieties varied significantly in terms of crop duration of rice (Table 4.4.6). The maximum crop duration (123.33 days) was observed from the combination of W_1V_1, while the minimum crop duration (100.33 days) was recorded from the combination of W_0V_4.

4.4.5 Number of effective tillers hill^{-1}

Number of effective tillers hill^{-1} of rice varied significantly due to different weed management (Table 4.4.5). The maximum number of effective tillers hill^{-1} (13.63) was recorded from W_1, whereas the minimum number of effective tillers hill^{-1} (11.72) was observed from W_0.

Different rice varieties showed significant differences in terms of number of effective tillers hill^{-1} of rice (Table 4.4.5). The maximum number of effective tillers hill^{-1} (14.07) was recorded from V_2 which was followed by other rice varieties and the minimum number (11.90) was found from V_4. Islam *et al.* (2009) reported that BRRI dhan3l had higher panicles plant^{-1}.

Combined effect of different weed management and rice varieties varied significantly in terms of number of effective tillers hill^{-1} of rice (Table 4.4.6). The maximum number of effective tillers hill^{-1} (14.53) was observed from the combination of W_1V_2, while minimum number (10.07) was found from the combination of W_0V_4.

Table 4.4.6. Combined effect of different weed management and selected rice varieties on crop duration, non-effective and total tillers hill^{-1} and panicle length in Aus season

Treatments combinations	Crop duration (days)	Non-effective tillers hill^{-1} (No.)	Total tillers hill^{-1} (No.)	Panicle length (cm)
W_0V_1	118.00 ab	3.47 a	14.80 ab	22.38 c
W_0V_2	112.00 bc	2.53 b	16.13 a	22.62 bc
W_0V_3	106.33 cd	2.47 b	14.33 bc	23.32 bc
W_0V_4	100.33 d	3.13 a	13.20 c	22.24 c
W_1V_1	123.33 a	1.47 d	14.33 bc	24.17 ab
W_1V_2	115.00 b	1.53 d	16.07 a	25.24 a
W_1V_3	112.00 bc	1.93 c	15.33 ab	24.29 ab
W_1V_4	104.00 cd	2.20 bc	15.93 a	22.46 c
Sx value	2.483	0.125	0.442	0.514
Level of significance	0.05	0.01	0.01	0.01
CV(%)	3.86	9.23	5.10	3.82

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

W_0: No weeding (control condition)

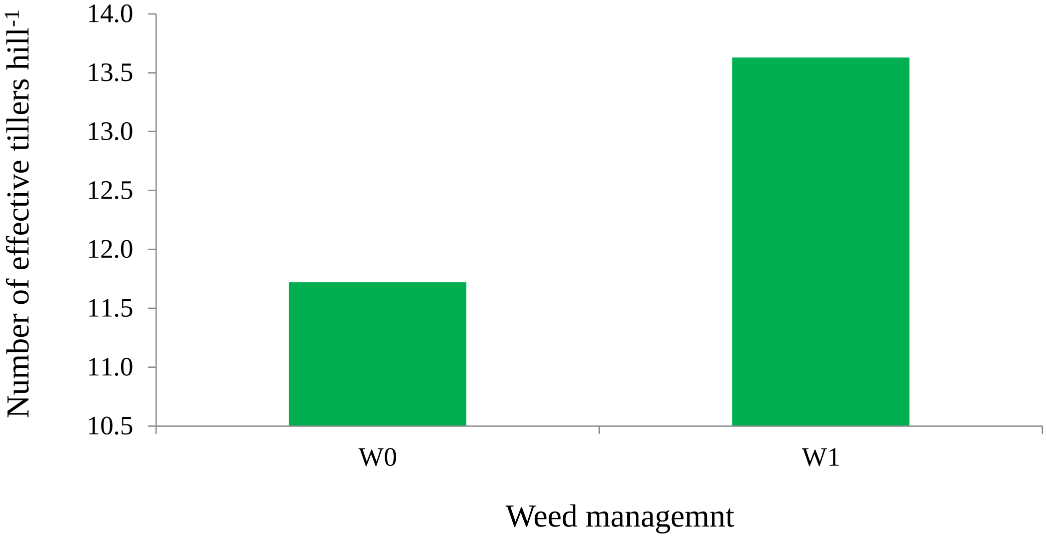
W_1: Hand weeding at 20 and 40 DAT

V_1: BR-14

V_2: BRRI dhan48

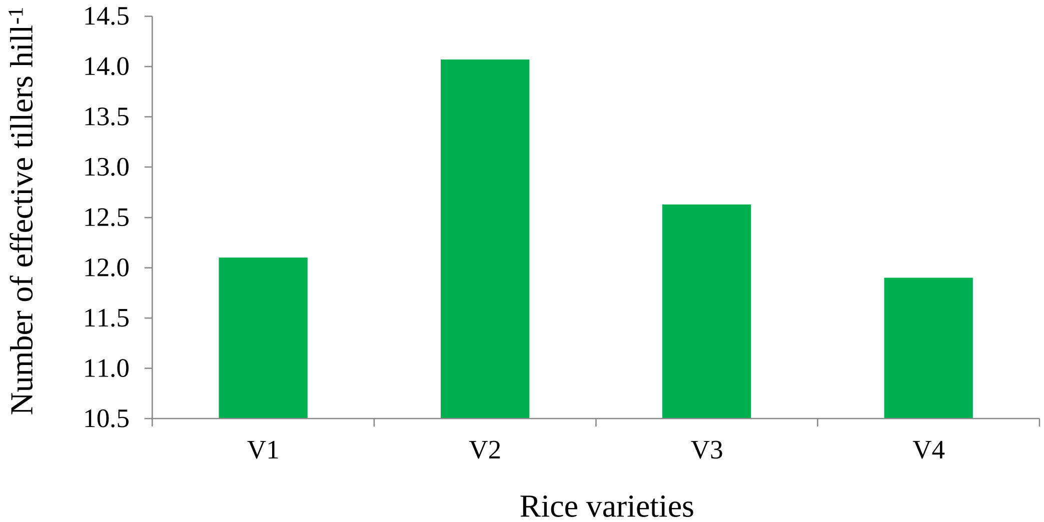
V_3: BRRI dhan55

V_4: BRRI dhan65



W_0: No weeding (control condition) W_1: Hand weeding at 20 and 40 DAT

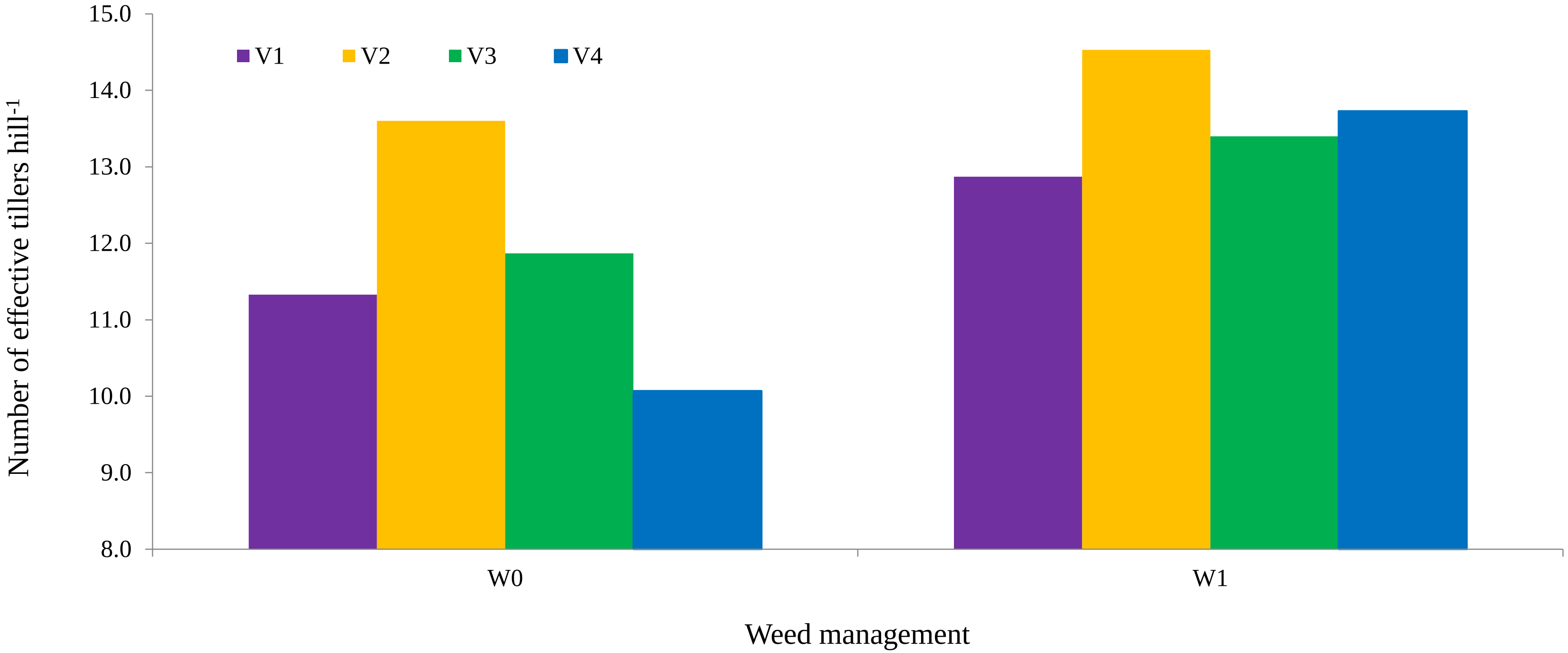
Figure 4.2.5. Effect of different levels of irrigation on number of effective tillers hill^{-1} of rice in Aus season (Sx = 0.220).



V_1: BR-14 V_2: BRRI dhan48

V_3: BRRI dhan55 V_4: BRRI dhan65

Figure 4.2.6. Effect of different selected rice varieties on number of effective tillers hill^{-1} in Aus season (Sx = 0.312).



W_0: No weeding (control condition) V_1: BR-14 V_2: BRRI dhan48

W_1: Hand weeding at 20 and 40 DAT V_3: BRRI dhan55 V_4: BRRI dhan65

Figure 4.4.7. Combined effect of different weed managemnt and selected rice varieties on number of effective tillers hill^{-1} in Aus season (Sx = 0.441).

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

Number of non-effective tillers hill^{-1} of rice varied significantly due to different weed management (Table 4.4.5). The minimum number of non-effective tillers hill^{-1} (1.78) was observed from W_1, while the maximum number (2.90) was recorded from W_0.

Different rice varieties showed significant differences in terms of number of non-effective tillers hill^{-1} of rice (Table 4.4.5). The minimum number of non-effective tillers hill^{-1} (2.67) was recorded from V_4 which was statistically similar (2.49) by V_1, whereas the maximum number (2.03) was observed from V_2 which was statistically similar (2.20) to V_3.

Combined effect of different weed management and rice varieties varied significantly in terms of number of non-effective tillers hill^{-1} of rice (Table 4.4.6). The minimum number of non-effective tillers hill^{-1} (1.47) was found from the combination of W_1V_1 and the maximum number (3.47) was recorded from the combination of W_0V_1.

4.4.7 Number of total tillers hill^{-1}

Number of total tillers hill^{-1} of rice varied significantly due to different weed management (Table 4.4.5). The maximum number of total tillers hill^{-1} (15.42) was recorded from W_1, while the minimum number (14.62) was found from W_0.

Different rice varieties showed significant differences in terms of number of total tillers hill^{-1} of rice (Table 4.4.5). The maximum number of total tillers hill^{-1} (16.10) was found from V_2 which was statistically similar with other varieties of this experiment but the minimum number (14.57) was observed from V_4.

Combined effect of different weed management and rice varieties varied significantly in terms of number of total tillers hill^{-1} of rice (Table 4.4.6). The maximum number of total tillers hill^{-1} (16.13) was observed from the combination of W_1V_2 and the minimum number (13.20) was recorded from the combination of W_0V_4.

4.4.8 Panicle length

Panicle length of rice varied significantly due to different weed management (Table 4.4.5). The longest panicle (24.04 cm) was found from W_1, whereas the shortest panicle (22.64 cm) was observed from W_0. Kishore *et al.* (2016) reported maximum length of panicle^{-1} with two hand weeding.

Different rice varieties showed significant differences in terms of panicle length of rice (Table 4.4.5). The longest panicle (23.93 cm) was recorded from V_2 which was statistically similar (23.80 cm and 23.27 cm) to V_3 and V_1, while the shortest panicle (22.35 cm) was found from V_4. Shaloie *et al.* (2014) reported that traits was significantly affected in terms of panicle length.

Combined effect of different weed management and rice varieties varied significantly in terms of panicle length of rice (Table 4.4.6). The longest panicle (25.24 cm) was attained from the combination of W_1V_2, whereas the shortest panicle (22.24 cm) was found from the combination of W_0V_4.

4.4.9 Filled grains panicle^{-1}

Number of filled grains panicle^{-1} of rice varied significantly due to different weed management (Table 4.4.7). The maximum number of filled grains panicle^{-1} (121.52) was recorded from W_1, while the minimum number (112.88) from W_0.

Different rice varieties showed significant differences in terms of number of filled grains panicle^{-1} of rice (Table 4.4.7). The maximum number of filled grains panicle^{-1} (123.23) was found from V_2 which was statistically similar (118.77) to V_3. On the other hand the minimum number (113.00) was recorded from V_1 which was statistically similar (113.80) to V_4.

Combined effect of different weed management and rice varieties varied significantly in terms of filled grains panicle^{-1} of rice (Table 4.4.8). The maximum number of filled grains panicle^{-1} (128.33) was found from the combination of W_1V_2 and the minimum number (109.07) was observed from the combination of W_0V_4.

Table 4.4.7. Effect of different weed management and selected rice varieties on filled and unfilled and total grains and weight of 1000 grains in Aus season

Treatments	Filled grains panicle^{-1} (No.)	Unfilled grains panicle^{-1} (No.)	Total grains panicle^{-1} (No.)	Weights of 1000 grains (g)
Weed management				
W_0	112.88 b	9.12 a	122.00 b	24.07 b
W_1	121.52 a	7.32 b	128.83 a	25.12 a
Sx value	1.470	0.125	1.458	0.293
Level of significance	0.01	0.01	0.01	0.05
CV(%)	4.35	5.25	4.03	4.13
Selected rice varieties				
V_1	113.00 b	8.57 b	121.57 b	24.34 bc
V_2	123.23 a	7.17 d	130.40 a	24.62 b
V_3	118.77 ab	7.87 c	126.63 ab	26.24 a
V_4	113.80 b	9.27 a	123.07 b	23.18 c
Sx value	2.079	0.176	2.062	0.415
Level of significance	0.01	0.01	0.05	0.01
CV(%)	4.35	5.25	4.03	4.13

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

W_0: No weeding (control condition) W_1: Hand weeding at 20 and 40 DAT

V_1: BR-14 V_2: BRRI dhan48

V_3: BRRI dhan55 V_4: BRRI dhan65

Table 4.4.8. Combined effect of different weed management and selected rice varieties on filled and unfilled and total grains and weight of 1000 grains in Aus season

Treatments combinations	Filled grains panicle^{-1} (No.)	Unfilled grains panicle^{-1} (No.)	Total grains panicle^{-1} (No.)	Weights of 1000 grains (g)
W_0V_1	113.67 c	9.80 a	123.47 b	24.17 b
W_0V_2	118.13 bc	8.13 b	126.27 ab	24.80 ab
W_0V_3	110.67 c	8.80 b	119.47 b	25.92 ab
W_0V_4	109.07 c	9.73 a	118.80 b	21.40 c
W_1V_1	112.33 c	7.33 c	119.67 b	24.51 b
W_1V_2	128.33 a	6.20 d	134.53 a	24.45 b
W_1V_3	126.87 ab	6.93 cd	133.80 a	26.56 a
W_1V_4	118.53 bc	8.80 b	127.33 ab	24.96 ab
Sx value	2.941	0.249	2.917	0.587
Level of significance	0.05	0.05	0.05	0.05
CV(%)	4.35	5.25	4.03	4.13

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

W_0: No weeding (control condition)

W_1: Hand weeding at 20 and 40 DAT

V_1: BR-14

V_2: BRRI dhan48

V_3: BRRI dhan55

V_4: BRRI dhan65

4.4.10 Unfilled grains panicle^{-1}

Number of unfilled grains panicle^{-1} of rice varied significantly due to different weed management (Table 4.4.7). The minimum number of unfilled grains panicle^{-1} (7.32) was observed from W_1, while the maximum number (9.12) was recorded from W_0.

Different rice varieties showed significant differences in terms of number of unfilled grains panicle^{-1} of rice (Table 4.4.7). The minimum number of unfilled grains panicle^{-1} (7.17) was found from V_2 which was followed (7.87) by V_3, whereas the maximum number (9.27) was observed from V_4 which was followed (8.57) by V_1.

Combined effect of different weed management and rice varieties varied significantly in terms of unfilled grains panicle^{-1} of rice (Table 4.4.8). The minimum number of unfilled grains panicle^{-1} (6.20) was observed from the combination of W_1V_2 and the maximum number (9.80) was recorded from the combination of W_0V_1.

4.4.11 Total grains panicle^{-1}

Number of total grains panicle^{-1} of rice varied significantly due to different weed management (Table 4.4.7). The maximum number of total grains panicle^{-1} (128.83) was found from W_1, whereas the minimum number (122.00) was recorded from W_0.

Different rice varieties showed significant differences in terms of number of total grains panicle^{-1} of rice (Table 4.4.7). The maximum number of total grains panicle^{-1} (130.40) was found from V_2 which was statistically similar (126.63) to V_3, while the minimum number (121.57) was observed from V_1 which was statistically similar (123.07) to V_4.

Combined effect of different weed management and rice varieties varied significantly in terms of total grains panicle^{-1} of rice under the present trial (Table 4.4.8). The maximum number of total grains panicle^{-1} (134.53) was observed from the combination of W_1V_2 and the minimum number (118.80) was found from the combination of W_0V_4.

4.4.12 Weight of 1000 grains

Weight of 1000 grains of rice varied significantly due to different weed management (Table 4.4.7). The highest weight of 1000 grains (25.12 g) was observed from W_1 and the lowest weight (24.07 g) was recorded from W_0. Kishore *et al.* (2016) reported the highest 1000-grain weight with two hand weeding. Nahar *et al.* (2010) observed that in BRRI dhan41 weeding regime had significant effect on all the parameters except 1000 grain weight.

Different rice varieties showed significant differences in terms of weight of 1000 grains of rice (Table 4.4.7). The highest weight of 1000 grains (26.24 g) was recorded from V_3 which was followed (24.62 g and 24.34 g) by V_2 and V_1, respectively and they were statistically similar, whereas the lowest weight (23.18 g) was observed from V_4.

Combined effect of different weed management and rice varieties varied significantly in terms of weight of 1000 grains of rice (Table 4.4.8). The highest weight of 1000 grains (26.56 g) was found from the combination of W_1V_3, while the lowest weight (21.40 g) was recorded from the combination of W_0V_4.

4.4.13 Grain yield

Grain yield of rice varied significantly due to different weed management (Table 4.4.9). The highest grain yield (5.18 t ha^{-1}) was found from W_1, whereas the lowest grain yield (4.66 t ha^{-1}) was observed from W_0. Kishore *et al.* (2016) reported the highest grain yield of 30.40 and 32.60 q ha^{-1} with two hand weeding. Chauhana *et al.* (2015) observed that the weed-free plots and herbicide treatments produced 84-614% and 58-504% higher rice grain yield, respectively, than the plots that's were in control i.e. no weed control.

Table 4.4.9. Effect of different weed management and selected rice varieties on grain, straw and biological yield and harvest index in Aus season

Treatments	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
Weed management				
W_0	4.66 b	5.38 b	10.04 b	46.24
W_1	5.18 a	5.99 a	11.17 a	46.29
Sx value	0.080	0.066	0.115	0.439
Level of significance	0.01	0.01	0.01	NS
CV(%)	5.60	4.00	3.76	3.28
Selected rice varieties				
V_1	5.17 ab	5.95 a	11.12 a	46.46 b
V_2	5.47 a	5.76 a	11.23 a	48.72 a
V_3	5.06 b	5.85 a	10.91 a	46.33 b
V_4	3.98 c	5.19 b	9.17 b	43.56 c
Sx value	0.113	0.093	0.163	0.620
Level of significance	0.01	0.01	0.01	0.01
CV(%)	5.60	4.00	3.76	3.28

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

W_0: No weeding (control condition)

W_1: Hand weeding at 20 and 40 DAT

V_1: BR-14

V_2: BRRI dhan48

V_3: BRRI dhan55

V_4: BRRI dhan65

Different rice varieties showed significant differences in terms of grain yield of rice (Table 4.4.9). The highest grain yield (5.47 t ha^{-1}) was recorded from V_2 which was statistically similar (5.17 t ha^{-1}) to V_1 and closely followed (5.06 t ha^{-1}) by V_3, respectively, while the lowest grain yield (3.98 t ha^{-1}) was observed from V_4.

Combined effect of different weed management and rice varieties varied significantly in terms of grain yield of rice (Table 4.4.10). The highest grain yield (5.73 t ha^{-1}) was observed from the combination of W_1V_2 and the lowest grain yield (3.64 t ha^{-1}) was recorded from the combination of W_0V_4.

4.4.14 Straw yield

Straw yield of rice varied significantly due to different weed management (Table 4.4.9). The highest straw yield (5.99 t ha^{-1}) was observed from W_1 and the lowest straw yield (5.38 t ha^{-1}) was found from W_0.

Different rice varieties showed significant differences in terms of straw yield of rice (Table 4.4.9). The highest straw yield 5.95 t ha^{-1}) was observed from V_1 which was statistically similar (5.85 t ha^{-1} and 5.76 t ha^{-1}) to V_3 and V_2, respectively whereas the lowest straw yield (5.19 t ha^{-1}) was recorded from V_4.

Combined effect of different weed management and rice varieties varied significantly in terms of straw yield of rice (Table 4.4.10). The highest straw yield (6.19 t ha^{-1}) was observed from the combination of W_1V_3 and the lowest straw yield (4.54 t ha^{-1}) was recorded from the combination of W_0V_4.

4.4.15 Biological yield

Biological yield of rice varied significantly due to different weed management (Table 4.4.9). The highest biological yield (11.17 t ha^{-1}) was observed from W_1, while the lowest biological yield (10.04 t ha^{-1}) was recorded from W_0.

Table 4.4.10. Combined effect of different weed management and selected rice varieties on grain, straw and biological yield and harvest index in Aus season

Treatments combinations	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
W_0V_1	5.09 bc	5.81 a-c	10.90 ab	46.61 bc
W_0V_2	5.21 ab	5.67 bc	10.88 ab	47.92 ab
W_0V_3	4.68 cd	5.50 c	10.18 b	45.92 bc
W_0V_4	3.64 e	4.54 d	8.19 c	44.53 cd
W_1V_1	5.24 ab	6.09 ab	11.33 a	46.31 bc
W_1V_2	5.73 a	5.84 a-c	11.58 a	49.53 a
W_1V_3	5.44 ab	6.19 a	11.63 a	46.74 bc
W_1V_4	4.32 d	5.83 a-c	10.15 b	42.59 d
Sx value	0.159	0.131	0.230	0.877
Level of significance	0.05	0.01	0.05	0.05
CV(%)	5.60	4.00	3.76	3.28

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

W_0: No weeding (control condition)

W_1: Hand weeding at 20 and 40 DAT

V_1: BR-14

V_2: BRRI dhan48

V_3: BRRI dhan55

V_4: BRRI dhan65

Different rice varieties showed significant differences in terms of biological yield of rice (Table 4.4.9). The highest biological yield (11.23 t ha^{-1}) was found from V_2 which was statistically similar (11.12 t ha^{-1} and 10.91 t ha^{-1}) to V_1 and V_3, respectively, whereas the lowest biological yield (9.17 t ha^{-1}) was found from V_4.

Combined effect of different weed management and rice varieties varied significantly in terms of biological yield of rice (Table 4.4.10). The highest biological yield (11.63 t ha^{-1}) was observed from the combination of W_1V_3 and the lowest biological yield (8.19 t ha^{-1}) was recorded from W_0V_4.

4.4.16 Harvest index

Harvest index of rice varied non-significantly due to different weed management (Table 4.4.9). The highest harvest index (46.29%) was found from W_1, while the lowest harvest index (46.24%) was observed from W_0.

Different rice varieties showed significant differences in terms of harvest index of rice (Table 4.4.9). The highest harvest index (48.72%) was observed from V_2 which was followed (46.46% and 46.33%) by V_1 and V_3, respectively, whereas the lowest harvest index (43.56%) was found from V_4.

Combined effect of different weed management and rice varieties varied significantly in terms of harvest index of rice (Table 4.4.10). The highest harvest index (49.53%) was recorded from the combination of W_1V_2 and the lowest harvest index (42.59%) was found from the combination of W_1V_4.

4.5 Experiment-5: Performance of Aus Rice Under Varying Irrigation Regime, Fertilizer Dose and Weeding Method

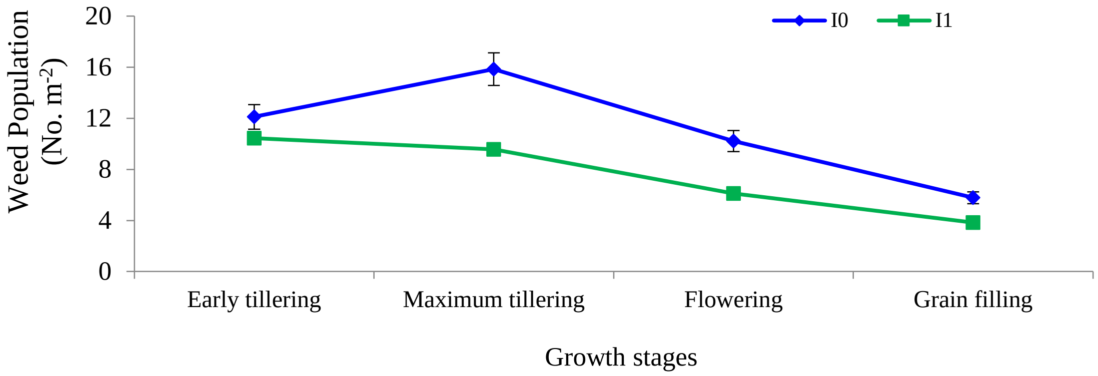
The experiment was conducted to find out the performance of Aus rice under varying irrigation regime, fertilizer dose and weeding method. The analyses of variance (ANOVA) of the data on different parameters are presented in Appendix XXVII-XXXVII. The results have been presented on tables and graphs and possible interpretations given under the following headings:

4.5.1 Weed population

Weed population showed statistically significant differences due to different irrigation regime at early tillering stage (ETS), maximum tillering stage (MTS), flowering stage (FS) and grain filling stage (Figure 4.5.1). At ETS, MTS, FS and GFS, the higher number of weed population (12.11, 15.85, 10.22 and 5.78, respectively) was recorded from I_0 (no irrigation), while the lower number of weed population (10.44, 9.56, 6.11 and 3.83, respectively) was found from I_1 (supplemental irrigation).

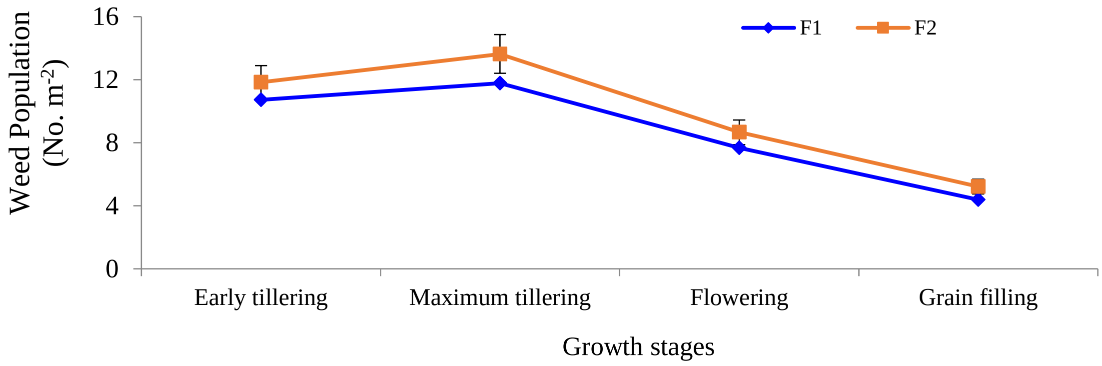
Statistically significant variation was observed in terms of weed population at ETS, MTS, FS and GFS due to different fertilizer doses (Figure 4.5.2). At ETS, MTS, FS and GFS, the highest number of weed population (11.83, 13.63, 8.67 and 5.22, respectively) was observed from F_2 (20% added with RFD), whereas the lowest number of weed population (10.72, 11.78, 7.67 and 4.39, respectively) was recorded from F_1 (recommended fertilizer dose-RFD).

Different weeding methods varied significantly in terms of weed population at ETS, MTS, FS and GFS due to (Figure 4.5.3). At ETS, MTS, FS and GFS, the highest number of weed population (16.67, 18.44, 12.42 and 6.50, respectively) was recorded from W_1 (hand weeding at 20 and 40 DAT) which was followed (15.75, 17.75, 9.83 and 5.42, respectively) by W_3 (weeding by BRRI hand weeder at 20 and 40 DAT), while the lowest number (1.42, 1.92, 2.25 and 2.50, respectively) was found from W_2 (pre emergence herbicide use at 4 DAT). Kishore *et al.* (2016) reported the lowest weed density with two hand weeding.



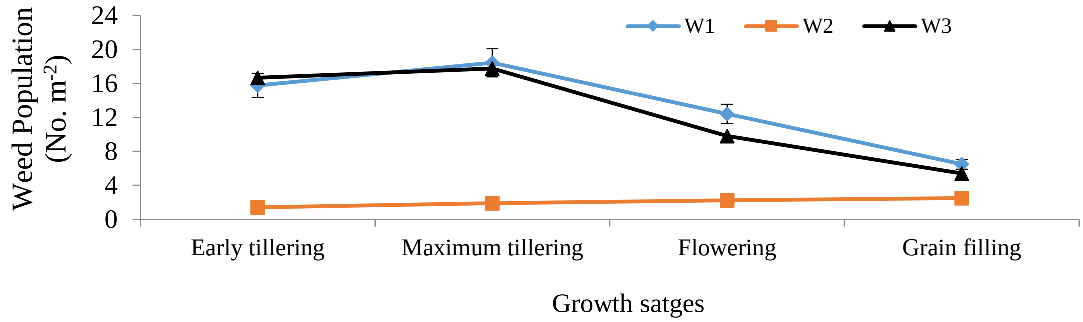
I_0: No irrigation I_1: Supplemental irrigation

Figure 4.5.1. Effect of different irrigation regime on weed population at different growth stages in Aus season (Sx = 0.136, 0.318, 0.196 and 0.336 at ETS, MTS, FS and GFS, respectively).



F_1: Recommended fertilizer dose-RFD F_2: 20% added with RFD

Figure 4.5.2. Effect of different fertilizer doses on weed population at different growth stages in Aus season (Sx = 0.056, 0.220, 0.088 and 0.111 at ETS, MTS, FS and GFS, respectively).



W_1: Hand weeding at 20 and 40 DAT W_2: Pre emergence herbicide use at 4 DAT
W_3: Weeding by BRRI hand weeder at 20 and 40 DAT

Figure 4.5.3. Effect of different weeding methods on weed population at different growth stages in Aus season (Sx = 0.207, 0.318, 0.177 and 0.198, respectively).

Combined effect of different irrigation regime and fertilizer doses varied significantly in terms of weed population at ETS, MTS, FS and GFS (Table 4.5.1). At ETS, MTS, FS and GFS, the highest weed population (12.33, 16.37, 10.33 and 6.00, respectively) was found from the combination of I_0F_2 (no irrigation and 20% added with RFD) and the lowest weed population (9.56, 8.22, 5.22 and 3.22, respectively) was observed from the combination of I_1F_1 (supplemental irrigation and Recommended fertilizers dose-RFD).

Combined effect of different irrigation regime and weeding methods varied significantly in terms of weed population at ETS, MTS, FS and GFS (Table 4.5.1). At ETS, MTS, FS and GFS, the highest weed population (17.50, 23.88, 15.00 and 7.50, respectively) was found from the combination of I_0W_1 (no irrigation and hand weeding at 20 and 40 DAT), whereas the lowest weed population (1.17, 1.83, 2.17 and 2.33, respectively) was found from I_1W_2 (supplemental irrigation and pre emergence herbicide use at 4 DAT).

Due to the combined effect of different fertilizer doses and weeding methods statistically significant differences was observed in terms of weed population at ETS, MTS, FS and GFS (Table 4.5.1). At ETS, MTS, FS and GFS, the highest weed population (17.17, 19.38, 13.67 and 7.50, respectively) was recorded from the combination of F_2W_1 (20% added with RFD dose and hand weeding at 20 and 40 DAT), whereas the lowest weed population (1.17, 1.50, 1.83 and 2.17, respectively) was found from the combination of F_1W_2 (recommended fertilizers dose-RFD and pre emergence herbicide use at 4 DAT).

Combined effect of different irrigation regime, fertilizer doses and weeding methods varied significantly in terms of weed population at ETS, MTS, FS and GFS (Table 4.5.2). At ETS, MTS, FS and GFS, the highest weed population (18.33, 24.00, 15.33 and 8.33, respectively) was observed from the combination of $I_0F_2W_1$ (no irrigation, 20% added with RFD dose and hand weeding at 20 and 40 DAT), whereas the lowest weed population (1.00, 1.33, 1.67 and 2.00, respectively) was found from the combination of $I_1F_1W_2$ (supplemental irrigation, recommended fertilizers dose-RFD and pre emergence herbicide use at 4 DAT).

Table 4.5.1. Combined effect of irrigation, fertilizer and weeding on weed population (m^{-2}) at different growth stages of BRRI dhan48 at different growth stages in Aus season

Treatments combinations	Growth stage			
	Early tillering (ETS)	Maximum tillering (MTS)	Flowering (FS)	Grain filling (GFS)
Irrigation regime × Fertilizer doses				
I_0F_1	11.89 b	15.33 a	10.11 a	5.56 a
I_0F_2	12.33 a	16.37 a	10.33 a	6.00 a
I_1F_1	9.56 d	8.22 c	5.22 c	3.22 c
I_1F_2	11.33 c	10.89 b	7.00 b	4.44 b
Sx value	0.079	0.311	0.157	0.124
Level of significance	0.01	0.05	0.01	0.05
CV(%)	2.10	7.35	5.77	7.76
Irrigation regime × Weeding methods				
I_0W_1	17.50 a	23.88 a	15.00 a	7.50 a
I_0W_2	1.67 d	2.00 d	2.33 e	2.50 d
I_0W_3	17.17 a	21.67 b	13.33 b	7.33 a
I_1W_1	14.00 c	13.00 c	9.83 c	5.50 b
I_1W_2	1.17 d	1.83 d	2.17 e	2.33 d
I_1W_3	16.17 b	13.83 c	6.33 d	3.50 c
Sx value	0.293	0.450	0.281	0.250
Level of significance	0.01	0.01	0.01	0.01
CV(%)	6.36	8.67	8.41	12.74
Fertilizer doses × Weeding methods				
F_1W_1	14.83 c	17.50 b	11.17 b	5.50 b
F_1W_2	1.17 d	1.50 c	1.83 d	2.17 c
F_1W_3	16.17 b	16.33 b	10.00 c	5.50 b
F_2W_1	17.17 a	19.38 a	13.67 a	7.50 a
F_2W_2	1.67 d	2.33 c	2.67 d	2.83 c
F_2W_3	16.67 ab	19.17 a	9.67 c	5.33 b
Sx value	0.293	0.450	0.281	0.250
Level of significance	0.05	0.05	0.01	0.01
CV(%)	6.36	8.67	8.41	12.74

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

I_0: No irrigation
I_1: Supplemental irrigation
F_1: Recommended fertilizer dose-RFD
F_2: 20% added with RFD
W_1: Hand weeding at 20 and 40 DAT
W_2: Pre emergence herbicide use at 4 DAT
W_3: Weeding by BRRI hand weeder at 20 and 40 DAT

Table 4.5.2. Combined effect of irrigation, fertilizer and weeding on weed population (m^{-2}) at different growth stages of BRRI dhan48 at different growth stages in Aus season

Treatments combinations	Growth stage			
	Early tillering (ETS)	Maximum tillering (MTS)	Flowering (FS)	Grain filling (GFS)
$I_0F_1W_1$	16.67 b	23.76 a	14.67 ab	6.67 b
$I_0F_1W_2$	1.33 e	1.67 e	2.00 g	2.33 ef
$I_0F_1W_3$	17.67 ab	20.33 b	13.67 bc	7.67 ab
$I_0F_2W_1$	18.33 a	24.00 a	15.33 a	8.33 a
$I_0F_2W_2$	2.00 e	2.33 e	2.67 g	2.67 d-f
$I_0F_2W_3$	16.67 b	23.00 a	13.00 cd	7.00 b
$I_1F_1W_1$	13.00 d	11.00 d	7.67 e	4.33 c
$I_1F_1W_2$	1.00 e	1.33 e	1.67 g	2.00 f
$I_1F_1W_3$	14.67 c	12.33 d	6.33 f	3.33 c-f
$I_1F_2W_1$	15.00 c	15.00 c	12.00 d	6.67 b
$I_1F_2W_2$	1.33 e	2.33 e	2.67 g	3.00 d-f
$I_1F_2W_3$	17.67 ab	15.33 c	6.33 f	3.67 cd
Sx value	0.414	0.636	0.397	0.354
Level of significance	0.01	0.05	0.05	0.01
CV(%)	6.36	8.67	8.41	12.74

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

I_0: No irrigation
I_1: Supplemental irrigation

F_1: Recommended fertilizer dose-RFD
F_2: 20% added with RFD

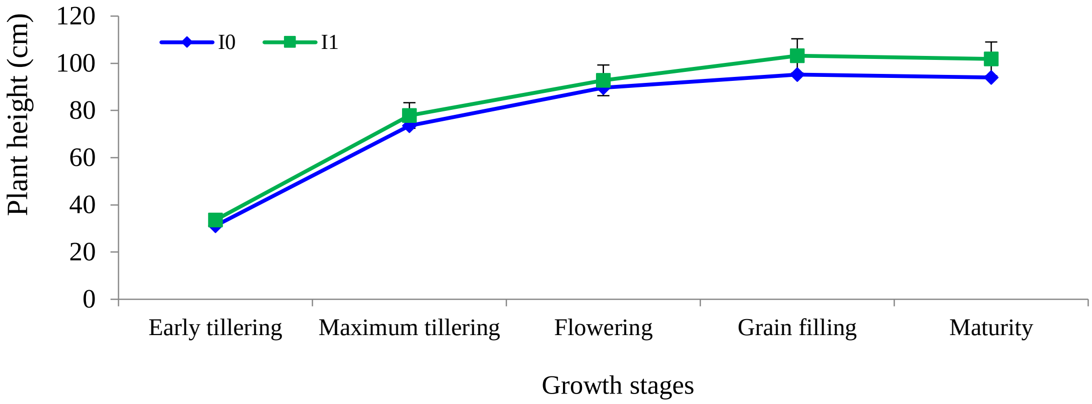
W_1: Hand weeding at 20 and 40 DAT
W_2: Pre emergence herbicide use at 4 DAT
W_3: Weeding by BRRI hand weeder at 20 and 40 DAT

4.5.2 Plant height

Statistically significant variation was observed in terms of plant height of BRRI dhan48 due to different irrigation regime at early tillering stage (ETS), maximum tillering stage (MTS), flowering stage (FS), grain filling stage and maturity stage (MS) (Figure 4.5.4). At ETS, MTS, FS, GFS and MS the longer plant (33.54, 77.88, 92.76, 103.17 and 101.87 cm, respectively) was observed from I_1, whereas the shorter plant (31.11, 73.51, 89.74, 95.29 and 94.03 cm, respectively) was found from I_0. From the above findings it was revealed that supplemental irrigation produced significantly taller plant compared to the no irrigation. Dou *et al*. (2016) reported that that cultivar selection is an important factors in deciding what water management option to practice. Khairi *et al.* (2015) reported that irrigation treatment affected plant height after 49 DAP.

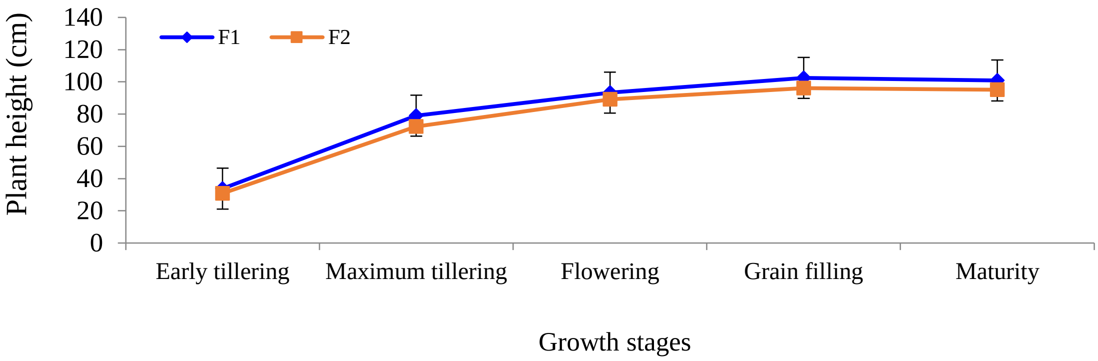
Plant height of BRRI dhan48 at ETS, MTS, FS, GFS and MS varied significantly in terms of due to different fertilizer doses (Figure 4.5.5). At ETS, MTS, FS, GFS and MS the longest plant (33.84, 79.11, 93.39, 102.46 and 100.79 cm, respectively) was found from F_1, while the shorter plant (30.81, 72.28, 89.11, 96.00 and 95.11 cm, respectively) was observed from F_2. Above findings stated that recommended fertilizer doses-RFD produced significantly taller plants 20% added with RFD. Hossaen *et al*. (2011) reported in earlier that recommended fertilizer significantly influence plant height of rice.

Statistically significant variation was observed in terms of plant height of BRRI dhan48 at ETS, MTS, FS, GFS and MS due to different weeding methods (Figure 4.5.6). At ETS, MTS, FS, GFS and MS the longest plant (33.57, 77.79, 92.47, 99.98 and 101.81 cm, respectively) was found from W_2 which was statistically similar (32.76, 76.63, 93.08, 98.88 and 99.73 cm, respectively) to W_3, while the shortest plant (30.64, 72.66, 88.20, 94.98 and 96.15 cm, respectively) was observed from W_1. Above mention findings reveled that pre-emergence herbicide use at 4 DAT produced tallest plant than the control condition. Bhuiyan *et al*. (2014) reported that that the different rice varieties significantly effects the plant height at maturity.



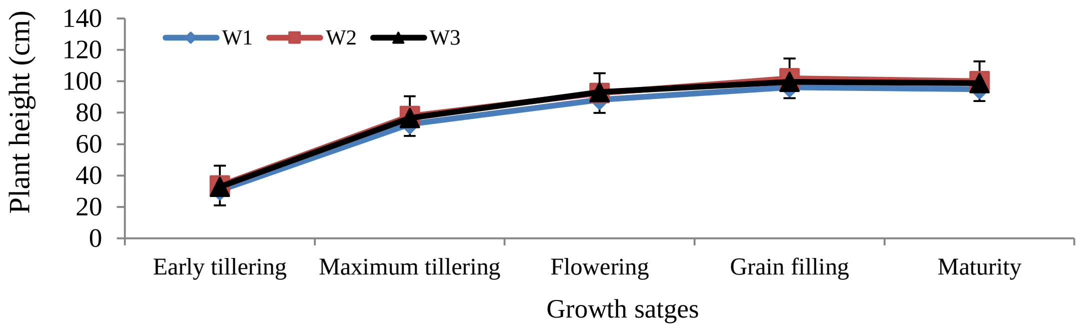
I_0: No irrigation I_1: Supplemental irrigation

Figure 4.5.4. Effect of different irrigation regime on plant height of BRRI dhan48 at different growth stages in Aus season (Sx = 0.335, 0.427, 0.436, 0.200 and 1.130 at ETS, MTS, FS, GFS and MS, respectively).



F_1: Recommended fertilizer dose-RFD F_2: 20% added with RFD

Figure 4.5.5. Effect of different fertilizer doses on plant height of BRRI dhan48 at different growth stages in Aus season (Sx = 0.571, 0.133, 0.987, 0.936 and 0.373 at ETS, MTS, FS, GFS and MS, respectively).



W_1: Hand weeding at 20 and 40 DAT W_2: Pre emergence herbicide use at 4 DAT
W_3: Weeding by BRRI hand weeder at 20 and 40 DAT

Figure 4.5.6. Effect of different weeding methods on plant height of BRRI dhan48 at different growth stages in Aus season (Sx = 0.480, 1.035, 0.926, 1.435 and 1.179 at ETS, MTS, FS, GFS and MS, respectively).

Combined effect of different irrigation regime and fertilizer doses varied significantly in terms of plant height of BRRI dhan48 at ETS, MTS, FS, GFS and MS (Table 4.5.3). At ETS, MTS, FS, GFS and MS the longest plant (36.25, 83.43, 94.96, 108.60 and 106.52 cm, respectively) was observed from the combination of I_1F_1, whereas the shortest plant (30.78, 72.23, 87.66, 94.25 and 92.99 cm, respectively) was recorded from the combination of I_0F_2.

Combined effect of different irrigation regime and weeding methods varied significantly in terms of plant height of BRRI dhan48 at ETS, MTS, FS, GFS and MS (Table 4.5.3). At ETS, MTS, FS, GFS and MS the longest plant (34.11, 78.12, 93.46, 104.06 and 102.56 cm, respectively) was observed from the combination of I_1W_2, whereas the shortest plant (28.09, 67.71, 82.93, 89.16 and 87.39 cm, respectively) was recorded from the combination of I_0W_1.

Combined effect of different fertilizer doses and weeding methods varied significantly in terms of plant height of BRRI dhan48 at ETS, MTS, FS, GFS and MS (Table 4.5.3). At ETS, MTS, FS, GFS and MS the longest plant (36.17, 82.46, 94.80, 106.61 and 104.23 cm, respectively) was observed from the combination of F_1W_2, whereas the shortest plant (29.26, 69.12, 84.55, 93.64 and 92.06 cm respectively) was recorded from the combination of F_2W_1.

Combined effect of different irrigation regime, fertilizer doses and weeding methods varied significantly in terms of plant height of BRRI dhan48 at ETS, MTS, FS, GFS and MS (Table 4.5.4). At ETS, MTS, FS, GFS and MS the longest plant (39.13, 85.46, 95.65, 112.78 and 108.84 cm, respectively) was observed from the combination of $I_1F_1W_2$, whereas the shortest plant (26.35, 64.16, 76.42, 86.14 and 83.56 cm, respectively) was recorded from $I_0F_2W_1$.

Table 4.5.3. Combined effect of irrigation and fertilizer, irrigation and weeding, fertilizer and weeding on plant height (cm) of BRRI dhan48 at different growth stages in Aus season

Treatments combinations	Growth stage				
	Early tillering (ETS)	Maximum tillering (MTS)	Flowering (FS)	Grain filling (GFS)	Maturity (MS)
Irrigation regime × Fertilizer doses					
I_0F_1	31.44 b	74.79 b	91.82 ab	96.32 b	95.06 c
I_0F_2	30.78 b	72.23 c	87.66 b	94.25 b	92.99 c
I_1F_1	36.25 a	83.43 a	94.96 a	108.60 a	106.52 a
I_1F_2	30.84 b	72.33 c	90.55 ab	97.75 b	97.22 b
Sx value	0.808	0.188	1.396	1.324	0.528
Level of significance	0.05	0.01	0.05	0.05	0.01
CV(%)	7.50	2.75	4.59	4.00	1.62
Irrigation regime × Weeding methods					
I_0W_1	28.09 b	67.71 b	82.93 b	89.16 c	87.39 c
I_0W_2	33.03 a	77.47 a	93.54 a	99.57 ab	98.48 ab
I_0W_3	32.21 a	75.35 a	92.75 a	97.14 b	96.20 b
I_1W_1	33.20 a	77.61 a	91.39 a	103.14 ab	101.49 ab
I_1W_2	34.11 a	78.12 a	93.46 a	104.06 a	102.56 a
I_1W_3	33.32 a	77.90 a	93.42 a	102.32 ab	101.57 ab
Sx value	0.679	1.464	1.309	2.030	1.667
Level of significance	0.01	0.01	0.01	0.05	0.01
CV(%)	5.14	4.74	3.51	5.01	4.17
Fertilizer doses × Weeding methods					
F_1W_1	32.02 bc	76.20 bc	91.85 ab	98.65 bc	97.90 b
F_1W_2	36.17 a	82.46 a	94.80 a	106.61 a	104.23 a
F_1W_3	33.33 b	78.67 ab	93.53 ab	102.11 ab	100.25 ab
F_2W_1	29.26 d	69.12 d	84.55 c	93.64 c	92.06 c
F_2W_2	30.97 cd	73.13 cd	90.13 b	97.01 bc	95.74 bc
F_2W_3	32.19 bc	74.59 bc	92.64 ab	97.35 bc	97.52 b
Sx value	0.679	1.464	1.309	2.030	1.667
Level of significance	0.05	0.01	0.05	0.05	0.05
CV(%)	5.14	4.74	3.51	5.01	4.17

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

I_0: No irrigation
I_1: Supplemental irrigation
F_1: Recommended fertilizer dose-RFD
F_2: 20% added with RFD
W_1: Hand weeding at 20 and 40 DAT
W_2: Pre emergence herbicide use at 4 DAT
W_3: Weeding by BRRI hand weeder at 20 and 40 DAT

Table 4.5.4. Combined effect of different irrigation, fertilizer and weeding on plant height (cm) of BRRI dhan48 at different growth stages in Aus season

Treatments combinations	Growth stage				
	Early tillering (ETS)	Maximum tillering (MTS)	Flowering (FS)	Grain filling (GFS)	Maturity (MS)
$I_0F_1W_1$	29.83 de	71.27 e	89.44 ab	92.18 de	91.23 e
$I_0F_1W_2$	33.21 bc	79.46 a-d	93.96 a	100.45 b-d	99.62 b-d
$I_0F_1W_3$	31.28 c-e	73.65 de	92.06 ab	96.34 cd	94.34 de
$I_0F_2W_1$	26.35 f	64.16 f	76.42 c	86.14 e	83.56 f
$I_0F_2W_2$	32.85 b-d	75.48 c-e	93.12 ab	98.68 b-d	97.34 c-e
$I_0F_2W_3$	33.13 bc	77.06 b-e	93.44 a	97.94 cd	98.06 c-e
$I_1F_1W_1$	34.21 bc	81.13 a-c	94.25 a	105.12 a-c	104.56 a-c
$I_1F_1W_2$	39.13 a	85.46 a	95.65 a	112.78 a	108.84 a
$I_1F_1W_3$	35.39 b	83.69 ab	95.00 a	107.89 ab	106.15 ab
$I_1F_2W_1$	32.18 c-e	74.09 de	92.68 ab	101.15 b-d	100.56 b-d
$I_1F_2W_2$	29.08 ef	70.78 e	87.14 b	95.34 d	94.13 de
$I_1F_2W_3$	31.26 c-e	72.12 e	91.84 ab	96.75 cd	96.98 c-e
Sx value	0.960	2.070	1.851	2.870	2.358
Level of significance	0.01	0.05	0.01	0.05	0.05
CV(%)	5.14	4.74	3.51	5.01	4.17

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

I_0: No irrigation
I_1: Supplemental irrigation

F_1: Recommended fertilizer dose-RFD
F_2: 20% added with RFD

W_1: Hand weeding at 20 and 40 DAT
W_2: Pre emergence herbicide use at 4 DAT
W_3: Weeding by BRRI hand weeder at 20 and 40 DAT

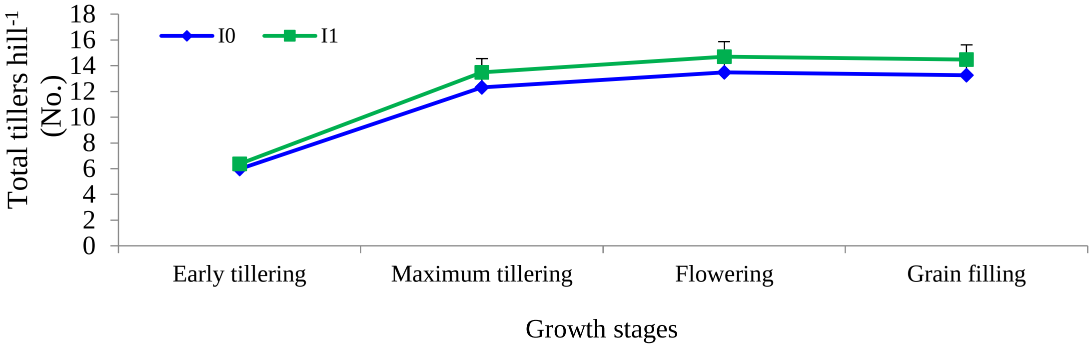
4.5.3 Number of tillers hill^{-1}

Number of tillers hill^{-1} of BRRI dhan48 showed statistically significant differences due to different irrigation regime at early tillering stage (ETS), maximum tillering stage (MTS), flowering stage (FS), grain filling stage (GFS) and maturity stage (MS) (Figure 4.5.7). At ETS, MTS, FS and GFS the maximum number of tillers hill^{-1} (6.36, 13.47, 14.70 and 14.47, respectively) was found from I_1, while the minimum number (5.97, 12.32, 13.48 and 13.26, respectively) was observed from I_0. Nasir *et al.* (2014) recoded the highest number of tillers from irrigation management compared to others.

Statistically significant variation was observed in terms of number of tillers hill^{-1} of BRRI dhan48 at ETS, MTS, FS and GFS due to different fertilizer doses (Figure 4.5.8). At ETS, MTS, FS and GFS the maximum number of tillers hill^{-1} (6.33, 13.46, 14.64 and 14.40, respectively) was recorded from F_1, while the minimum number (5.99, 12.33, 13.53 and 13.32, respectively) was observed from F_2. Hossain (2013) reported that number of tillers hill^{-1} varied for different fertility regime.

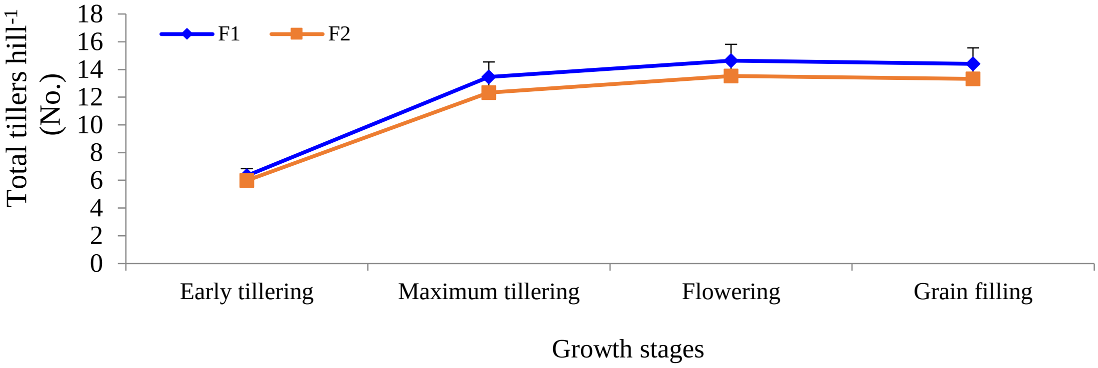
Number of tillers hill^{-1} of BRRI dhan48 at ETS, MTS, FS and GFS showed statistically significant difference in terms of due to different weeding methods (Figure 4.5.9). At ETS, MTS, FS and GFS the maximum number of tillers hill^{-1} (6.38, 13.25, 14.47 and 14.23, respectively) was recorded from W_2 which was statistically similar (6.15, 13.08, 14.37 and 14.13, respectively) to W_3, while the minimum number of tillers hill^{-1} (5.95, 12.35, 13.43 and 13.22, respectively) was observed from W_1.

Combined effect of different irrigation regime and fertilizer doses varied significantly in terms of number of tillers hill^{-1} of BRRI dhan48 at ETS, MTS, FS and GFS (Table 4.5.5). At ETS, MTS, FS and GFS the maximum number of tillers hill^{-1} (6.69, 14.38, 15.47 and 15.20, respectively) was recorded from the combination of I_1F_1, whereas the minimum number (5.96, 12.11, 13.13 and 12.91, respectively) was observed from the combination of I_0F_2.



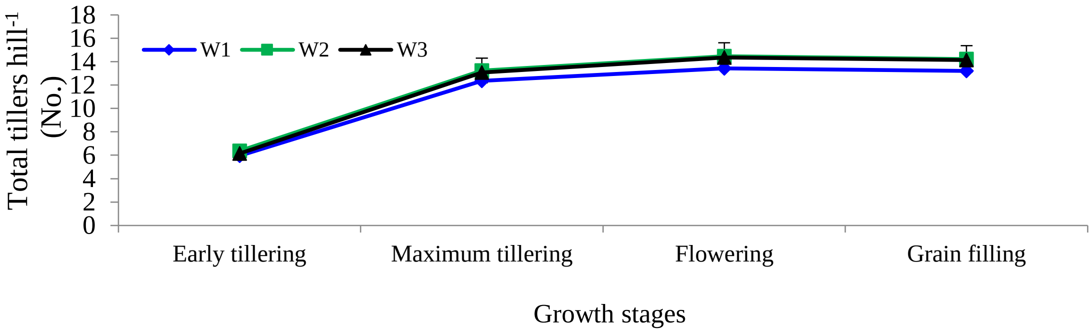
I_0: No irrigation I_1: Supplemental irrigation

Figure 4.5.7. Effect of different irrigation regime on number of total tillers hill^{-1} of BRRI dhan48 at different growth stages in Aus season (Sx = 0.034, 0.137, 0.140 and 0.155 at ETS, MTS, FS and GFS, respectively).



F_1: Recommended fertilizer dose-RFD F_2: 20% added with RFD

Figure 4.5.8. Effect of different fertilizer doses on number of total tillers hill^{-1} of BRRI dhan48 at different growth stages in Aus season (Sx = 0.069, 0.135, 0.132 and 0.152 at ETS, MTS, FS and GFS, respectively).



W_1: Hand weeding at 20 and 40 DAT W_2: Pre emergence herbicide use at 4 DAT
W_3: Weeding by BRRI hand weeder at 20 and 40 DAT

Figure 4.5.9. Effect of different weeding methods on number of total tillers hill^{-1} of BRRI dhan48 at different growth stages in Aus season (Sx = 0.093, 0.155, 0.151 and 0.165 at ETS, MTS, FS and GFS, respectively).

Combined effect of different irrigation regime and weeding methods varied significantly for number of tillers hill^{-1} of BRRI dhan48 at ETS, MTS, FS and GFS (Table 4.5.5). At ETS, MTS, FS and GFS the maximum number of tillers hill^{-1} (6.47, 13.50, 14.53 and 14.77, respectively) was found from I_1W_2, while the minimum number (5.60, 11.20, 11.90 and 12.13, respectively) from I_0W_1.

Fertilizer doses and weeding methods varied significantly due to combined effect for number of tillers hill^{-1} of BRRI dhan48 at ETS, MTS, FS and GFS (Table 4.5.5). At ETS, MTS, FS and GFS the maximum number of tillers hill^{-1} (6.67, 14.03, 14.97 and 15.17, respectively) was observed from the combination of F_1W_2, whereas the minimum number (5.80, 11.77, 12.50 and 12.70, respectively) was found from the combination of F_2W_1.

Combined effect of different irrigation regime, fertilizer doses and weeding methods varied significantly in terms of number of tillers hill^{-1} of BRRI dhan48 at ETS, MTS, FS, and GFS (Table 4.5.6). At ETS, MTS, FS and GFS the maximum number of tillers hill^{-1} (6.93, 14.73, 15.67 and 15.87, respectively) was recorded from the combination of $I_1F_1W_2$, whereas the minimum number (5.47, 10.53, 10.80 and 11.07, respectively) was observed from $I_0F_2W_1$.

4.5.4 Leaf area index

Different irrigation regime at early tillering stage (ETS), maximum tillering stage (MTS), flowering stage (FS), grain filling stage (GFS) and maturity stage (MS) of BRRI dhan48 varied significantly for leaf area index (Figure 4.5.10). At ETS, MTS, FS and GFS the highest leaf area index (1.46, 3.18, 4.50 and 4.30, respectively) was found from I_1, whereas the lowest (1.37, 2.59, 3.28 and 3.00, respectively) from I_0.

Statistically significant variation was observed in terms of leaf area index of BRRI dhan48 at ETS, MTS, FS and GFS due to different fertilizer doses (Figure 4.5.11). At ETS, MTS, FS and GFS the highest leaf area index (1.46, 3.15, 4.42 and 4.23, respectively) was recorded from F_1, while the lowest (1.37, 2.61, 3.36 and 3.07, respectively) was observed from F_2.

Table 4.5.5. Combined effect of irrigation and fertilizer, irrigation and weeding, fertilizer and weeding on number of total tillers hill^{-1} of BRRI dhan48 at different growth stages in Aus season

Treatments combinations	Growth stage			
	Early tillering (ETS)	Maximum tillering (MTS)	Flowering (FS)	Grain filling (GFS)
Irrigation regime × Fertilizer doses				
I_0F_1	5.98 b	12.53 b	13.82 bc	13.60 b
I_0F_2	5.96 b	12.11 c	13.13 c	12.91 b
I_1F_1	6.69 a	14.38 a	15.47 a	15.20 a
I_1F_2	6.02 b	12.56 b	13.93 b	13.73 b
Sx value	0.097	0.050	0.186	0.216
Level of significance	0.05	0.01	0.05	0.01
CV(%)	4.70	1.15	3.96	4.66
Irrigation regime × Weeding methods				
I_0W_1	5.60 c	11.20 c	12.13 c	11.90 b
I_0W_2	6.30 ab	13.07 ab	14.33 ab	14.10 a
I_0W_3	6.00 b	12.70 b	13.97 b	13.77 a
I_1W_1	6.30 ab	13.43 a	14.60 ab	14.37 a
I_1W_2	6.47 a	13.50 a	14.77 a	14.53 a
I_1W_3	6.30 ab	13.47 a	14.73 a	14.50 a
Sx value	0.131	0.219	0.213	0.233
Level of significance	0.05	0.01	0.01	0.01
CV(%)	5.20	4.16	3.71	4.12
Fertilizer doses × Weeding methods				
F_1W_1	6.10 bc	12.93 bc	14.17 bc	13.93 bc
F_1W_2	6.67 a	14.03 a	15.17 a	14.97 a
F_1W_3	6.23 b	13.40 ab	14.60 ab	14.30 ab
F_2W_1	5.80 c	11.77 d	12.70 d	12.50 d
F_2W_2	6.10 bc	12.47 c	13.77 c	13.50 c
F_2W_3	6.07 bc	12.77 bc	14.13 bc	13.97 bc
Sx value	0.131	0.219	0.213	0.233
Level of significance	0.05	0.01	0.05	0.05
CV(%)	5.20	4.16	3.71	4.12

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

I_0: No irrigation
I_1: Supplemental irrigation

F_1: Recommended fertilizer dose-RFD
F_2: 20% added with RFD

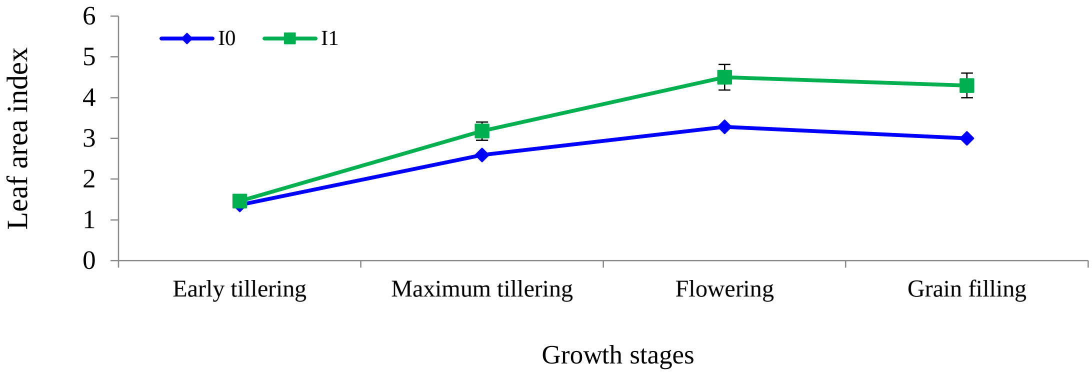
W_1: Hand weeding at 20 and 40 DAT
W_2: Pre emergence herbicide use at 4 DAT
W_3: Weeding by BRRI hand weeder at 20 and 40 DAT

Table 4.5.6. Combined effect of different irrigation, fertilizer and weeding on number of total tillers hill^{-1} of BRRI dhan48 at different growth stages in Aus season

Treatments	Growth stage			
	Early tillering (ETS)	Maximum tillering (MTS)	Flowering (FS)	Grain filling (GFS)
$I_0F_1W_1$	5.73 ef	11.87 e	13.20 f	13.00 e
$I_0F_1W_2$	6.40 a-d	13.33 bc	14.47 b-d	14.27 b-d
$I_0F_1W_3$	5.80 d-f	12.40 c-e	13.80 d-f	13.53 de
$I_0F_2W_1$	5.47 f	10.53 f	11.07 g	10.80 f
$I_0F_2W_2$	6.20 b-e	12.80 c-e	14.20 c-f	13.93 c-e
$I_0F_2W_3$	6.20 b-e	13.00 cd	14.13 d-f	14.00 b-e
$I_1F_1W_1$	6.47 a-c	14.00 ab	15.13 a-c	14.87 a-c
$I_1F_1W_2$	6.93 a	14.73 a	15.87 a	15.67 a
$I_1F_1W_3$	6.67 ab	14.40 a	15.40 ab	15.07 ab
$I_1F_2W_1$	6.13 b-e	13.00 cd	14.33 c-e	14.20 b-d
$I_1F_2W_2$	6.00 c-f	12.13 de	13.33 ef	13.07 e
$I_1F_2W_3$	5.93 c-f	12.53 c-e	14.13 d-f	13.93 c-e
Sx value	0.185	0.310	0.302	0.330
Level of significance	0.05	0.01	0.01	0.01
CV(%)	5.20	4.16	3.71	4.12

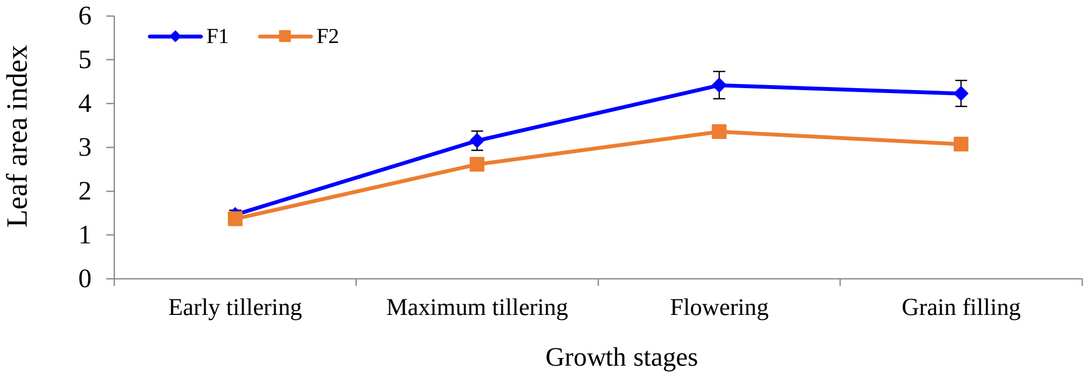
In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

I_0: No irrigation
I_1: Supplemental irrigation
F_1: Recommended fertilizer dose-RFD
F_2: 20% added with RFD
W_1: Hand weeding at 20 and 40 DAT
W_2: Pre emergence herbicide use at 4 DAT
W_3: Weeding by BRRI hand weeder at 20 and 40 DAT



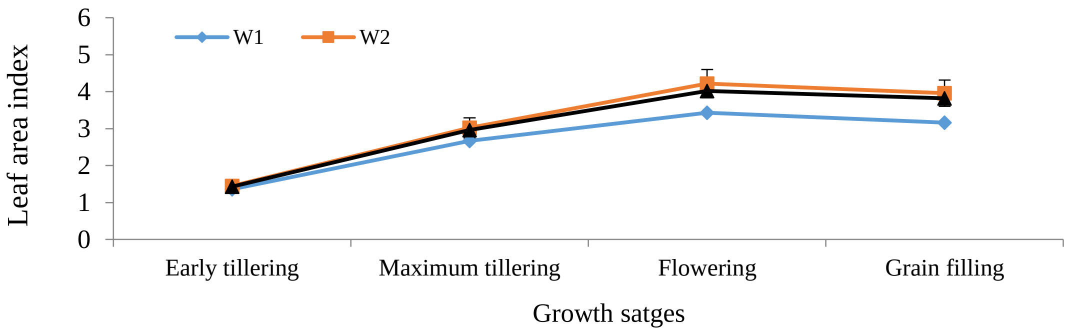
I_0: No irrigation I_1: Supplemental irrigation

Figure 4.5.10. Effect of different irrigation regime on leaf area index of BRRI dhan48 at different growth stages in Aus season (Sx = 0.009, 0.077, 0.152 and 0.167 at ETS, MTS, FS and GFS, respectively).



F_1: Recommended fertilizer dose-RFD F_2: 20% added with RFD

Figure 4.5.11. Effect of different fertilizer doses on leaf area index of BRRI dhan48 at different growth stages in Aus season (Sx = 0.023, 0.047, 0.104 and 0.116 at ETS, MTS, FS and GFS, respectively).



W_1: Hand weeding at 20 and 40 DAT W_2: Pre emergence herbicide use at 4 DAT
W_3: Weeding by BRRI hand weeder at 20 and 40 DAT

Figure 4.5.12. Effect of different weeding methods on leaf area index of BRRI dhan48 at different growth stages in Aus season (Sx = 0.020, 0.081, 0.211 and 0.234 at ETS, MTS, FS and GFS, respectively).

Statistically significant variation was observed in terms of leaf area index of BRRI dhan48 at ETS, MTS, FS and GFS due to different weeding methods (Figure 4.5.12). At ETS, MTS, FS and GFS the highest leaf area index (1.45, 3.02, 4.22 and 3.96, respectively) was found from W_2 which was statistically similar (1.43, 2.96, 4.02 and 3.82, respectively) to W_3, while the lowest (1.36, 2.67, 3.43 and 3.16, respectively) was recorded from W_1.

Combined effect of different irrigation regime and fertilizer doses varied significantly in terms of leaf area index of BRRI dhan48 at ETS, MTS, FS and GFS (Table 4.5.7). At ETS, MTS, FS and GFS the highest leaf area index (1.55, 3.74, 4.51 and 4.49, respectively) was found from the combination of I_1F_1, whereas the lowest (1.36, 2.57, 3.23 and 2.98, respectively) was recorded from the combination of I_0F_2.

Combined effect of different irrigation regime and weeding methods varied significantly in terms of leaf area index of BRRI dhan48 at ETS, MTS, FS and GFS (Table 4.5.7). At ETS, MTS, FS and GFS the highest leaf area index (1.47, 3.26, 4.72 and 4.47, respectively) was observed from the combination of I_1W_1 and the lowest (1.27, 2.07, 2.13 and 1.86, respectively) was found from I_0W_1.

Combined effect of different fertilizer doses and weeding methods varied significantly in terms of leaf area index of BRRI dhan48 at ETS, MTS, FS and GFS (Table 4.5.7). At ETS, MTS, FS and GFS the highest leaf area index (1.53, 3.49, 5.13 and 4.97, respectively) was found from the combination of F_1W_2, whereas the lowest (1.32, 2.50, 3.05 and 2.78, respectively) from F_2W_1.

Combined effect of different irrigation regime, fertilizer doses and weeding methods varied significantly in terms of leaf area index of BRRI dhan48 at ETS, MTS, FS, and GFS (Table 4.5.8). At ETS, MTS, FS and GFS the highest leaf area index (1.62, 3.86, 5.69 and 4.80, respectively) was recorded from the combination of $I_1F_1W_2$, whereas the lowest (1.22, 2.02, 2.19 and 1.72, respectively) was found from the combination of $I_0F_2W_1$.

Table 4.5.7. Combined effect of irrigation and fertilizer, irrigation and weeding, fertilizer and weeding on leaf area index of BRRI dhan48 at different growth stages in Aus season

Treatments combinations	Growth stage			
	Early tillering (ETS)	Maximum tillering (MTS)	Flowering (FS)	Grain filling (GFS)
Irrigation regime × Fertilizer doses				
I_0F_1	1.37 b	2.60 b	3.33 b	3.02 b
I_0F_2	1.36 b	2.57 b	3.23 b	2.98 b
I_1F_1	1.55 a	3.74 a	5.51 a	4.49 a
I_1F_2	1.37 b	2.63 b	4.49 b	3.11 b
Sx value	0.032	0.066	0.147	0.164
Level of significance	0.05	0.01	0.01	0.01
CV(%)	6.71	2.87	2.77	3.35
Irrigation regime × Weeding methods				
I_0W_1	1.27 b	2.07 c	2.13 c	1.86 c
I_0W_2	1.43 a	2.98 ab	4.16 ab	3.86 ab
I_0W_3	1.40 a	2.71 b	3.54 b	3.28 b
I_1W_1	1.47 a	3.26 a	4.72 a	4.47 a
I_1W_2	1.46 a	3.07 a	4.27 ab	4.07 ab
I_1W_3	1.46 a	3.22 a	4.51 a	4.36 a
Sx value	0.029	0.114	0.298	0.331
Level of significance	0.05	0.01	0.01	0.01
CV(%)	4.97	4.05	4.59	5.53
Fertilizer doses × Weeding methods				
F_1W_1	1.41 bc	2.84 bc	3.80 bc	3.55 bc
F_1W_2	1.53 a	3.49 a	5.13 a	4.97 a
F_1W_3	1.45 ab	3.14 b	4.33 ab	4.18 ab
F_2W_1	1.32 c	2.50 c	3.05 c	2.78 c
F_2W_2	1.37 bc	2.56 c	3.31 c	2.96 c
F_2W_3	1.41 bc	2.79 bc	3.72 bc	3.46 bc
Sx value	0.029	0.114	0.298	0.331
Level of significance	0.05	0.05	0.01	0.01
CV(%)	4.97	4.05	4.59	5.53

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

I_0: No irrigation
I_1: Supplemental irrigation

F_1: Recommended fertilizer dose-RFD
F_2: 20% added with RFD

W_1: Hand weeding at 20 and 40 DAT
W_2: Pre emergence herbicide use at 4 DAT
W_3: Weeding by BRRI hand weeder at 20 and 40 DAT

Table 4.5.8. Combined effect of irrigation, fertilizer and weeding on leaf area index of BRRI dhan48 at different growth stages in Aus season

Treatments combinations	Growth stage			
	Early tillering (ETS)	Maximum tillering (MTS)	Flowering (FS)	Grain filling (GFS)
$I_0F_1W_1$	1.31 de	2.12 ef	2.38 ef	2.01 f
$I_0F_1W_2$	1.45 b-d	3.11 bc	4.57 a-c	4.14 b-d
$I_0F_1W_3$	1.37 cd	2.48 d-f	3.03 d-f	2.78 d-f
$I_0F_2W_1$	1.22 e	2.02 f	2.19 f	1.72 f
$I_0F_2W_2$	1.42 b-d	2.84 cd	3.76 c-e	3.57 c-e
$I_0F_2W_3$	1.44 b-d	2.94 cd	4.05 b-d	3.78 c-e
$I_1F_1W_1$	1.50 a-c	3.55 ab	5.23 ab	4.61 ab
$I_1F_1W_2$	1.62 a	3.86 a	5.69 a	4.80 a
$I_1F_1W_3$	1.53 ab	3.80 a	4.63 a	4.59 ab
$I_1F_2W_1$	1.42 b-d	2.98 cd	4.21 b-d	3.85 c-e
$I_1F_2W_2$	1.31 de	2.27 ef	2.86 d-f	2.35 ef
$I_1F_2W_3$	1.38 cd	2.64 c-e	3.39 c-e	3.13 d-f
Sx value	0.041	0.161	0.421	0.468
Level of significance	0.05	0.05	0.05	0.01
CV(%)	4.97	4.05	4.59	5.53

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

I_0: No irrigation
I_1: Supplemental irrigation

F_1: Recommended fertilizer dose-RFD
F_2: 20% added with RFD

W_1: Hand weeding at 20 and 40 DAT
W_2: Pre emergence herbicide use at 4 DAT
W_3: Weeding by BRRI hand weeder at 20 and 40 DAT

4.5.5 Total dry matter

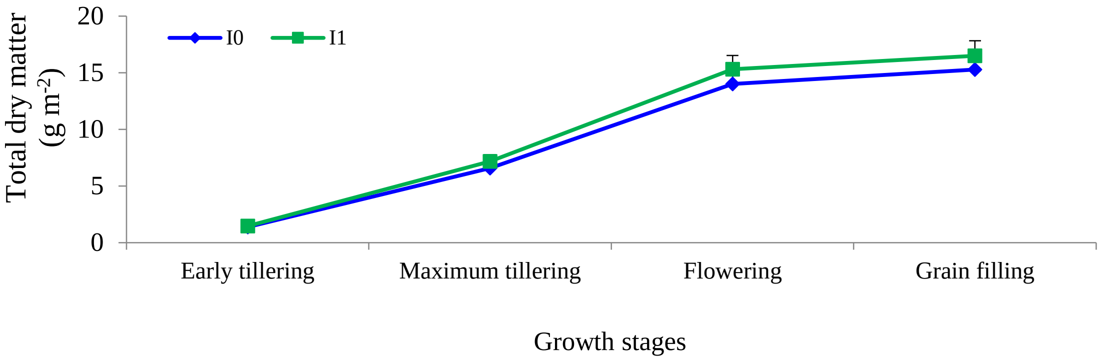
Total dry matter (TDM) of BRRI dhan48 showed statistically significant differences due to different irrigation regime at early tillering stage (ETS), maximum tillering stage (MTS), flowering stage (FS), grain filling stage (GFS) and maturity stage (MS) (Figure 4.5.13). At ETS, MTS, FS and GFS the highest TDM (174.32, 471.00, 646.85 and 779.14 g m^{-2}, respectively) was recorded from I_1, whereas the lowest TDM (160.37, 428.87, 591.45 and 704.05 g m^{-2}, respectively) was observed from I_0.

Statistically significant variation was observed in terms of total dry matter of BRRI dhan48 at ETS, MTS, FS and GFS due to different fertilizer doses (Figure 4.5.14). At ETS, MTS, FS and GFS the highest TDM (173.38, 466.59, 641.56 and 773.81 g m^{-2}, respectively) was found from F_1, while the lowest TDM (161.30, 433.29, 596.74 and 709.38 g m^{-2}, respectively) was observed from F_2.

Total dry matter of BRRI dhan48 at ETS, MTS, FS and GFS varied significantly due to different weeding methods (Figure 4.5.15). At ETS, MTS, FS and GFS the highest TDM (171.18, 460.88, 633.98 and 762.92 g m^{-2}, respectively) was recorded from W_2 which was statistically similar (167.98, 451.31, 621.53 and 745.81 g m^{-2}, respectively) to W_3, while the lowest TDM (162.87, 437.62, 601.93 and 716.05 g m^{-2}, respectively) was found from W_1.

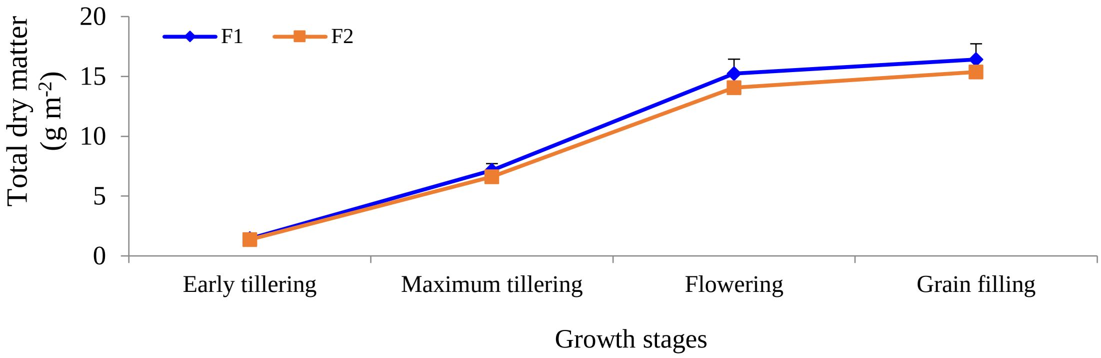
Combined effect of different irrigation regime and fertilizer doses varied significantly in terms of total dry matter of BRRI dhan48 at ETS, MTS, FS and GFS (Table 4.5.9). At ETS, MTS, FS and GFS the highest TDM (186.80, 506.48, 694.17 and 845.60 g m^{-2}, respectively) was observed from I_1F_1, whereas the lowest TDM (159.97, 426.69, 588.95 and 702.01 g m^{-2}, respectively) from I_0F_2.

Combined effect of different irrigation regime and weeding methods varied significantly in terms of total dry matter of BRRI dhan48 at ETS, MTS, FS and GFS (Table 4.5.9). At ETS, MTS, FS and GFS the highest TDM (175.47, 472.96, 649.55 and 783.54 g m^{-2}, respectively) was found from the combination of I_1W_2, whereas the lowest TDM (150.26, 402.28, 554.32 and 648.56 g m^{-2}, respectively) was observed from the combination of I_0W_1.



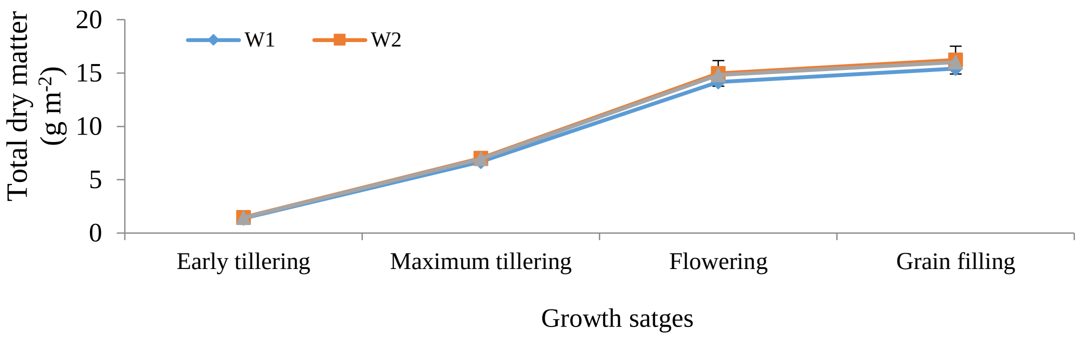
I_0: No irrigation I_1: Supplemental irrigation

Figure 4.5.13. Effect of different irrigation regime on total dry matter of BRRI dhan48 at different growth stages in Aus season (Sx = 1.638, 6.40, 8.94 and 7.90 at ETS, MTS, FS and GFS, respectively).



F_1: Recommended fertilizer dose-RFD F_2: 20% added with RFD

Figure 4.5.14. Effect of different fertilizer doses on total dry matter of BRRI dhan48 at different growth stages in Aus season (Sx = 1.244, 4.33, 6.55 and 5.30 at ETS, MTS, FS and GFS, respectively).



W_1: Hand weeding at 20 and 40 DAT W_2: Pre emergence herbicide use at 4 DAT
W_3: Weeding by BRRI hand weeder at 20 and 40 DAT

Figure 4.5.15. Effect of different weeding methods on total dry matter of BRRI dhan48 at different growth stages in Aus season (Sx = 1.809, 6.03, 9.53 and 7.56 at ETS, MTS, FS and GFS, respectively).

Table 4.5.9. Combined effect of irrigation and fertilizer, irrigation and weeding, fertilizer and weeding on Total Dry Matter-TDM (g m^{-2}) of BRRI dhan48 at different growth stages in Aus season

Treatments combinations	Growth stage			
	Early tillering (ETS)	Maximum tillering (MTS)	Flowering (FS)	Grain filling (GFS)
Irrigation regime × Fertilizer doses				
I_0F_1	160.76 b	431.05 b	593.95 b	706.09 b
I_0F_2	159.97 b	426.69 b	588.95 b	702.01 b
I_1F_1	186.80 a	506.48 a	694.17 a	845.60 a
I_1F_2	161.84 b	435.53 b	599.53 b	712.67 b
Sx value	1.760	6.13	7.49	9.26
Level of significance	0.01	0.01	0.01	0.01
CV(%)	3.15	4.09	3.63	3.74
Irrigation regime × Weeding methods				
I_0W_1	150.26 c	402.28 c	554.32 c	648.56 c
I_0W_2	168.17 ab	449.84 ab	620.39 ab	746.48 ab
I_0W_3	162.67 b	434.49 b	599.63 b	717.11 b
I_1W_1	174.18 a	471.92 a	647.56 a	779.36 a
I_1W_2	175.47 a	472.96 a	649.55 a	783.54 a
I_1W_3	173.30 a	468.13 a	643.43 a	774.51 a
Sx value	2.559	8.53	10.69	13.48
Level of significance	0.01	0.05	0.01	0.01
CV(%)	3.75	4.65	4.23	4.45
Fertilizer doses × Weeding methods				
F_1W_1	166.29 bc	445.22 bc	612.86 bc	734.31 bc
F_1W_2	182.53 a	493.38 a	677.17 a	823.39 a
F_1W_3	171.33 b	461.17 b	634.65 b	763.72 b
F_2W_1	159.45 c	428.39 c	590.78 c	697.78 c
F_2W_2	159.82 c	430.02 c	591.01 c	702.45 c
F_2W_3	164.63 bc	441.45 bc	608.41 bc	727.89 bc
Sx value	2.559	8.53	10.69	13.48
Level of significance	0.01	0.01	0.01	0.01
CV(%)	3.75	4.65	4.23	4.45

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

I_0: No irrigation
I_1: Supplemental irrigation

F_1: Recommended fertilizer dose-RFD
F_2: 20% added with RFD

W_1: Hand weeding at 20 and 40 DAT
W_2: Pre emergence herbicide use at 4 DAT
W_3: Weeding by BRRI hand weeder at 20 and 40 DAT

Combined effect of different fertilizer doses and weeding methods varied significantly in terms of total dry matter of BRRI dhan48 at ETS, MTS, FS and GFS (Table 4.5.9). At ETS, MTS, FS and GFS the highest TDM (182.53, 493.38, 677.17 and 823.39 g m^{-2}, respectively) was recorded from the combination of F_1W_2, while the lowest TDM (159.45, 428.39, 590.78 and 697.78 g m^{-2}, respectively) was recorded from the combination of F_2W_1.

Combined effect of different irrigation regime, fertilizer doses and weeding methods varied significantly in terms of total dry matter of BRRI dhan48 at ETS, MTS, FS, and GFS (Table 4.5.10). At ETS, MTS, FS and GFS the highest TDM (194.32, 529.67, 724.05 and 886.45 g m^{-2}, respectively) was observed from the combination of $I_1F_1W_2$, whereas the lowest TDM (149.19, 402.74, 553.67 and 642.82 g m^{-2}, respectively) was found from the combination of $I_0F_2W_1$.

4.5.6 Crop growth rate (CGR)

Different irrigation regime of BRRI dhan48 varied non-significantly due to Crop growth rate (CGR) at early tillering stage to maximum tillering stage but significantly for maximum tillering stage to flowering stage and flowering stage to grain filling stage (Table 4.5.11). At ETS to MTS, MTS to FS and FS to GFS the highest CGR (19.78, 11.72 and 8.82 g $m^{-2}day^{-1}$, respectively) was found from I_1 and the lowest CGR (17.90, 10.84 and 7.51 g $m^{-2}day^{-1}$, respectively) from I_0.

Statistically significant variation was observed in terms of CGR of BRRI dhan48 at ETS to MTS, MTS to FS and FS to GFS due to different fertilizer doses (Table 4.5.11). At ETS to MTS, MTS to FS and FS to GFS the highest CGR (19.55, 11.66 and 8.82 g $m^{-2}day^{-1}$, respectively) was observed from F_1, while the lowest CGR (18.13, 10.90 and 7.51 g $m^{-2}day^{-1}$, respectively) from F_2.

CGR of BRRI dhan48 at ETS to MTS, MTS to FS and FS to GFS varied significantly due to different weeding methods (Table 4.5.11). At ETS to MTS, MTS to FS and FS to GFS the highest CGR (19.31, 11.54 and 8.60 g $m^{-2}day^{-1}$, respectively) was recorded from W_2 which was statistically similar (18.89, 11.35 and 8.28 g $m^{-2}day^{-1}$, respectively) to W_3, while the lowest CGR (18.32, 10.95 and 7.61 g $m^{-2}day^{-1}$, respectively) was found from W_1.

Table 4.5.10. Combined effect of irrigation, fertilizer and weeding on Total Dry Matter-TDM (g m^{-2}) of BRRI dhan48 at different growth stages in Aus season

Treatments combinations	Growth stage			
	Early tillering (ETS)	Maximum tillering (MTS)	Flowering (FS)	Grain filling (GFS)
$I_0F_1W_1$	151.33 gh	401.82 f	554.97 f	654.29 gh
$I_0F_1W_2$	170.74 cd	457.08 cd	630.30 cd	760.33 cd
$I_0F_1W_3$	157.83 e-h	421.18 d-f	581.58 d-f	691.41 e-h
$I_0F_2W_1$	149.19 h	402.74 f	553.67 f	642.82 h
$I_0F_2W_2$	165.60 d-f	442.61 de	610.49 de	732.63 d-f
$I_0F_2W_3$	167.50 de	447.80 de	617.68 de	742.80 de
$I_1F_1W_1$	181.24 bc	488.62 bc	670.74 bc	814.33 bc
$I_1F_1W_2$	194.32 a	529.67 a	724.05 a	886.45 a
$I_1F_1W_3$	184.83 ab	501.15 ab	687.72 ab	836.03 ab
$I_1F_2W_1$	169.70 de	457.31 cd	628.36 cd	752.74 de
$I_1F_2W_2$	154.04 f-h	414.17 ef	571.08 ef	672.27 f-h
$I_1F_2W_3$	161.77 d-g	435.10 d-f	599.14 d-f	712.99 d-g
Sx value	3.619	12.07	15.12	19.06
Level of significance	0.05	0.05	0.05	0.05
CV(%)	3.75	4.65	4.23	4.45

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

I_0: No irrigation
I_1: Supplemental irrigation

F_1: Recommended fertilizer dose-RFD
F_2: 20% added with RFD

W_1: Hand weeding at 20 and 40 DAT
W_2: Pre emergence herbicide use at 4 DAT
W_3: Weeding by BRRI hand weeder at 20 and 40 DAT

Table 4.5.11. Effect of different irrigation, fertilizer and weeding on Crop Growth Rate-CGR (g $m^{-2}day^{-1}$) of BRRI dhan48 at different growth stages in Aus season

Treatments	Growth stage		
	Early tillering to (ETS) maximum tillering (MTS)	Maximum tillering (MTS) to flowering (FS)	Flowering (FS) to grain filling (GFS)
Irrigation regime			
I_0	17.90	10.84 b	7.51 b
I_1	19.78	11.72 a	8.82 a
Sx value	0.321	0.102	0.126
Level of significance	NS	0.01	0.05
CV(%)	7.23	3.83	6.57
Fertilizer doses			
F_1	19.55 a	11.66 a	8.82 a
F_2	18.13 b	10.90 b	7.51 b
Sx value	0.221	0.074	0.190
Level of significance	0.01	0.01	0.01
CV(%)	4.98	2.76	9.88
Weeding methods			
W_1	18.32 b	10.95 b	7.61 b
W_2	19.31 a	11.54 a	8.60 a
W_3	18.89 ab	11.35 a	8.28 ab
Sx value	0.297	0.109	0.243
Level of significance	0.05	0.01	0.05
CV(%)	5.46	3.35	10.32

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

I_0: No irrigation
I_1: Supplemental irrigation

F_1: Recommended fertilizer dose-RFD
F_2: 20% added with RFD

W_1: Hand weeding at 20 and 40 DAT
W_2: Pre emergence herbicide use at 4 DAT
W_3: Weeding by BRRI hand weeder at 20 and 40 DAT

CGR of BRRI dhan48 at ETS to MTS, MTS to FS and FS to GFS showed statistically significant differences due to the combined effect of different irrigation regime and fertilizer doses (Table 4.5.12). Data revealed that at ETS to MTS, MTS to FS and FS to GFS the highest CGR (21.31, 12.51 and 10.10 g $m^{-2}day^{-1}$, respectively) was observed from the combination of I_1F_1, whereas the lowest CGR (17.78, 10.82 and 7.48 g $m^{-2}day^{-1}$, respectively) was recorded from the combination of I_0F_2.

Combined effect of different irrigation regime and weeding methods varied significantly in terms of CGR of BRRI dhan48 at ETS to MTS, MTS to FS and FS to GFS (Table 4.5.12). At ETS to MTS, MTS to FS and FS to GFS the highest CGR (g $m^{-2}day^{-1}$, respectively) was observed from the combination of I_1W_2, whereas the lowest CGR (g $m^{-2}day^{-1}$, respectively) was recorded from the combination of I_0W_1.

CGR of BRRI dhan48 at ETS to MTS, MTS to FS and FS to GFS showed statistically significant differences due to the combined effect of different fertilizer doses and weeding methods (Table 4.5.12). At ETS to MTS, MTS to FS and FS to GFS the highest CGR (19.85, 11.77 and 8.93 g $m^{-2}day^{-1}$, respectively) was observed from the combination of F_1W_2, whereas the lowest CGR (16.80, 10.14 and 6.28 g $m^{-2}day^{-1}$, respectively) was recorded from the combination of F_2W_1.

Statistically significant differences was observed due to the combined effect of different irrigation regime, fertilizer doses and weeding methods in terms of CGR of BRRI dhan48 at ETS to MTS, MTS to FS and FS to GFS (Table 4.5.13). At ETS to MTS, MTS to FS and FS to GFS the highest CGR (22.36, 12.96 and 10.83 g $m^{-2}day^{-1}$, respectively) was observed from the combination of $I_1F_1W_2$, whereas the lowest CGR (16.70, 10.06 and 5.94 g $m^{-2}day^{-1}$, respectively) was recorded from the combination of $I_0F_2W_1$.

Table 4.5.12. Combined effect of irrigation and fertilizer, irrigation and weeding, fertilizer and weeding on Crop Growth Rate-CGR (g $m^{-2}day^{-1}$) of BRRI dhan48 at different growth stages in Aus season

Treatments combinations	Growth stage		
	Early tillering to (ETS) maximum tillering (MTS)	Maximum tillering (MTS) to flowering (FS)	Flowering (FS) to grain filling (GFS)
Irrigation regime × Fertilizer doses			
I_0F_1	17.78 b	10.82 b	7.48 b
I_0F_2	18.02 b	10.86 b	7.54 b
I_1F_1	21.31 a	12.51 a	10.10 a
I_1F_2	18.25 b	10.93 b	7.54 b
Sx value	0.313	0.104	0.269
Level of significance	0.01	0.01	0.01
CV(%)	4.98	2.76	9.88
Irrigation regime × Weeding methods			
I_0W_1	16.80 c	10.14 c	6.28 b
I_0W_2	18.78 ab	11.37 ab	8.41 a
I_0W_3	18.12 b	11.01 b	7.83 a
I_1W_1	19.83 a	11.71 a	8.79 a
I_1W_2	19.85 a	11.77 a	8.93 a
I_1W_3	19.66 a	11.69 a	8.74 a
Sx value	0.420	0.155	0.344
Level of significance	0.05	0.01	0.01
CV(%)	5.46	3.35	10.32
Fertilizer doses × Weeding methods			
F_1W_1	18.60 bc	11.18 bc	8.10 bc
F_1W_2	20.72 a	12.25 a	9.75 a
F_1W_3	19.32 b	11.57 b	8.60 b
F_2W_1	18.04 bc	10.73 c	7.12 c
F_2W_2	17.90 c	10.83 c	7.44 c
F_2W_3	18.45 bc	11.13 bc	7.97 bc
Sx value	0.420	0.155	0.344
Level of significance	0.05	0.01	0.05
CV(%)	5.46	3.35	10.32

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

I_0: No irrigation
I_1: Supplemental irrigation

F_1: Recommended fertilizer dose-RFD
F_2: 20% added with RFD

W_1: Hand weeding at 20 and 40 DAT
W_2: Pre emergence herbicide use at 4 DAT
W_3: Weeding by BRRI hand weeder at 20 and 40 DAT

Table 4.5.13. Combined effect of irrigation, fertilizer and weeding on Crop Growth Rate-CGR (g $m^{-2}day^{-1}$) of BRRI dhan48 at different growth stages in Aus season

Treatments combinations	Growth stage		
	Early tillering to (ETS) maximum tillering (MTS)	Maximum tillering (MTS) to flowering (FS)	Flowering (FS) to grain filling (GFS)
$I_0F_1W_1$	16.90 d	10.21 g	6.62 fg
$I_0F_1W_2$	19.09 bc	11.55 cd	8.67 b-d
$I_0F_1W_3$	17.56 cd	10.69 e-g	7.32 d-g
$I_0F_2W_1$	16.70 d	10.06 g	5.94 g
$I_0F_2W_2$	18.47 cd	11.19 de	8.14 c-f
$I_0F_2W_3$	18.69 b-d	11.33 de	8.34 b-e
$I_1F_1W_1$	20.49 ab	12.14 bc	9.57 a-c
$I_1F_1W_2$	22.36 a	12.96 a	10.83 a
$I_1F_1W_3$	21.09 a	12.44 ab	9.89 ab
$I_1F_2W_1$	19.17 bc	11.40 de	8.29 b-e
$I_1F_2W_2$	17.34 cd	10.46 fg	6.75 e-g
$I_1F_2W_3$	18.22 cd	10.94 d-f	7.59 d-f
Sx value	0.594	0.219	0.486
Level of significance	0.05	0.05	0.05
CV(%)	5.46	3.35	10.32

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

I_0: No irrigation
I_1: Supplemental irrigation

F_1: Recommended fertilizer dose-RFD
F_2: 20% added with RFD

W_1: Hand weeding at 20 and 40 DAT
W_2: Pre emergence herbicide use at 4 DAT
W_3: Weeding by BRRI hand weeder at 20 and 40 DAT

4.5.7 Relative growth rate (RGR)

Different irrigation regime varied non-significantly in terms of relative growth rate (RGR) of BRRI dhan48 at early tillering stage to maximum tillering stage, maximum tillering stage to flowering stage and flowering stage to grain filling stageS (Table 4.5.14). At ETS to MTS, MTS to FS and FS to GFS the highest RGR (28.76, 9.31 and 5.35 mg $g^{-1}day^{-1}$, respectively) was found from I_1, whereas the lowest RGR (28.47, 9.19 and 5.03 mg $g^{-1}day^{-1}$, respectively) from I_0.

Statistically non-significant variation was observed in terms of RGR of BRRI dhan48 at ETS to MTS, MTS to FS and FS to GFS due to different fertilizer doses (Table 4.5.14). At ETS to MTS, MTS to FS and FS to GFS the highest RGR (28.62, 9.27 and 5.39 mg $g^{-1}day^{-1}$, respectively) was found from F_1, while the lowest RGR (28.61, 9.24 and 4.99 mg $g^{-1}day^{-1}$, respectively) from F_2.

RGR of BRRI dhan48 at ETS to MTS, MTS to FS and FS to GFS varied non-significantly in terms of due to different weeding methods (Table 4.5.14). At ETS to MTS, MTS to FS and FS to GFS the highest RGR (28.64, 9.27 and 5.33 mg $g^{-1}day^{-1}$, respectively) was found from W_2, while the lowest RGR (28.60, 9.24 and 4.98 mg $g^{-1}day^{-1}$, respectively) was observed from W_1.

Combined effect of different irrigation regime and fertilizer doses varied non-significantly in terms of RGR of BRRI dhan48 at ETS to MTS, MTS to FS and FS to GFS (Table 4.5.15). At ETS to MTS, MTS to FS and FS to GFS the highest RGR (28.86, 9.34 and 5.71 mg $g^{-1}day^{-1}$, respectively) was observed from the combination of I_1F_1, whereas the lowest RGR (28.38, 9.13 and 4.98 mg $g^{-1}day^{-1}$, respectively) was recorded from the combination of I_0F_2.

Combined effect of different irrigation regime and weeding methods varied non-significantly in terms of RGR of BRRI dhan48 at ETS to MTS, MTS to FS and FS to GFS (Table 4.5.15). At ETS to MTS, MTS to FS and FS to GFS the highest RGR (28.82, 9.33 and 5.42 mg $g^{-1}day^{-1}$, respectively) was observed from the combination of I_1W_2, whereas the lowest RGR (28.44, 9.18 and 4.54 mg $g^{-1}day^{-1}$, respectively) was recorded from the combination of I_0W_1.

Table 4.5.14. Effect of irrigation, fertilizer and weeding on Relative Growth Rate-RGR (mg $g^{-1}day^{-1}$) of BRRI dhan48 at different growth stages in Aus season

Treatments	Growth stage		
	Early tillering to (ETS) maximum tillering (MTS)	Maximum tillering (MTS) to flowering (FS)	Flowering (FS) to grain filling (GFS)
Irrigation regime			
I_0	28.47	9.19	5.03
I_1	28.76	9.31	5.35
Sx value	0.140	0.041	0.066
Level of significance	NS	NS	NS
CV(%)	2.07	1.87	5.42
Fertilizer doses			
F_1	28.62	9.27	5.39
F_2	28.61	9.24	4.99
Sx value	0.142	0.043	0.105
Level of significance	NS	NS	NS
CV(%)	2.10	1.93	8.56
Weeding methods			
W_1	28.60	9.24	4.98
W_2	28.64	9.27	5.33
W_3	28.61	9.25	5.25
Sx value	0.163	0.047	0.130
Level of significance	NS	NS	NS
CV(%)	1.97	1.75	8.70

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

I_0: No irrigation
I_1: Supplemental irrigation
F_1: Recommended fertilizer dose-RFD
F_2: 20% added with RFD
W_1: Hand weeding at 20 and 40 DAT
W_2: Pre emergence herbicide use at 4 DAT
W_3: Weeding by BRRI hand weeder at 20 and 40 DAT

Table 4.5.15. Combined effect of irrigation and fertilizer, irrigation and weeding, fertilizer and weeding on Relative Growth Rate-RGR (mg $g^{-1}day^{-1}$) of BRRI dhan48 at different growth stages in Aus season

Treatments combinations	Growth stage		
	Early tillering to (ETS) maximum tillering (MTS)	Maximum tillering (MTS) to flowering (FS)	Flowering (FS) to grain filling (GFS)
Irrigation regime × Fertilizer doses			
I_0F_1	28.56	9.28	5.07
I_0F_2	28.38	9.13	4.98
I_1F_1	28.86	9.34	5.71
I_1F_2	28.66	9.25	4.99
Sx value	0.200	0.060	0.148
Level of significance	NS	NS	NS
CV(%)	2.10	1.93	8.56
Irrigation regime × Weeding methods			
I_0W_1	28.44	9.18	4.54
I_0W_2	28.47	9.31	5.36
I_0W_3	28.50	9.28	5.17
I_1W_1	28.71	9.19	5.30
I_1W_2	28.82	9.33	5.42
I_1W_3	28.76	9.21	5.33
Sx value	0.231	0.066	0.184
Level of significance	NS	NS	NS
CV(%)	1.97	1.75	8.70
Fertilizer doses × Weeding methods			
F_1W_1	28.73	9.26	5.19
F_1W_2	28.74	9.31	5.66
F_1W_3	28.64	9.26	5.33
F_2W_1	28.49	9.19	4.78
F_2W_2	28.55	9.21	5.00
F_2W_3	28.56	9.29	5.18
Sx value	0.231	0.066	0.184
Level of significance	NS	NS	NS
CV(%)	1.97	1.75	8.70

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

I_0: No irrigation
I_1: Supplemental irrigation
F_1: Recommended fertilizer dose-RFD
F_2: 20% added with RFD
W_1: Hand weeding at 20 and 40 DAT
W_2: Pre emergence herbicide use at 4 DAT
W_3: Weeding by BRRI hand weeder at 20 and 40 DAT

Combined effect of different fertilizer doses and weeding methods varied non-significantly in terms of RGR of BRRI dhan48 at ETS to MTS, MTS to FS and FS to GFS (Table 4.5.15). At ETS to MTS, MTS to FS and FS to GFS the highest RGR (28.74, 9.31 and 5.66 mg $g^{-1}day^{-1}$, respectively) was observed from the combination of F_1W_2 and the lowest RGR (28.49, 9.19 and 4.78 mg $g^{-1}day^{-1}$, respectively) was recorded from the combination of F_2W_1.

Statistically non-significant differences was observed in terms of RGR of BRRI dhan48 at ETS to MTS, MTS to FS and FS to GFS due to the combined effect of different irrigation regime, fertilizer doses and weeding methods (Table 4.5.16). At ETS to MTS, MTS to FS and FS to GFS the highest RGR (29.00, 9.36 and 5.87 mg $g^{-1}day^{-1}$, respectively) was observed from the combination of $I_1F_1W_2$, whereas the lowest RGR (28.26, 9.15 and 4.32 mg $g^{-1}day^{-1}$, respectively) was recorded from the combination of $I_0F_2W_1$.

4.5.8 Net assimilation rate (NAR)

Net assimilation rate (NAR) of BRRI dhan48 showed non-statistically significant differences due to different irrigation regime at early tillering stage to maximum tillering stage, maximum tillering stage to flowering stage and flowering satge to grain filling stage (Table 4.5.17). At ETS to MTS, MTS to FS and FS to GFS the highest NAR (7.96, 1.60 and 0.80 g $m^{-2}day^{-1}$, respectively) was observed from I_1, whereas the lowest NAR (7.82, 1.58 and 0.74 g $m^{-2}day^{-1}$, respectively) was recorded from I_0.

Statistically non-significant variation was observed in terms of NAR of BRRI dhan48 at ETS to MTS but significant at MTS to FS and FS to GFS due to different fertilizer doses (Table 4.5.17). At ETS to MTS, MTS to FS and FS to GFS the highest NAR (7.90, 1.60 and 0.80 g $m^{-2}day^{-1}$, respectively) was found from F_1, while the lowest NAR (7.88, 1.58 and 0.74 g $m^{-2}day^{-1}$, respectively) was observed from F_2.

Table 4.5.16. Combined effect of irrigation, fertilizer and weeding on Relative Growth Rate-RGR (mg $g^{-1}day^{-1}$) of BRRI dhan48 at different growth stages in Aus season

Treatments combinations	Growth stage		
	Early tillering to (ETS) maximum tillering (MTS)	Maximum tillering (MTS) to flowering (FS)	Flowering (FS) to grain filling (GFS)
$I_0F_1W_1$	28.26	9.15	4.32
$I_0F_1W_2$	28.48	9.32	5.45
$I_0F_1W_3$	28.41	9.35	5.01
$I_0F_2W_1$	28.75	9.22	4.76
$I_0F_2W_2$	28.46	9.31	5.28
$I_0F_2W_3$	28.48	9.31	5.33
$I_1F_1W_1$	28.71	9.17	5.61
$I_1F_1W_2$	29.00	9.36	5.87
$I_1F_1W_3$	28.88	9.16	5.64
$I_1F_2W_1$	28.70	9.20	5.23
$I_1F_2W_2$	28.64	9.30	4.72
$I_1F_2W_3$	28.65	9.26	5.03
Sx value	0.326	0.094	0.261
Level of significance	NS	NS	NS
CV(%)	1.97	1.75	8.70

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

I_0: No irrigation
I_1: Supplemental irrigation

F_1: Recommended fertilizer dose-RFD
F_2: 20% added with RFD

W_1: Hand weeding at 20 and 40 DAT
W_2: Pre emergence herbicide use at 4 DAT
W_3: Weeding by BRRI hand weeder at 20 and 40 DAT

Table 4.5.17. Effect of irrigation, fertilizer and weeding on Net Assimilation Rate-NAR (g $m^{-2}day^{-1}$) of BRRI dhan48 at different growth stages in Aus season

Treatments	Growth stage		
	Early tillering to (ETS) maximum tillering (MTS)	Maximum tillering (MTS) to flowering (FS)	Flowering (FS) to grain filling (GFS)
Irrigation regime			
I_0	7.82	1.58	0.74
I_1	7.96	1.60	0.80
Sx value	0.095	0.003	0.010
Level of significance	NS	NS	NS
CV(%)	5.12	1.99	5.82
Fertilizer doses			
F_1	7.90	1.60 a	0.80 a
F_2	7.88	1.58 b	0.74 b
Sx value	0.099	0.002	0.014
Level of significance	NS	0.01	0.05
CV(%)	5.36	1.99	8.22
Weeding methods			
W_1	7.82	1.58	0.74
W_2	7.93	1.60	0.79
W_3	7.91	1.59	0.78
Sx value	0.088	0.008	0.021
Level of significance	NS	NS	NS
CV(%)	3.86	1.83	9.20

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

I_0: No irrigation
I_1: Supplemental irrigation

F_1: Recommended fertilizer dose-RFD
F_2: 20% added with RFD

W_1: Hand weeding at 20 and 40 DAT
W_2: Pre emergence herbicide use at 4 DAT
W_3: Weeding by BRRI hand weeder at 20 and 40 DAT

Statistically non-significant variation was observed in terms of NAR of BRRI dhan48 at ETS to MTS, MTS to FS and FS to GFS due to different weeding methods (Table 4.5.17). At ETS to MTS, MTS to FS and FS to GFS the highest NAR (7.93, 1.60 and 0.79 g $m^{-2}day^{-1}$, respectively) was found from W_2, while the lowest NAR (7.82, 1.58 and 0.74 g $m^{-2}day^{-1}$, respectively) from W_1.

Combined effect of different irrigation regime and fertilizer doses varied non-significantly in terms of NAR of BRRI dhan48 at ETS to MTS but significant for MTS to FS and FS to GFS (Table 4.5.18). At ETS to MTS, MTS to FS and FS to GFS the highest NAR (8.01, 1.61 and 0.86 g $m^{-2}day^{-1}$, respectively) was observed from the combination of I_1F_1, whereas the lowest NAR (7.75, 1.57 and 0.73 g $m^{-2}day^{-1}$, respectively) was recorded from the combination of I_0F_2.

Combined effect of different irrigation regime and weeding methods varied non-significantly in terms of NAR of BRRI dhan48 at ETS to MTS and FS to GFS but significant at MTS to FS (Table 4.5.18). At ETS to MTS, MTS to FS and FS to GFS the highest NAR (8.05, 1.62 and 0.81 g $m^{-2}day^{-1}$, respectively) was observed from the combination of I_1W_2, whereas the lowest NAR (7.74, 1.56 and 0.67 g $m^{-2}day^{-1}$, respectively) was recorded from the combination of I_0W_1.

Combined effect of different fertilizer doses and weeding methods varied non-significantly in terms of NAR of BRRI dhan48 at ETS to MTS, MTS to FS and FS to GFS (Table 4.5.18). At ETS to MTS, MTS to FS and FS to GFS the highest NAR (8.04, 1.61 and 0.85 g $m^{-2}day^{-1}$, respectively) was observed from the combination of F_1W_2, whereas the lowest NAR (7.81, 1.57 and 0.71 g $m^{-2}day^{-1}$, respectively) was recorded from the combination of F_2W_1.

Combined effect of different irrigation regime, fertilizer doses and weeding methods varied significantly in terms of NAR of BRRI dhan48 at ETS to MTS, MTS to FS and FS to GFS (Table 4.5.19). At ETS to MTS, MTS to FS and FS to GFS the highest NAR (8.19, 1.63 and 0.91 g $m^{-2}day^{-1}$, respectively) was observed from the combination of $I_1F_1W_2$, whereas the lowest NAR (7.73, 1.55 and 0.65 g $m^{-2}day^{-1}$, respectively) was recorded from $I_0F_2W_1$.

Table 4.5.18. Combined effect of irrigation and fertilizer, irrigation and weeding, fertilizer and weeding on Net Assimilation Rate-NAR (g m^{-2}day^{-1}) of BRRI dhan48 at different growth stages in Aus season

Treatments combinations	Growth stage		
	Early tillering to (ETS) maximum tillering (MTS)	Maximum tillering (MTS) to flowering (FS)	Flowering (FS) to grain filling (GFS)
Irrigation regime × Fertilizer doses			
I_0F_1	7.88	1.60 a	0.74 b
I_0F_2	7.75	1.57 b	0.73 b
I_1F_1	8.01	1.61 a	0.86 a
I_1F_2	7.91	1.60 a	0.74 b
Sx value	0.141	0.003	0.020
Level of significance	NS	0.01	0.05
CV(%)	5.36	1.99	8.22
Irrigation regime × Weeding methods			
I_0W_1	7.74	1.56 b	0.67
I_0W_2	7.77	1.58 b	0.79
I_0W_3	7.93	1.59 ab	0.76
I_1W_1	7.94	1.61 a	0.80
I_1W_2	8.05	1.62 a	0.81
I_1W_3	7.90	1.57 b	0.79
Sx value	0.124	0.012	0.030
Level of significance	NS	0.01	NS
CV(%)	3.86	1.83	9.20
Fertilizer doses × Weeding methods			
F_1W_1	7.83	1.59	0.77
F_1W_2	8.04	1.61	0.85
F_1W_3	7.83	1.58	0.79
F_2W_1	7.81	1.57	0.71
F_2W_2	7.83	1.60	0.74
F_2W_3	7.99	1.59	0.77
Sx value	0.124	0.012	0.030
Level of significance	NS	NS	NS
CV(%)	3.86	1.83	9.53

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

I_0: No irrigation
I_1: Supplemental irrigation

F_1: Recommended fertilizer dose-RFD
F_2: 20% added with RFD

W_1: Hand weeding at 20 and 40 DAT
W_2: Pre emergence herbicide use at 4 DAT
W_3: Weeding by BRRI hand weeder at 20 and 40 DAT

Table 4.5.19. Combined effect of irrigation, fertilizer and weeding on Net Assimilation Rate-NAR (g $m^{-2}day^{-1}$) of BRRI dhan48 at different growth stages in Aus season

Treatments combinations	Growth stage		
	Early tillering to (ETS) maximum tillering (MTS)	Maximum tillering (MTS) to flowering (FS)	Flowering (FS) to grain filling (GFS)
$I_0F_1W_1$	8.13	1.62	0.70
$I_0F_1W_2$	7.80	1.57	0.79
$I_0F_1W_3$	7.74	1.60	0.74
$I_0F_2W_1$	7.73	1.55	0.65
$I_0F_2W_2$	7.75	1.59	0.78
$I_0F_2W_3$	7.75	1.58	0.79
$I_1F_1W_1$	7.92	1.56	0.83
$I_1F_1W_2$	8.19	1.63	0.91
$I_1F_1W_3$	7.93	1.59	0.83
$I_1F_2W_1$	7.95	1.58	0.77
$I_1F_2W_2$	7.92	1.62	0.69
$I_1F_2W_3$	7.88	1.60	0.74
Sx value	0.176	0.017	0.042
Level of significance	NS	NS	NS
CV(%)	3.86	1.83	9.20

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

I_0: No irrigation
I_1: Supplemental irrigation
F_1: Recommended fertilizer dose-RFD
F_2: 20% added with RFD
W_1: Hand weeding at 20 and 40 DAT
W_2: Pre emergence herbicide use at 4 DAT
W_3: Weeding by BRRI hand weeder at 20 and 40 DAT

4.5.9 Crop duration

Crop duration of BRRI dhan48 showed statistically significant differences due to different irrigation regime (Table 4.5.20). Data revealed that the highest crop duration (111.94 days) was found from I_1 and the lowest crop duration (105.95 days) was observed from I_0.

Different fertilizer doses showed statistically significant differences in terms of crop duration of BRRI dhan48 (Table 4.5.20). The highest crop duration (112.17 days) was recorded from F_2, while the lowest crop duration (105.72 days) was found from F_2.

Statistically non-significant variation was observed in terms of crop duration of BRRI dhan48 due to different weeding methods (Table 4.5.20). The highest crop duration (110.17 days) was found from W_1, while the lowest crop duration (107.83 days) was observed from W_1.

Crop duration of BRRI dhan48 showed statistically significant differences due to the combined effect of different irrigation regime and fertilizer doses (Table 4.5.21). The highest crop duration (118.11 days) was observed from the combination of I_1F_2, while the lowest crop duration (105.67 days) was found from the combination of I_0F_1.

Combined effect of different irrigation regime and weeding methods varied significantly in terms of crop duration of BRRI dhan48 (Table 4.5.21). The highest crop duration (109.83 days) was found from the combination of I_0W_1, whereas the lowest crop duration (103.33 days) was recorded from the combination of I_0W_2.

Combined effect of different fertilizer doses and weeding methods varied significantly in terms of crop duration of BRRI dhan48 (Table 4.5.21). The highest crop duration (113.00 days) was recorded from the combination of F_2W_2, whereas the lowest crop duration (102.67 days) was found from the combination of F_2W_1.

Table 4.5.20. Effect of irrigation, fertilizer and weeding on crop duration, effective, non-effective and total tillers hill^{-1} of BRRI dhan48 in Aus season

Treatments	Crop duration (days)	Total tillers hill^{-1} (No.)	Effective tillers hill^{-1} (No.)	Non-effective tillers hill^{-1} (No.)
Irrigation regime				
I_0	105.94 b	14.51 b	12.21 b	2.30 a
I_1	111.94 a	15.56 a	13.40 a	2.12 b
Sx value	0.836	0.162	0.183	0.021
Level of significance	0.05	0.05	0.05	0.05
CV(%)	3.26	4.92	6.05	4.05
Fertilizer doses				
F_1	105.72 b	15.73 a	13.69 a	2.01 b
F_2	112.17 a	14.33 b	11.92 b	2.41 a
Sx value	0.502	0.094	0.086	0.029
Level of significance	0.01	0.01	0.01	0.01
CV(%)	1.95	11.99	2.84	5.72
Weeding methods				
W_1	110.17	14.45 b	12.10 b	2.35 a
W_2	107.83	15.45 a	13.28 a	2.12 b
W_3	108.83	15.20 a	13.03 a	2.17 b
Sx value	1.127	0.213	0.217	0.051
Level of significance	NS	0.01	0.01	0.01
CV(%)	3.58	4.91	5.87	8.05

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

I_0: No irrigation
I_1: Supplemental irrigation

F_1: Recommended fertilizer dose-RFD
F_2: 20% added with RFD

W_1: Hand weeding at 20 and 40 DAT
W_2: Pre emergence herbicide use at 4 DAT
W_3: Weeding by BRRI hand weeder at 20 and 40 DAT

Table 4.5.21. Combined effect of irrigation and fertilizer, irrigation and weeding, fertilizer and weeding on crop duration, effective, non-effective and total tillers hill^{-1} of BRRI dhan48 in Aus season

Treatments combinations	Crop duration (days)	Total tillers hill^{-1} (No.)	Effective tillers hill^{-1} (No.)	Non-effective tillers hill^{-1} (No.)
Irrigation regime × Fertilizer doses				
I_0F_1	105.67 b	14.67 b	12.42 b	2.24 b
I_0F_2	106.22 b	14.36 b	12.00 bc	2.36 ab
I_1F_1	105.78 b	16.80 a	14.96 a	1.78 c
I_1F_2	118.11 a	14.31 b	11.84 c	2.47 a
Sx value	0.709	0.133	0.121	0.042
Level of significance	0.01	0.01	0.01	0.01
CV(%)	1.95	11.99	2.84	5.72
Irrigation regime × Weeding methods				
I_0W_1	109.83 a	13.40 b	10.73 b	2.67 a
I_0W_2	103.33 b	15.33 a	13.30 a	2.03 b
I_0W_3	104.67 b	14.80 a	12.60 a	2.20 b
I_1W_1	110.50 a	15.50 a	13.47 a	2.03 b
I_1W_2	112.33 a	15.57 a	13.27 a	2.20 b
I_1W_3	113.00 a	15.60 a	13.47 a	2.13 b
Sx value	1.594	0.302	0.307	0.073
Level of significance	0.05	0.05	0.01	0.01
CV(%)	3.58	4.91	5.87	8.05
Fertilizer doses × Weeding methods				
F_1W_1	108.50 ab	15.03 bc	12.90 b	2.13 c
F_1W_2	102.67 c	16.57 a	14.67 a	1.80 d
F_1W_3	106.00 bc	15.60 b	13.50 b	2.10 c
F_2W_1	111.83 a	13.87 d	11.30 d	2.57 a
F_2W_2	113.00 a	14.33 cd	11.90 cd	2.43 ab
F_2W_3	111.67 a	14.80 b-d	12.57 bc	2.23 bc
Sx value	1.594	0.302	0.307	0.073
Level of significance	0.05	0.05	0.05	0.01
CV(%)	3.58	4.91	5.87	8.05

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

I_0: No irrigation
I_1: Supplemental irrigation
F_1: Recommended fertilizer dose-RFD
F_2: 20% added with RFD
W_1: Hand weeding at 20 and 40 DAT
W_2: Pre emergence herbicide use at 4 DAT
W_3: Weeding by BRRI hand weeder at 20 and 40 DAT

Combined effect of different irrigation regime, fertilizer doses and weeding methods varied significantly in terms of crop duration of BRRI dhan48 (Table 4.5.22). The highest crop duration (120.33 days) was found from the combination of $I_1F_2W_3$, whereas the lowest crop duration (100.67 days) was found from $I_0F_1W_2$.

4.5.10 Number of total tillers hill^{-1}

Number of total tillers hill^{-1} of BRRI dhan48 showed statistically significant differences due to different irrigation regime (Table 4.5.20). The maximum number of total tillers hill^{-1} (15.56) was observed from I_1, whereas the minimum number (14.51) was recorded from I_0.

Statistically significant variation was observed in terms of number of total tillers hill^{-1} of BRRI dhan48 due to different fertilizer doses (Table 4.5.20). The maximum number of total tillers hill^{-1} (15.73) was recorded from F_1, while the minimum number (14.33) was found from F_2. Vetayasuporn (2012) reported that maximum number of total panicle hill^{-1} (14.82) from RFD-chemical fertilizer.

Statistically significant variation was observed in terms of number of total tillers hill^{-1} of BRRI dhan48 due to different weeding methods (Table 4.5.20). The maximum number of total tillers hill^{-1} (15.45) was found from W_2 which was statistically similar (15.20) to W_3, whereas the minimum number (14.45) was observed from W_1.

Combined effect of different irrigation regime and fertilizer doses varied significantly in terms of number of total tillers hill^{-1} of BRRI dhan48 (Table 4.5.21). The maximum number of total tillers hill^{-1} (16.80) was found from the combination of I_1F_1, while the minimum number (14.31) was recorded from I_1F_2.

Combined effect of different irrigation regime and weeding methods varied significantly in terms of number of total tillers hill^{-1} of BRRI dhan48 (Table 4.5.21). The maximum number of total tillers hill^{-1} (15.60) was observed from the combination of I_1W_3, whereas the minimum number (13.40) was recorded from the combination of I_0W_1.

Table 4.5.22. Combined effect of irrigation, fertilizer and weeding on crop duration, effective, non-effective and total tillers hill^{-1} of BRRI dhan48 in Aus season

Treatments combinations	Crop duration (days)	Total tillers hill^{-1} (No.)	Effective tillers hill^{-1} (No.)	Non-effective tillers hill^{-1} (No.)
$I_0F_1W_1$	110.00 bc	13.87 e-g	11.40 f-h	2.47 bc
$I_0F_1W_2$	100.67 d	15.73 b-d	13.80 b-d	1.93 e-g
$I_0F_1W_3$	106.33 cd	14.40 d-f	12.07 e-g	2.33 cd
$I_0F_2W_1$	109.67 bc	12.93 g	10.07 h	2.87 a
$I_0F_2W_2$	106.00 cd	14.93 c-f	12.80 d-f	2.13 c-f
$I_0F_2W_3$	103.00 cd	15.20 c-e	13.13 c-e	2.07 d-f
$I_1F_1W_1$	107.00 b-d	16.20 a-c	14.40 a-c	1.80 fg
$I_1F_1W_2$	104.67 cd	17.40 a	15.53 a	1.67 g
$I_1F_1W_3$	105.67 cd	16.80 ab	14.93 ab	1.87 fg
$I_1F_2W_1$	114.00 ab	14.80 c-f	12.53 d-f	2.27 c-e
$I_1F_2W_2$	120.00 a	13.73 fg	11.00 gh	2.73 ab
$I_1F_2W_3$	120.33 a	14.40 d-f	12.00 e-g	2.40 cd
Sx value	2.255	0.427	0.434	0.103
Level of significance	0.05	0.05	0.05	0.05
CV(%)	3.58	4.91	5.87	8.05

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

I_0: No irrigation
I_1: Supplemental irrigation

F_1: Recommended fertilizer dose-RFD
F_2: 20% added with RFD

W_1: Hand weeding at 20 and 40 DAT
W_2: Pre emergence herbicide use at 4 DAT
W_3: Weeding by BRRI hand weeder at 20 and 40 DAT

Combined effect of different fertilizer doses and weeding methods varied significantly in terms of number of total tillers hill^{-1} of BRRI dhan48 (Table 4.5.21). The maximum number of total tillers hill^{-1} (16.57) was observed from the combination of F_1W_2, whereas the minimum number (13.87) was found from the combination of F_2W_1.

Combined effect of different irrigation regime, fertilizer doses and weeding methods varied significantly in terms of number of total tillers hill^{-1} of BRRI dhan48 (Table 4.5.22). The maximum number of total tillers hill^{-1} (17.40) was found from the combination of $I_1F_1W_2$, while the minimum number (12.93) was recorded from the combination of $I_0F_2W_1$.

4.5.11 Number of effective tillers hill^{-1}

Number of effective tillers hill^{-1} of BRRI dhan48 showed statistically significant differences due to different irrigation regime (Table 4.5.20). The maximum number of effective tillers hill^{-1} (13.40) was observed from I_1, whereas the minimum number (12.21) was found from I_0. Haque *et al.* (2015) reported that stagnation of water and continuous 2-5 cm standing water in the field had no significant effect on number of effective tillers hill^{-1}.

Statistically significant variation was observed in terms of number of effective tillers hill^{-1} of BRRI dhan48 due to different fertilizer doses (Table 4.5.20). The maximum number of effective tillers hill^{-1} (13.69) was recorded from F_1, while the minimum number (11.92) was observed from F_2.

Statistically significant variation was observed in terms of number of effective tillers hill^{-1} of BRRI dhan48 due to different weeding methods (Table 4.5.20). The maximum number of effective tillers hill^{-1} (13.28) was found from W_2 which was statistically similar (13.03) to W_3, while the minimum number (12.10) was observed from W_1.

Combined effect of different irrigation regime and fertilizer doses varied significantly in terms of number of effective tillers hill^{-1} of BRRI dhan48 (Table

4.5.21). The maximum number of effective tillers hill^{-1} (14.96) was observed from the combination of I_1F_1, whereas the minimum number (11.84) was found from the combination of I_1F_2.

Combined effect of different irrigation regime and weeding methods varied significantly in terms of number of effective tillers hill^{-1} of BRRI dhan48 (Table 4.5.21). The maximum number of effective tillers hill^{-1} (13.47) was found from the combination of I_1W_1 and I_1W_3, whereas the minimum number (10.73) was attained from the combination of I_0W_1.

Combined effect of different fertilizer doses and weeding methods varied significantly in terms of number of effective tillers hill^{-1} of BRRI dhan48 (Table 4.5.21). The maximum number of effective tillers hill^{-1} (14.67) was observed from the combination of F_1W_2, whereas the minimum number (11.30) was found from the combination of F_2W_1.

Combined effect of different irrigation regime, fertilizer doses and weeding methods varied significantly in terms of number of effective tillers hill^{-1} of BRRI dhan48 (Table 4.5.22). The maximum number of effective tillers hill^{-1} (15.53) was observed from the combination of $I_1F_1W_2$, whereas the minimum number (10.07) was recorded from the combination of $I_0F_2W_1$.

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

Number of non-effective tillers hill^{-1} of BRRI dhan48 showed statistically significant differences due to different irrigation regime (Table 4.5.20). The minimum number of non-effective tillers hill^{-1} (2.12) was observed from I_1, whereas the maximum number (2.30) was recorded from I_0.

Statistically significant variation was observed in terms of number of non-effective tillers hill^{-1} of BRRI dhan48 due to different fertilizer doses (Table 4.5.20). The minimum number of non-effective tillers hill^{-1} (2.01) was recorded from F_1, while the maximum number (2.41) was observed from F_2.

Statistically significant variation was observed in terms of number of non-effective tillers hill^{-1} of BRRI dhan48 due to different weeding methods (Table 4.5.20). The minimum number of non-effective tillers hill^{-1} (2.12) was found from W_2 which was statistically similar (2.17) to W_3, while the maximum number (2.35) was observed from W_1.

Combined effect of different irrigation regime and fertilizer doses varied significantly in terms of number of non-effective tillers hill^{-1} of BRRI dhan48 (Table 4.5.21). The minimum number of non-effective tillers hill^{-1} (1.78) was found from the combination of I_1F_1, whereas the maximum number (2.47) was recorded from the combination of I_1F_2.

Combined effect of different irrigation regime and weeding methods varied significantly in terms of number of non-effective tillers hill^{-1} of BRRI dhan48 (Table 4.5.21). The minimum number of non-effective tillers hill^{-1} (2.03) was found from the combination of I_0W_2 and I_1W_1, whereas the maximum number (2.67) was recorded from the combination of I_0W_1.

Combined effect of different fertilizer doses and weeding methods varied significantly in terms of number of non-effective tillers hill^{-1} of BRRI dhan48 (Table 4.5.21). The minimum number of non-effective tillers hill^{-1} (1.80) was observed from the combination of F_1W_2, whereas the maximum number (2.57) was recorded from the combination of F_2W_1.

Combined effect of different irrigation regime, fertilizer doses and weeding methods varied significantly in terms of number of non-effective tillers hill^{-1} of BRRI dhan48 (Table 4.5.22). The minimum number of non-effective tillers hill^{-1} (1.67) was found from the combination of $I_1F_1W_2$ and the maximum number (2.87) was recorded from the combination of $I_0F_2W_1$.

4.5.13 Panicle length

Panicle length of BRRI dhan48 showed statistically significant differences due to different irrigation regime (Table 4.5.23). The longest panicle (23.59 cm) was observed from I_1, whereas the shortest panicle (22.07 cm) was recorded from I_0. Wang *et al*. (2006) reported that compared with conventional cultivars, the high yielding varieties had larger panicles.

Statistically significant variation was observed in terms of panicle length of BRRI dhan48 due to different fertilizer doses (Table 4.5.23). The longest panicle (23.48 cm) was found from F_1, while the shortest panicle (22.18 cm) was observed from F_2.

Statistically significant variation was observed in terms of panicle length of BRRI dhan48 due to different weeding methods (Table 4.5.23). Data revealed that the longest panicle (23.19 cm) was found from W_2 which was statistically similar (23.09 cm) to W_3, while the shortest panicle (22.21 cm) was observed from W_1. Kishore *et al.* (2016) reported maximum length of panicle^{-1} with two hand weeding.

Combined effect of different irrigation regime and fertilizer doses varied significantly in terms of panicle length of BRRI dhan48 (Table 4.5.24). The longest panicle (24.88 cm) was observed from the combination of I_1F_1, whereas the shortest panicle (22.06 cm) was recorded from the combination of I_0F_2.

Combined effect of different irrigation regime and weeding methods varied significantly in terms of panicle length of BRRI dhan48 (Table 4.5.24). The longest panicle (23.92 cm) was observed from the combination of I_1W_1 and the shortest panicle (20.50 cm) was found from the combination of I_0W_1.

Combined effect of different fertilizer doses and weeding methods varied significantly in terms of panicle length of BRRI dhan48 (Table 4.5.24). The longest panicle (24.26 cm) was observed from the combination of F_1W_2, whereas the shortest panicle (21.61 cm) was found from the combination of F_2W_1.

Table 4.5.23. Effect of irrigation, fertilizer and weeding on panicle length, filled, unfilled, total grains panicle^{-1} and weight of 1000 grains of BRRI dhan48 in Aus season

Treatments	Panicle length (cm)	Filled grains panicle^{-1} (No.)	Unfilled grains panicle^{-1} (No.)	Total grains panicle^{-1} (No.)	Weights of 1000 grains (g)
Irrigation regime					
I_0	22.07 b	108.14 b	7.07 a	115.20 b	21.70 b
I_1	23.59 a	118.07 a	6.56 b	124.62 a	23.56 a
Sx value	0.210	1.102	0.048	1.131	0.168
Level of significance	0.05	0.05	0.05	0.05	0.01
CV(%)	3.91	4.13	2.97	4.00	3.15
Fertilizer doses					
F_1	23.48 a	117.37 a	6.54 b	123.92 a	23.53 a
F_2	22.18 b	108.83 b	7.08 a	115.91 b	21.73 b
Sx value	0.276	0.725	0.048	0.750	0.192
Level of significance	0.05	0.01	0.01	0.01	0.01
CV(%)	5.12	2.72	3.01	2.65	3.60
Weeding methods					
W_1	22.21 b	109.57 b	7.07 a	116.64 b	22.49
W_2	23.19 a	116.08 a	6.67 b	122.75 a	22.92
W_3	23.09 a	113.65 a	6.70 b	120.35 ab	22.48
Sx value	0.264	1.275	0.107	1.258	0.364
Level of significance	0.05	0.01	0.05	0.01	NS
CV(%)	4.01	3.91	5.46	3.63	5.58

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

I_0: No irrigation
I_1: Supplemental irrigation

F_1: Recommended fertilizer dose-RFD
F_2: 20% added with RFD

W_1: Hand weeding at 20 and 40 DAT
W_2: Pre emergence herbicide use at 4 DAT
W_3: Weeding by BRRI hand weeder at 20 and 40 DAT

Table 4.5.24. Combined effect of irrigation and fertilizer, irrigation and weeding, fertilizer and weeding on panicle length, filled, unfilled, total grains panicle^{-1} and weight of 1000 grains of BRRI dhan48 in Aus season

Treatments combinations	Panicle length (cm)	Filled grains panicle^{-1} (No.)	Unfilled grains panicle^{-1} (No.)	Total grains panicle^{-1} (No.)	Weights of 1000 grains (g)
Irrigation regime × Fertilizer doses					
I_0F_1	22.08 b	107.70 b	7.02 a	114.72 b	21.72 b
I_0F_2	22.06 b	108.58 b	7.11 a	115.69 b	21.69 b
I_1F_1	24.88 a	127.04 a	6.07 b	133.11 a	25.35 a
I_1F_2	22.30 b	109.09 b	7.04 a	116.13 b	21.77 b
Sx value	0.390	1.025	0.069	1.060	0.271
Level of significance	0.05	0.01	0.01	0.01	0.01
CV(%)	5.12	2.72	3.01	2.65	3.60
Irrigation regime × Weeding methods					
I_0W_1	20.50 c	100.88 c	7.63 a	108.51 c	20.73 c
I_0W_2	23.19 ab	113.70 ab	6.70 b	120.40 ab	22.56 b
I_0W_3	22.51 b	109.83 b	6.87 b	116.70 b	21.82 bc
I_1W_1	23.92 a	118.27 a	6.50 b	124.77 a	24.26 a
I_1W_2	23.18 ab	118.47 a	6.63 b	125.10 a	23.28 ab
I_1W_3	23.67 ab	117.47 a	6.53 b	124.00 a	23.14 ab
Sx value	0.374	1.804	0.152	1.779	0.515
Level of significance	0.01	0.01	0.01	0.01	0.05
CV(%)	4.01	3.91	5.46	3.63	5.58
Fertilizer doses × Weeding methods					
F_1W_1	22.82 bc	111.65 bc	6.83 ab	118.48 bc	23.09 ab
F_1W_2	24.26 a	124.30 a	6.27 c	130.57 a	24.56 a
F_1W_3	23.35 ab	116.17 b	6.53 bc	122.70 b	22.95 a-c
F_2W_1	21.61 d	107.50 c	7.30 a	114.80 c	21.90 bc
F_2W_2	22.11 cd	107.87 c	7.07 a	114.93 c	21.29 c
F_2W_3	22.83 bc	111.13 bc	6.87 ab	118.00 bc	22.01 bc
Sx value	0.374	1.804	0.152	1.779	0.515
Level of significance	0.05	0.01	0.05	0.01	0.05
CV(%)	4.01	3.91	5.46	3.63	5.58

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

I_0: No irrigation
I_1: Supplemental irrigation
F_1: Recommended fertilizer dose-RFD
F_2: 20% added with RFD
W_1: Hand weeding at 20 and 40 DAT
W_2: Pre emergence herbicide use at 4 DAT
W_3: Weeding by BRRI hand weeder at 20 and 40 DAT

Combined effect of different irrigation regime, fertilizer doses and weeding methods varied significantly in terms of panicle length of BRRI dhan48 (Table 4.5.25). The longest panicle (25.05 cm) was observed from the combination of $I_1F_1W_2$, while the shortest panicle (20.10 cm) was recorded from $I_0F_2W_1$.

4.5.14 Filled grains panicle^{-1}

Number of filled grains panicle^{-1} of BRRI dhan48 showed statistically significant differences due to different irrigation regime (Table 4.5.23). The maximum number of filled grains panicle^{-1} (118.07) was observed from I_1 and the minimum number (108.14) was recorded from I_0.

Statistically significant variation was observed in terms of number of filled grains panicle^{-1} of BRRI dhan48 due to different fertilizer doses (Table 4.5.23). The maximum number of filled grains panicle^{-1} (117.37) was found from F_1, whereas the minimum number (108.83) was observed from F_2.

Statistically significant variation was observed in terms of number of filled grains panicle^{-1} of BRRI dhan48 due to different weeding methods (Table 4.5.23). The maximum number of filled grains panicle^{-1} (116.08) was recorded from W_2 which was statistically similar (113.65) to W_3, while the minimum number (109.57) was observed from W_1.

Combined effect of different irrigation regime and fertilizer doses varied significantly in terms of number of filled grains panicle^{-1} of BRRI dhan48 (Table 4.5.24). The maximum number of filled grains panicle^{-1} (127.04) was found from the combination of I_1F_1, whereas the minimum number (107.70) was recorded from the combination of I_0F_1.

Combined effect of different irrigation regime and weeding methods varied significantly in terms of number of filled grains panicle^{-1} of BRRI dhan48 (Table 4.5.24). The maximum number of filled grains panicle^{-1} (118.47) was observed from the combination of I_1W_2, whereas the minimum number (100.88) was recorded from the combination of I_0W_1.

Table 4.5.25. Combined effect of irrigation, fertilizer and weeding on panicle length, filled, unfilled, total grains panicle^{-1} and weight of 1000 grains of BRRI dhan48 in Aus season

Treatments combinations	Panicle length (cm)	Filled grains panicle^{-1} (No.)	Unfilled grains panicle^{-1} (No.)	Total grains panicle^{-1} (No.)	Weights of 1000 grains (g)
$I_0F_1W_1$	20.91 fg	101.09 g	7.40 ab	108.49 g	21.10 de
$I_0F_1W_2$	23.47 a-d	115.53 cd	6.60 d-g	122.13 cd	22.91 b-d
$I_0F_1W_3$	21.85 d-f	106.47 e-g	7.07 b-d	113.53 e-g	21.14 de
$I_0F_2W_1$	20.10 g	100.67 g	7.87 a	108.53 g	20.36 e
$I_0F_2W_2$	22.91 de	111.87 d-f	6.80 b-e	118.67 d-f	22.22 de
$I_0F_2W_3$	23.18 b-d	113.20 de	6.67 c-f	119.87 de	22.49 c-e
$I_1F_1W_1$	24.73 a-c	122.20 bc	6.27 e-g	128.47 bc	25.08 ab
$I_1F_1W_2$	25.05 a	133.07 a	5.93 g	139.00 a	26.21 a
$I_1F_1W_3$	24.86 ab	125.87 ab	6.00 fg	131.87 ab	24.76 a-c
$I_1F_2W_1$	23.12 cd	114.33 c-e	6.73 b-e	121.07 c-e	23.43 b-d
$I_1F_2W_2$	21.32 e-g	103.87 fg	7.33 a-c	111.20 fg	20.35 e
$I_1F_2W_3$	22.47 d-f	109.07 d-g	7.07 b-d	116.13 d-g	21.53 de
Sx value	0.528	2.551	0.215	2.516	0.729
Level of significance	0.05	0.05	0.05	0.05	0.05
CV(%)	4.01	3.91	5.46	3.63	5.58

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

I_0: No irrigation
I_1: Supplemental irrigation
F_1: Recommended fertilizer dose-RFD
F_2: 20% added with RFD
W_1: Hand weeding at 20 and 40 DAT
W_2: Pre emergence herbicide use at 4 DAT
W_3: Weeding by BRRI hand weeder at 20 and 40 DAT

Combined effect of different fertilizer doses and weeding methods varied significantly in terms of number of filled grains panicle^{-1} of BRRI dhan48 (Table 4.5.24). The maximum number of filled grains panicle^{-1} (124.30) was observed from the combination of F_1W_2, whereas the minimum number (107.50) was recorded from the combination of F_2W_1.

Combined effect of different irrigation regime, fertilizer doses and weeding methods varied significantly in terms of number of filled grains panicle^{-1} of BRRI dhan48 (Table 4.5.25). The maximum number of filled grains panicle^{-1} (133.07) was observed from the combination of $I_1F_1W_2$, whereas the minimum number (100.67) was found from the combination of $I_0F_2W_1$.

4.5.15 Unfilled grains panicle^{-1}

Number of unfilled grains panicle^{-1} of BRRI dhan48 showed statistically significant differences due to different irrigation regime (Table 4.5.23). The minimum number of unfilled grains panicle^{-1} (6.56) was observed from I_1, whereas the maximum number (7.07) was recorded from I_0. Haque *et al.* (2015) reported that stagnation of water and continuous 2-5 cm standing water in the field had no significant effect on number of unfilled grains panicle^{-1}.

Statistically significant variation was observed in terms of number of unfilled grains panicle^{-1} of BRRI dhan48 due to different fertilizer doses (Table 4.5.23). The minimum number of filled grains panicle^{-1} (6.54) was recorded from F_1, while the maximum number (7.08) was found from F_2.

Statistically significant variation was observed in terms of number of unfilled grains panicle^{-1} of BRRI dhan48 due to different weeding methods (Table 4.5.23). The minimum number of unfilled grains panicle^{-1} (6.67) was found from W_2 which was statistically similar (6.70) to W_3, while the maximum number (7.07) was observed from W_1.

Combined effect of different irrigation regime and fertilizer doses varied significantly in terms of number of unfilled grains panicle^{-1} of BRRI dhan48

(Table 4.5.24). The minimum number of unfilled grains panicle^{-1} (6.07) was observed from the combination of I_1F_1, whereas the maximum number (7.11) was recorded from the combination of I_0F_2.

Combined effect of different irrigation regime and weeding methods varied significantly in terms of number of unfilled grains panicle^{-1} of BRRI dhan48 (Table 4.5.24). The minimum number of unfilled grains panicle^{-1} (6.50) was found from the combination of I_1W_1, whereas the maximum number (7.63) was recorded from the combination of I_0W_1.

Combined effect of different fertilizer doses and weeding methods varied significantly in terms of number of unfilled grains panicle^{-1} of BRRI dhan48 (Table 4.5.24). The minimum number of unfilled grains panicle^{-1} (6.27) was observed from the combination of F_1W_2, whereas the maximum number (7.30) was found from the combination of F_2W_1.

Combined effect of different irrigation regime, fertilizer doses and weeding methods varied significantly in terms of number of unfilled grains panicle^{-1} of BRRI dhan48 (Table 4.5.25). The minimum number of unfilled grains panicle^{-1} (5.93) was observed from the combination of $I_1F_1W_2$, whereas the maximum number (7.87) was recorded from the combination of $I_0F_2W_1$.

4.5.16 Total grains panicle^{-1}

Number of total grains panicle^{-1} of BRRI dhan48 showed statistically significant differences due to different irrigation regime (Table 4.5.23). The maximum number of total grains panicle^{-1} (124.62) was found from I_1, whereas the minimum number (115.20) was observed from I_0.

Statistically significant variation was observed in terms of number of total grains panicle^{-1} of BRRI dhan48 due to different fertilizer doses (Table 4.5.23). The maximum number of total grains panicle^{-1} (123.92) was recorded from F_1, while the minimum number (115.91) was observed from F_2. Vetayasuporn (2012) reported that maximum number of grain per panicle (108.20) from RFD-chemical fertilizer.

Statistically significant variation was observed in terms of number of total grains panicle^{-1} of BRRI dhan48 due to different weeding methods (Table 4.5.23). The maximum number of total grains panicle^{-1} (122.75) was observed from W_2 which was statistically similar (120.35) to W_3, while the minimum number (116.64) was recorded from W_1.

Combined effect of different irrigation regime and fertilizer doses varied significantly in terms of number of total grains panicle^{-1} of BRRI dhan48 (Table 4.5.24). The maximum number of total grains panicle^{-1} (133.11) was observed from the combination of I_1F_1, whereas the minimum number (114.72) was recorded from the combination of I_0F_1.

Combined effect of different irrigation regime and weeding methods varied significantly in terms of number of total grains panicle^{-1} of BRRI dhan48 (Table 4.5.24). The maximum number of total grains panicle^{-1} (125.10) was observed from the combination of I_1W_2, whereas the minimum number (108.51) was recorded from the combination of I_0W_1.

Combined effect of different fertilizer doses and weeding methods varied significantly in terms of number of total grains panicle^{-1} of BRRI dhan48 (Table 4.5.24). The maximum number of total grains panicle^{-1} (130.57) was observed from the combination of F_1W_2, whereas the minimum number (114.80) was recorded from the combination of F_2W_1.

Combined effect of different irrigation regime, fertilizer doses and weeding methods varied significantly in terms of number of total grains panicle^{-1} of BRRI dhan48 (Table 4.5.25). The maximum number of total grains panicle^{-1} (139.00) was observed from the combination of $I_1F_1W_2$, whereas the minimum number (108.53) was recorded from the combination of $I_0F_2W_1$.

4.5.17 Weight of 1000 grains

Weight of 1000 grains of BRRI dhan48 showed statistically significant differences due to different irrigation regime (Table 4.5.23). The highest weight of 1000 grains (23.56 g) was observed from I_1, whereas the lowest weight (21.70 g) was recorded from I_0. Haque *et al.* (2015) reported that stagnation and continuous 2-5 cm standing water in the field had no significant effect on 1000-grain weight.

Statistically significant variation was observed in terms of weight of 1000 grains of BRRI dhan48 due to different fertilizer doses (Table 4.5.23). The highest weight of 1000 grains (23.53 g) was found from F_1, while the lowest weight (21.73 g) was observed from F_2.

Statistically non-significant variation was observed for weight of 1000 grains of BRRI dhan48 due to different weeding methods (Table 4.5.23). The highest weight of 1000 grains (22.92 g) was found from W_2, while the lowest weight (22.48 g) from W_3. Kishore *et al.* (2016) recorded the highest 1000-grain weight with two hand weeding. Nahar *et al.* (2010) found that in BRRI dhan41 weeding regime had significant effect on all the parameters except 1000 grain weight.

Combined effect of different irrigation regime and fertilizer doses varied significantly in terms of weight of 1000 grains of BRRI dhan48 (Table 4.5.24). The highest weight of 1000 grains (25.35 g) was observed from the combination of I_1F_1 and the lowest weight (21.69 g) was found from the combination of I_0F_2.

Combined effect of different irrigation regime and weeding methods varied significantly in terms of weight of 1000 grains of BRRI dhan48 (Table 4.5.24). The highest weight of 1000 grains (24.26 g) was observed from the combination of I_1W_1, whereas the lowest weight (20.73 g) was recorded from I_0W_1.

Combined effect of different fertilizer doses and weeding methods varied significantly in terms of weight of 1000 grains of BRRI dhan48 (Table 4.5.24). The highest weight of 1000 grains (24.56 g) was found from the combination of F_1W_2, whereas the lowest weight (21.29 g) was recorded from F_2W_2.

Weight of 1000 grains of BRRI dhan48 varied significantly due to the combined effect of different irrigation regime, fertilizer doses and weeding methods (Table 4.5.25). The highest weight of 1000 grains (26.21 g) was observed from the combination of $I_1F_1W_2$, whereas the lowest weight (20.35 g) from $I_1F_2W_2$.

4.5.18 Grain yield

Grain yield of BRRI dhan48 showed statistically significant differences due to different irrigation regime (Table 4.5.26). The highest grain yield (5.17 t ha^{-1}) was recorded from I_1, whereas the lowest grain yield (4.71 t ha^{-1}) was found from I_0. Afroja (2004) observed that treatment with 1-7 cm continuous standing water gave the highest yield of 7.39 t ha^{-1}, whereas, treatment with no irrigation gave the lowest yield of 3.98 t ha^{-1}. Karim *et al.* (2014) reported that grain yield was 7.62% higher in sprinkler and 4.72% higher in AWD irrigation method over flood irrigation method.

Statistically significant variation was observed in terms of grain yield of BRRI dhan48 due to different fertilizer doses (Table 4.5.26). The highest grain yield (5.16 t ha^{-1}) was observed from F_1 and the lowest grain yield (4.71 t ha^{-1}) was found from F_2. Vetayasuporn (2012) reported that maximum grain yield (5.57 t ha^{-1}) was obtained from RFD-chemical fertilizer which also gave the highest all yield parameters such as number of grain panicle^{-1}, total number panicle per hill, plant height and percentage of filled grain.

Statistically non-significant variation was observed in terms of grain yield of BRRI dhan48 due to different weeding methods (Table 4.5.26). The highest grain yield (5.06 t ha^{-1}) was recorded from W_2 which was statistically similar (4.98 t ha^{-1} and 4.77 t ha^{-1}) to W_3 and W_1 and the grain yield of W_1 also the lowest grain yield. Chauhana *et al.* (2015) observed that the weed-free plots and herbicide treatments produced 84-614% and 58-504% higher rice grain yield, respectively, than the weedy plots.

Table 4.5.26. Effect of irrigation, fertilizer and weeding on grain, straw and biological yield and harvest index of BRRI dhan48 in Aus season

Treatments	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
Irrigation regime				
I_0	4.71 b	5.02 b	9.73 b	48.40
I_1	5.17 a	5.46 a	10.63 a	48.63
Sx value	0.064	0.034	0.098	0.148
Level of significance	0.05	0.01	0.05	NS
CV(%)	5.51	2.70	4.06	1.29
Fertilizer doses				
F_1	5.16 a	5.49 a	10.65 a	48.50
F_2	4.71 b	5.00 b	9.71 b	48.53
Sx value	0.050	0.030	0.073	0.179
Level of significance	0.01	0.01	0.01	NS
CV(%)	4.30	2.70	4.06	1.29
Weeding methods				
W_1	4.77 b	5.07 b	9.84 b	48.53
W_2	5.06 a	5.35 a	10.40 a	48.61
W_3	4.98 a	5.31 a	10.30 a	48.41
Sx value	0.060	0.068	0.118	0.233
Level of significance	0.01	0.01	0.01	NS
CV(%)	4.21	2.41	4.01	1.67

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

I_0: No irrigation
I_1: Supplemental irrigation

F_1: Recommended fertilizer dose-RFD
F_2: 20% added with RFD

W_1: Hand weeding at 20 and 40 DAT
W_2: Pre emergence herbicide use at 4 DAT
W_3: Weeding by BRRI hand weeder at 20 and 40 DAT

Grain yield of BRRI dhan48 showed statistically significant differences due to the combined effect of different irrigation regime and fertilizer doses (Table 4.5.27). The highest grain yield (5.59 t ha^{-1}) was found from the combination of I_1F_1, whereas the lowest grain yield (4.68 t ha^{-1}) was recorded from the combination of I_0F_2.

Combined effect of different irrigation regime and weeding methods varied significantly in terms of grain yield of BRRI dhan48 (Table 4.5.27). The highest grain yield (5.18 t ha^{-1}) was recorded from the combination of I_1W_1, whereas the lowest grain yield (4.36 t ha^{-1}) was observed from the combination of I_0W_1.

Combined effect of different fertilizer doses and weeding methods showed statistically significant differences in terms of grain yield of BRRI dhan48 (Table 4.5.27). The highest grain yield (5.40 t ha^{-1}) was found from the combination of F_1W_2, whereas the lowest grain yield (4.58 t ha^{-1}) was recorded from the combination of F_2W_1.

Combined effect of different irrigation regime, fertilizer doses and weeding methods varied significantly in terms of grain yield of BRRI dhan48 (Table 4.5.28). The highest grain yield (5.79 t ha^{-1}) was recorded from the combination of $I_1F_1W_2$, while the lowest grain yield (4.23 t ha^{-1}) was observed from the combination of $I_0F_2W_1$.

Table 4.5.27. Combined effect of irrigation and fertilizer, irrigation and weeding, fertilizer and weeding on grain, straw and biological yield and harvest index of BRRI dhan48 in Aus season

Treatments combinations	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
Irrigation regime × Fertilizer doses				
I_0F_1	4.73 b	5.03 b	9.76 b	48.49
I_0F_2	4.68 b	5.01 b	9.69 b	48.32
I_1F_1	5.59 a	5.94 a	11.53 a	48.51
I_1F_2	4.74 b	4.99 b	9.73 b	48.74
Sx value	0.070	0.043	0.103	0.253
Level of significance	0.01	0.01	0.01	NS
CV(%)	4.30	2.41	3.03	1.57
Irrigation regime × Weeding methods				
I_0W_1	4.36 c	4.57 c	8.93 c	48.83
I_0W_2	4.95 ab	5.33 ab	10.29 ab	48.15
I_0W_3	4.81 b	5.16 b	9.97 b	48.22
I_1W_1	5.18 a	5.57 a	10.75 a	48.23
I_1W_2	5.16 a	5.36 ab	10.52 a	49.06
I_1W_3	5.16 a	5.46 ab	10.62 a	48.60
Sx value	0.085	0.095	0.167	0.330
Level of significance	0.01	0.01	0.01	NS
CV(%)	4.21	4.46	4.01	1.67
Fertilizer doses × Weeding methods				
F_1W_1	4.96 bc	5.30 b	10.26 b	48.45
F_1W_2	5.40 a	5.73 a	11.13 a	48.50
F_1W_3	5.12 b	5.43 b	10.55 b	48.55
F_2W_1	4.58 d	4.84 d	9.42 d	48.61
F_2W_2	4.71 cd	4.96 cd	9.68 cd	48.72
F_2W_3	4.85 c	5.19 bc	10.04 bc	48.27
Sx value	0.085	0.095	0.167	0.330
Level of significance	0.05	0.05	0.05	NS
CV(%)	4.21	4.46	4.01	1.67

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

I_0: No irigation | F_1: Recommended fertilizer dose-RFD | W_1: Hand weeding at 20 and 40 DAT

I_1: Supplemental irrigation | F_2: 20% added with RFD | W_2: Pre emergence herbicide use at 4 DAT

W_3: Weeding by BRRI hand weeder at 20 and 40 DAT

Table 4.5.28. Combined effect of irrigation, fertilizer and weeding on grain, straw and biological yield and harvest index of BRRI dhan48 in Aus season

Treatments combinations	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
$I_0F_1W_1$	4.49 de	4.68 ef	9.18 de	48.96
$I_0F_1W_2$	5.02 b	5.48 b	10.50 b	47.77
$I_0F_1W_3$	4.69 b-d	4.93 de	9.62 cd	48.73
$I_0F_2W_1$	4.23 e	4.45 f	8.68 e	48.71
$I_0F_2W_2$	4.89 bc	5.19 b-d	10.07 bc	48.53
$I_0F_2W_3$	4.94 bc	5.39 bc	10.33 bc	47.72
$I_1F_1W_1$	5.43 a	5.91 a	11.34 a	47.95
$I_1F_1W_2$	5.79 a	5.97 a	11.76 a	49.22
$I_1F_1W_3$	5.56 a	5.93 a	11.49 a	48.37
$I_1F_2W_1$	4.93 bc	5.23 b-d	10.16 bc	48.51
$I_1F_2W_2$	4.54 c-e	4.74 ef	9.28 de	48.90
$I_1F_2W_3$	4.76 b-d	4.99 c-e	9.74 b-d	48.82
Sx value	0.120	0.135	0.236	0.467
Level of significance	0.05	0.05	0.05	NS
CV(%)	4.21	4.46	4.01	1.67

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

I_0: No irrigation
I_1: Supplemental irrigation

F_1: Recommended fertilizer dose-RFD
F_2: 20% added with RFD

W_1: Hand weeding at 20 and 40 DAT
W_2: Pre emergence herbicide use at 4 DAT
W_3: Weeding by BRRI hand weeder at 20 and 40 DAT

4.5.19 Straw yield

Straw yield of BRRI dhan48 showed statistically significant differences due to different irrigation regime (Table 4.5.26). The highest straw yield (5.46 t ha^{-1}) was observed from I_1, whereas the lowest straw yield (5.02 t ha^{-1}) was recorded from I_0.

Statistically significant variation was observed in terms of straw yield of BRRI dhan48 due to different fertilizer doses (Table 4.5.26). The highest straw yield (5.49 t ha^{-1}) was found from F_1, while the lowest straw yield (5.00 t ha^{-1}) was observed from F_2.

Statistically non-significant variation was observed in terms of straw yield of BRRI dhan48 due to different weeding methods (Table 4.5.26). The highest straw yield (5.35 t ha^{-1}) was found from W_2 which was statistically similar (5.31 t ha^{-1}) to W_3, while the lowest straw yield (5.07 t ha^{-1}) was observed from W_1.

Combined effect of different irrigation regime and fertilizer doses varied significantly in terms of straw yield of BRRI dhan48 (Table 4.5.27). The highest straw yield (5.94 t ha^{-1}) was observed from the combination of I_1F_1, whereas the lowest straw yield (4.99 t ha^{-1}) was recorded from the combination of I_1F_2.

Combined effect of different irrigation regime and weeding methods varied significantly in terms of straw yield of BRRI dhan48 (Table 4.5.27). The highest straw yield (5.57 t ha^{-1}) was observed from the combination of I_1W_2, whereas the lowest straw yield (4.57 t ha^{-1}) was recorded from the combination of I_0W_1.

Combined effect of different fertilizer doses and weeding methods varied significantly in terms of straw yield of BRRI dhan48 (Table 4.5.27). The highest straw yield (5.73 t ha^{-1}) was observed from the combination of F_1W_2, whereas the lowest straw yield (4.84 t ha^{-1}) was recorded from the combination of F_2W_1.

Combined effect of different irrigation regime, fertilizer doses and weeding methods varied significantly in terms of straw yield of BRRI dhan48 (Table

4.5.28). The highest straw yield (5.97 t ha^{-1}) was observed from the combination of $I_1F_1W_2$, whereas the lowest straw yield (4.45 t ha^{-1}) was recorded from the combination of $I_0F_2W_1$.

4.5.20 Biological yield

Biological yield of BRRI dhan48 showed statistically significant differences due to different irrigation regime (Table 4.5.26). The highest biological yield (10.63 t ha^{-1}) was found from I_1, whereas the lowest biological yield (9.73 t ha^{-1}) was recorded from I_0.

Statistically significant variation was observed in terms of biological yield of BRRI dhan48 due to different fertilizer doses (Table 4.5.26). The highest biological yield (10.65 t ha^{-1}) was found from F_1, while the lowest biological yield (9.71 t ha^{-1}) was observed from F_2.

Statistically significant variation was observed in terms of biological yield of BRRI dhan48 due to different weeding methods (Table 4.5.26). The highest biological yield (10.40 t ha^{-1}) was recorded from W_2 which was statistically similar (10.30 t ha^{-1}) to W_3, while the lowest biological yield (9.84 t ha^{-1}) was observed from W_1.

Combined effect of different irrigation regime and fertilizer doses varied significantly in terms of biological yield of BRRI dhan48 (Table 4.5.27). The highest biological yield (11.53 t ha^{-1}) was found from the combination of I_1F_1, whereas the lowest biological yield (9.69 t ha^{-1}) was recorded from the combination of I_0F_2.

Biological yield of BRRI dhan48 varied significantly due to the combined effect of different irrigation regime and weeding methods (Table 4.5.27). The highest biological yield (10.75 t ha^{-1}) was observed from the combination of I_1W_1, whereas the lowest biological yield (8.93 t ha^{-1}) was recorded from the combination of I_0W_1.

Statistically significant variation was recorded for the combined effect of different fertilizer doses and weeding methods in terms of biological yield of BRRI dhan48 (Table 4.5.27). The highest biological yield (11.13 t ha^{-1}) was observed from the combination of F_1W_2, whereas the lowest biological yield (9.42 t ha^{-1}) was found from the combination of F_2W_1.

Combined effect of different irrigation regime, fertilizer doses and weeding methods varied significantly in terms of biological yield of BRRI dhan48 (Table 4.5.28). The highest biological yield (11.76 t ha^{-1}) was found from the combination of $I_1F_1W_2$, whereas the lowest biological yield (8.68 t ha^{-1}) was recorded from the combination of $I_0F_2W_1$.

4.5.21 Harvest index

Harvest index of BRRI dhan48 showed statistically non-significant differences due to different irrigation regime (Table 4.5.26). The highest harvest index (48.63%) was found from I_1, whereas the lowest harvest index (48.40%) was observed from I_0.

Statistically non-significant variation was observed in terms of harvest index of BRRI dhan48 due to different fertilizer doses (Table 4.5.26). The highest harvest index (48.53%) was recorded from F_1 and the lowest harvest index (48.50%) was found from F_2.

Statistically non-significant variation was observed in terms of harvest index of BRRI dhan48 due to different weeding methods (Table 4.5.26). The highest harvest index (48.61%) was observed from W_2, while the lowest harvest index (48.41%) was recorded from W_3.

Combined effect of different irrigation regime and fertilizer doses varied non-significantly in terms of harvest index of BRRI dhan48 (Table 4.5.27). The highest harvest index (48.74%) was found from the combination of I_1F_2, whereas the lowest harvest index (48.32%) was recorded from the combination of I_0F_2.

Harvest index of BRRI dhan48 showed statistically non-significantly differences due to the combined effect of different irrigation regime and weeding methods (Table 4.5.27). The highest harvest index (49.06%) was recorded from the combination of I_1W_2, whereas the lowest harvest index (48.15%) was found from the combination of I_0W_2.

Statistically non-significant variation was observed due to the combined effect of different fertilizer doses and weeding methods in terms of harvest index of BRRI dhan48 (Table 4.5.27). The highest harvest index (48.72%) was found from the combination of F_2W_2, whereas the lowest harvest index (48.27%) was recorded from the combination of F_2W_3.

Combined effect of different irrigation regime, fertilizer doses and weeding methods varied non-significantly in terms of harvest index of BRRI dhan48 (Table 4.5.28). The highest harvest index (49.22%) was observed from the combination of $I_1F_1W_2$ and the lowest harvest index (47.72%) was recorded from the combination of $I_0F_2W_3$.

In this study it was observed that the irrigated plots showed significantly higher grain yields compared to that of the non-irrigated ones. This plots also gave the maximum number of total tillers hill^{-1} I_1, longest panicle, maximum number of total grains panicle^{-1}. Such improvement in the yield and yield attributes was also demonstrated by the earlier workers. Timon *et al.* (2015) showed that there were significant differences in terms of plant height in irrigated and non-irrigated rice cultivation. Wang *et al.* (2010) found that tiller number hill^{-1} increased as the irrigation water depth increased. Khairi *et al.* (2015) reported that irrigation treatment affected plant height after 49 days after planting. Nasir *et al.* (2014) recorded maximum number of effective tillers hill^{-1} (21.5) from irrigation management. Afroja (2004) observed that treatment with 1-7 cm continuous standing water gave the highest yield of 7.39 t ha^{-1}, whereas, treatment with no irrigation gave the lowest yield of 3.98 t ha^{-1}. Karim *et al.* (2014) reported that grain yield was 7.62% higher in sprinkler and 4.72% higher in AWD irrigation method over flood irrigation method. Khairi *et al.* (2015) reported that AWD treatment produced longest panicle, 1000 seed weight and highest number of filled grains panicle^{-1}. Haque *et al.* (2015) reported that stagnation of water and continuous 2-5 cm standing water in the field had no significant effect on number of unfilled grains panicle^{-1}. Khairi *et al.* (2015) reported that AWD treatment affected weight of 1000-grains.

Aus rice needs supplemental irrigation mostly at the early stage of life. Aus rice in Bangladesh is usually sown or planted in the months of March and April depending on the harvest of the preceding rabi crop. If Boro rice is grown it takes more times to harvest compared to oil or pulse crops stretching the crop duration even up to April. In this case aus sowing or transplanting is delayed or in most of the time does not become possible to grow.

The onset of rainfall happens in March and the amount of rainfall during first or second month the sown or transplanted crop may suffer from soil moisture due the lack of rainfall for an elongated period. In this situation if supplemental irrigation is not provided the crop suffers from drought stress causing reduction in the subsequent growth. The incidence increases with advancement of time up to August. However, the pattern does not remain uniform that is even in the rainy season, there may be occasional drought. So, supplemental irrigation may be needed during these periods when less or no raining happens. It is an established fact that undisturbed supply of water to crop plants results in proper growth and yield. But if the moisture supply is limiting, there must be reduction in these parameters and the extent depends on the degree of drought. This phenomenon has been observed in this study showing lower values of most of the plant parameters such as tiller number per hill, leaf area index, dry matter accumulation, crop growth rate and also the yield parameters when no supplemental irrigation was not provided. This indicates under no supplemental irrigation plants may have suffered from soil moisture stress at some or certain stage of development.

In respect of varieties it was observed that out of twelve, the local varieties yielded 27% lower than the high yielders. Three varieties (BRRI dhan14, BRRI dhan48 and BRRI dhan55) showed higher yield seed yields among which BRRI dhan48 showed the highest grain yield along with the yield attributes under irrigated condition in all the cases. The crop variety has the major effect of the yield productivity and the varieties high yielding ones typically yield 10 to 20% more than conventional varieties on similar soil which Li *et al*. (2009) and Zhou *et al*. (2012) attributed to the heterotic effect. Hossain and Deb (2003) reported that although farmers got about 16% yield advantage in the cultivation of high yielding varieties compared to the popularly grown inbred varieties, the yield gains were not stable. Moreover, Lyman and Nalley (2013) commented that although local varieties usually have lower seed yields, they have higher milling quality than high yielding modern rice varieties. It is also reported that the local varieties has more moister stress tolerance capability than the modern ones. However, in this study this fact has not been proved.

Evidences of the varietal differences have been proved in the works of the previous scientists. The varieties also differed to respond under varying irrigation regimes. Different researchers recorded different plant height in earlier experiment due to different rice cultivars (Jisan *et al*., 2014; Haque and Biswash, 2014; Khalifa, 2009; Masum *et al*., 2008). Generally, plant height is a genetical character and it is controlled by the genetic make up of the varieties. Ghosh *et al.* (2014) reported that water management practices exerted significant influence on plant height. Similar findings regarding plant height also stated by Ibraheem (2015) in earlier. Munoz *et al.* (1996) noted that IR8025A high yielding rice cultivar produced 16% longer plant than the commercial variety Oryzica Yacu-9. Khalifa (2009) reported that high yielding rice variety surpassed other varieties in terms of plant height. Bhuiyan *et al*. (2014) reported that the different high yielding rice varieties had significant effects on plant height at maturity. Bhuiyan *et al*. (2014) reported that that the different rice varieties significant effects the plant height at maturity. Bhuiyan *et al*. (2014) reported that that the different rice varieties significantly effects the plant height at maturity. Jisan *et al*. (2014) BRRI dhan52 showed the tallest plant (117.20 cm), whereas the lowest plant height by BRRI dhan57. Haque and Biswash (2014) reported that the highest plant height was 101.5 cm from BRRI dhan28 and the lowest plant height from Richer (82.5 cm). Khalifa (2009) reported that high yielding rice variety surpassed other varieties in consideration of tillers hill^{-1}. Khalifa (2009) reported that high yielding rice variety surpassed other varieties in consideration of effective tillers hill^{-1}. Obulamma *et al.* (2004) recorded highest number of filled grain panicle^{-1} in APHR 2 than DRRH 1. Hossain (2013) reported that number of tillers hill^{-1} varied for different fertility regime. Nizersail was achieved maximum (25.63) tiller at 45 DAT, whereas in the case of BRRI dhan44, maximum (18.92) tiller production was observed around panicle initiation stage at 60 DAT. Masum *et al*. (2008) reported that BRRI dhan52 produced the highest number of effective tillers hill^{-1} (11.28), while the lowest values of these parameters were produced by BRRI dhan57. Shaloie *et al*. (2014) reported that traits were significantly affected in terms of panicle length. Islam *et al.* (2009) reported that BRRI dhan3l had higher panicles plant^{-1}. Guilani *et al*. (2003) found that number of grains panicle^{-1} was not significantly different among cultivars. Jisan *et al*. (2014) reported that the highest grain yield (5.69 t ha^{-1}) was obtained from BRRI dhan52 followed by BRRI dhan49 (5.15 t ha^{-1}) and the lowest one (4.25 t ha^{-1}) was obtained from BRRI dhan57. Haque and Biswash (2014) reported that number of filled grains panicle^{-1} was the highest for BRRI dhan29 (163.3), whereas, Jagoron only 118. Haque and Biswash (2014) reported from earlier that number of total grains was highest in BRRI dhan29 (201.7) and for Jagoron it was 133.7 only. Hosain *et al*. (2014) reported that BRRI dhan48 produced the highest grain yield (5.51 t ha^{-1}). Patel (2000) observed significantly higher grain and straw yield from Kranti than IR36. Haque and Biswash (2014) reported that In case of biological yield (g), BRRI dhan29 showed highest yield (49.6 g) and Hira only 18 g.

Hosain *et al*. (2014) reported that varieties Heera2 and Aloron gave the higher spikelet sterility. Jisan *et al*. (2014) reported that among the varieties, BRRI dhan52 produced the highest 1000-grain weight (23.65 g), whereas the lowest values of these parameters was produced by BRRI dhan57. Kanfany *et al*. (2014) reported that grain yield of rice high yielding was not significantly higher than that of the check cultivar. Wang *et al*. (2006) reported that high yielding had larger panicles compared with conventional cultivars. Obulamma *et al.* (2004) recorded highest number of filled grains panicle^{-1} in APHR 2 than DRRH 1. Wang *et al*. (2006) reported that high yielding had heavier seeds compared with conventional cultivars.

Grain yields in the improved varieties were far good performers in this study. Local varieties' leaves are droopy contributing lesser to photosynthesis compared to the high yielders having erect leaves which has a good angle orientation to the sun. These modern rice varieties intercept more sunlight and produced yield more dry matter compared to the local or conventional ones (Hubbart *et al*., 2007). However, local varieties may also have yield potentials. For example the local variety China (Muladi local) yielded 3.51 t ha^{-1} which not so lower than that of BRRI dhan42 (3.91) in Experiment-I. Such indicational results have also been demonstrated in many researches. Although the local varieties yield lesser than those of the high yielders, these local landraces are better adapted to some of the harsh environmental condition which have enduring capability to varying stresses both abiotic and biotic ones (Ullah *et al*., 2016). Moreover, in some of the localities the high yielders do not perform owing to the environmental and adaphic constraints where farmers do not have other choice without growing the local ones (Hamid *et al*., 2015).

Grain yield in cereals is the result of dry matter partitioning towards the reproductive part of the plant which depends on the sink capacity. More the capacity of the sink more the weight of the reproductive part. In general in the local varieties the sink is smaller compared to the source which produces assimilates for the sink. In this study it has also been observed showing higher values of the sink traits such as number of panicles (through tiller number), panicle length, number of grains per panicles. However, effect of the varieties on the harvest index was not significant indicating that the higher seed yield in the high yielders was due to more dry matte accumulation in the modern ones compared to the local ones. The higher dry matter accumulation in the high yielding varieties were also due to the higher leaf area index which has been found to the positively related with the dry matter accumulation. Evidence revealed that there was also no remarkable difference in the 1000 seed weight between the high yielders and the local ones. This is obvious as this traits of the cereals are solely governed by the genetic make up (that is variety) and in the same variety this conservative trait may be influenced by the agronomic management.

The varieties also differed their response to weeded and un-weeded conditions in the field in the Experiment III and IV wherein it was found that under hand weeding condition all the varieties had identical seed yields, but under weeded condition, the BRRI dhan48 gave significantly higher grain yields (5.73 t ha^{-1}) over others along with the higher values in other yield contributing parameters. It was also observed that BRRI dhan48 had higher weed suppression capacity under un-weeded situation. Out of weeding methods tested in this study the herbicide application yielded a comparable yield with the hand weeded method. Such finding agrees well with those of the previous investigations. Weeding reduces plant competitions between crops and weed plants improving the growth and yield parameters. Hasanuzz*aman et al.* (2007) stated that plant height was significantly affected by different weeding treatments. Chauhana *et al.* (2015) observed that the weed-free plots and herbicide treatments produced 84-614% and 58-504% higher rice grain yield, respectively, than the plots that’s were in control i.e. no weed control. Kishore *et al.* (2016) reported the lowest weed density, longer panicles, more panicles and 1000-seed weight with two hand weeding. Nahar *et al.* (2010) observed that in BRRI dhan41 weeding regime had significant effect on all the parameters except 1000 grain weight. Kishore *et al.* (2016) recorded the highest 1000-grain weight with two hand weeding.

Weeds competes with crop for water, nutrients, light and ear and reduces yield which is greater than the combined losses of insect pests and diseases. Reviewing the previous trials in Bangladesh, it was concluded that the weed infestation reduces the grain yield by 70-80% in Aus rice (early summer), 30-40% for transplanted Amon rice (autumn) and 22-36% for modern Boro rice cultivars (winter rice) (Mamun, 1995; BRRI, 2008). Moreover, for weeding rice fields the total cost of production also increases. Like in other trials of the previous workers all the parameters which normally keep positive relations with the yield, showed higher values in weeded plots compared to those in the unweeded ones.

Weeds become detrimental to crops by changing the pH of soil, decreasing the nutrient availability, which inturn reduces straw yield by 13-38% and grain yield by 25-47% (Manandhar *et al*., 2007; Sureshkumar *et al*., 2016). Herbicides offer the most effective, economical and practical way of weed management (Nivetha *et al*., 2017).

Weed plants compete with the crop plants. Such studies may be helpful to be applied at planning of integrated management practices such as crop rotation, succession (Ceccon, 2007) and help allow modeling the dynamics of weeds infestation and optimizing the system as a whole, based in dry mass accumulation, plants height, number of tillers or branches, number of inflorescences and other directly measured variables (Galon *et al*., 2007; Fleck *et al*., 2008; Bianchi *et al*., 2010). There is a big gap between physiological studies and application of the obtained results for practical everyday weed management inside crops is very wide especially in the developed countries (Concenco *et al*., 2012). Weed biologists, mainly from under developed countries, often do not use physiological parameters in association to the directly measured variables as tools (basic study) for supporting their findings which my support the applied studies (Aliyev, 2010). However in this study only the population dynamics (change of weed population due to the change in surrounding environment) in terms of weed number per unit area has been monitored, but other weed attributes were not measured.

Weeds are at present the major biotic constraint to increased rice production worldwide. The importance of their control has been emphasized in the past by various authors (De Datta and Baltazar, 1996; Labrada, 1996).

The varieties also showed differential results under varying regimes of irrigation, fertilizer and weed control in the 5th experiment in the next season (third year). It was revealed that significantly the highest grain yield in this study was obtained from irrigation, recommended fertilizer and weeding by pre-emergence herbicide (5.79 t ha^{-1}) which was over 37% higher as was shown by the highest dose of fertilizer under weeded but not irrigated condition (4.23 t ha^{-1}). Khairi *et al.* (2015) reported that AWD treatment produced minimum number of non-effective tillers hill^{-1} in rice. Khairi *et al.* (2015) reported that AWD treatment produced minimum number of non-effective tillers hill^{-1} in rice. Haque *et al.* (2015) reported that stagnation of water and continuous 2-5 cm standing water in the field had no significant effect on number of effective tillers hill^{-1}. Vetayasuporn (2012) reported that maximum number of total panicle hill^{-1} (14.82) from RFD-chemical fertilizer. Vetayasuporn (2012) reported that maximum number of grain per panicle (108.20) from RFD-chemical fertilizer. Vetayasuporn (2012) reported that maximum grain yield (5.57 t ha^{-1}) was obtained from RFD-chemical fertilizer which also gave the highest all yield parameters such as number of grain panicle^{-1}, total number panicle per hill, plant height and percentage of filled grain. Basu *et al*. (2012) reported that the highest grain yield was observed in treatment containing the full recommended dose of chemical fertilizers along with the double dose of cowdung (F_1M_3) and it was the lowest in without chemical fertilizers and recommended dose of cowdung (F_0M_1). Vetayasuporn (2012) reported that maximum grain yield (5.57 t ha^{-1}) was obtained from RFD-chemical fertilizer which also gave the highest all yield parameters such as number of grain panicle^{-1}, total number panicle per hill, plant height and percentage of filled grain.

The usefulness of fertilizer application has previously been demonstrated by many authors (Kamrunnahar *et al.*, 2016). Nitrogen, P, K and S affect rice production and its physiological activity. Efficient use of N increases the rate of photosynthesis by increasing the number of chlorophyll; and is an important complementary strategy for improving rice yield (Islam *et al.*, 2016). Phosphorus is intimately associated with all energy involved life processes along with photophosphorylation in photosynthesis and a vital constituent of every living cell. This element tends to be concentrated in the seed and stimulates early root formation and growth of the plant. Without adequate supply of P plant cannot reach its maximum yield. Since in many soils, much of the available P is derived through the mineralization of organic matter, the repeated addition of P fertilizer appears to be the only satisfactory way of supplying plant needs for this nutrient (Ali *et al.*, 2004). Potassium is luxuriously absorbed by plants. Modern high-yielding rice varieties remove much higher amount of K than P or even N from the soil (Islam and Muttaleb, 2016; Islam *et al.*, 2016). It increases crop yields by accelerating photosynthesis, controlling stomata opening, efficient utilization of N and promoting the transport of assimilates. Problem of S deficiency in soil can be aggravated with the use of excess P fertilizer (Ali *et al.*, 2004). Hossaen *et al.* (2011) reported that recommended fertilizer significantly influence plant height of rice. Vetayasuporn (2012) reported that maximum number of total panicle hill^{-1} (14.82) from RFD-chemical fertilizer.

So, from the above discussion on the results as were obtained in this study, it may be concluded that the Aus rice variety BRRI dhan48 may be grown using supplemental irrigation and pre-emergence weedicide under recommended dose of fertilizer.

Chapter 5

Summary and Conclusion

CHAPTER 5

SUMMARY AND CONCLUSION

The field experiments were conducted in the farm area of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka for three consecutive years as April to August, 2015 as 1^{st} year, April to August, 2016 as 2^{nd} year and April to August, 2017 as 3^{rd} year to find out the performance of Aus rice varieties as influenced by varying irrigation, fertilizer and weed managements. In 1^{st} year, 12 different Aus rice varieties were grown under irrigated and non-irrigated condition. In 2^{nd} year subsequently three experiments were conducted by picked up 4 best varieties among 12 with separately irrigated and non-irrigated condition, fertility regime and weeding methods. In 3^{rd} year the best 1 rice variety was picked up from the 4 rice varieties and an experiment was conducted under varying irrigation regime, fertilizer doses and weeding method.

5.1 Summary

5.1.1 Experiment-1: Growth and Yield Performance of Different Aus Rice Varieties under Irrigated and Non-irrigated Condition

The experiment was conducted during the period of April to August, 2015 to find out the growth and yield performance of different Aus rice varieties under irrigated and non-irrigated condition. The experiment comprised of two factors as Factor A: Irrigation (2 levels): I_0: No irrigation and I_1: Supplemental irrigation; Factor B: Rice varieties: V_1: BR-3, V_2: BR-14, V_3: BR-16, V_4: BRRI dhan27, V_5: BRRI dhan42, V_6: BRRI dhan48, V_7: BRRI dhan55, V_8: BRRI dhan65, V_9: China (Muladi local), V_{10}: Kali Shait-ta (Muladi local), V_{11}: Benamuri (Muladi local) and V_{12}: Abdul Hye (Jhalkathi local). The two factors experiment was laid out in split-plot design with three replications. Data were recorded on different growth characters, yield components and yield of rice and statistically significant variation was recorded for different treatment.

In case of different levels of irrigation, at ETS, MTS, FS, GFS and MS, the taller plant (41.00, 81.66, 109.44, 115.91 and 113.65 cm, respectively) was recorded from I_1 and the shorter plant (37.10, 80.85, 106.05, 113.41 and 111.47 cm, respectively) from I_0. At ETS, MTS, FS and GFS, the maximum number of tillers hill^{-1} (5.75, 12.78, 14.66 and 14.25, respectively) was found from I_1, whereas the minimum number (5.39, 12.04, 14.09 and 13.86, respectively) from I_0. The highest crop duration was recorded from I_1 (123.14 days), while the lowest from I_0 (118.33 days). The maximum number of effective tillers hill^{-1} was found from I_1 (10.49) and the minimum number from I_0 (10.12). The minimum number of non-effective tillers hill^{-1} was observed from I_0 (2.77), while the maximum number from I_1 (2.95). The maximum number of total tillers hill^{-1} was observed from I_1 (13.44), whereas the minimum number from I_0 (12.88). The longer panicle was recorded from I_1 (22.73 cm) while the shorter panicle from I_0 (21.83 cm). The maximum number of filled grains panicle^{-1} was found from I_1 (108.20) and the minimum number from I_0 (101.63). The minimum number of unfilled grains panicle^{-1} was recorded from I_0 (9.45), whereas the maximum number from I_1 (9.95). The maximum number of total grains panicle^{-1} was observed from I_1 (118.16) and the minimum from I_0 (111.08). The highest weight of 1000 grains was recorded from I_1 (25.87 g), while the lowest from I_0 (25.69 g). The highest grain yield was found from I_1 (4.22 t ha^{-1}), whereas the lowest from I_0 (3.90 t ha^{-1}). The highest straw yield was found from I_1 (5.69 t ha^{-1}) and the lowest from I_0 (5.02 t ha^{-1}). The highest biological yield was recorded from I_1 (9.91 t ha^{-1}), while the lowest from I_0 (8.92 t ha^{-1}). The highest harvest index was found from I_0 (43.57%) and the lowest from I_1 (42.37%).

For different rice varieties, at ETS, MTS, FS, GFS and MS, the tallest plant (45.16, 94.13, 134.72, 141.44 and 138.35 cm, respectively) was observed from V_4 (BRRI dhan27), whereas the shortest plant (35.95, 75.40, 95.14, 101.93 and 100.85 cm, respectively) from V_1. At ETS, MTS, FS and GFS, the maximum number of tillers hill^{-1} (6.70, 14.87, 16.60 and 16.27, respectively) was found from V_6, while the minimum number (4.93, 11.27, 12.93 and 12.67, respectively) from V_{11}. The highest crop duration was observed from V_1 (132.83 days), whereas the lowest from V_8 (106.50 days). The maximum number of effective tillers hill^{-1} was observed from V_6 (13.97), while the minimum number from V_{10} (6.80). The minimum number of non-effective tillers hill^{-1} was observed from V_6 (2.03), whereas the maximum number from V_{10} (3.67). The maximum number of total tillers hill^{-1} was observed from V_6 (16.00), while the minimum number from V_{10} (10.47). The longest panicle was observed from V_6 (23.90 cm), whereas the shortest panicle from V_{10} (20.78 cm). The maximum number of filled grains panicle^{-1} was observed from V_6 (122.56), while the minimum number from V_{10} (85.78). The minimum number of unfilled grains panicle^{-1} was observed from V_6 (7.39), whereas the maximum number from V_{10} (12.89). The maximum number of total grains panicle^{-1} was observed from V_6 (129.95), while the minimum number from V_{12} (98.61). The highest weight of 1000 grains was recorded from V_{12} (28.09 g) and the lowest from V_8 (23.68 g). The highest grain yield was observed from V_6 (5.22 t ha^{-1}), while the lowest from V_{10} (2.90 t ha^{-1}). The highest straw yield was observed from V_3 (6.39 t ha^{-1}) and the lowest from V_{10} (4.07 t ha^{-1}). The highest biological yield was recorded from V_2 (11.08 t ha^{-1}) and the lowest from V_{10} (6.97 t ha^{-1}). The highest harvest index was found from V_6 (48.19%), while the lowest from V_{11} (40.22%).

Due to the combined effect of different levels of irrigation and rice varieties, at ETS, MTS, FS, GFS and MS, the tallest plant (47.75, 96.44, 139.26, 145.94 and 142.83 cm, respectively) was recorded from the combination of I_1V_4, while the shortest plant (33.36, 75.12, 92.49, 100.88 and 100.27 cm, respectively) from I_0V_1. At ETS, MTS, FS and GFS, the maximum number of tillers hill^{-1} (7.00, 15.13, 16.73 and 16.33, respectively) was observed from I_1V_6 and the minimum number (4.67, 10.33, 12.00 and 11.73, respectively) from I_0V_{10}. The highest crop duration was observed from the combination of I_1V_1 (135.67 days), while the lowest duration from I_0V_8 (102.33 days). The maximum number of effective tillers hill^{-1} was recorded from I_1V_6 (14.00), whereas the minimum number from I_1V_{10} (6.60). The minimum number of non-effective tillers hill^{-1} was recorded from I_0V_6 (1.67) and the maximum number from I_0V_{11} (3.87). The maximum number of total tillers hill^{-1} was recorded from I_1V_6 (16.40), whereas the minimum number from I_1V_{10} (10.20). The longest panicle was observed from the combination of I_1V_7 (24.40 cm) and the shortest panicle from I_0V_{12} (20.22 cm). The maximum number of filled grains panicle^{-1} was recorded from I_1V_7 (124.89), whereas the minimum number from I_0V_{11} (83.67). The minimum number of unfilled grains panicle^{-1} was recorded from I_0V_6 (6.33) and the maximum number from I_1V_{10} (12.67). The maximum number of total grains panicle^{-1} was recorded from I_1V_7 (132.78), whereas the minimum number from I_0V_{12} (85.33). The highest weight of 1000 grains was recorded from I_0V_{12} (28.69 g), whereas the lowest weight from I_0V_8 (23.61 g). The highest grain yield was recorded from I_1V_6 (5.45 t ha^{-1}), whereas the lowest grain yield from I_0V_{10} (2.84 t ha^{-1}). The highest straw yield was recorded from the combination of I_1V_3 (6.68 t ha^{-1}), while the lowest from I_0V_{10} (3.72 t ha^{-1}). The highest biological yield was recorded from the combination of I_1V_3 (11.56 t ha^{-1}) and the lowest from I_0V_{10} (6.56 t ha^{-1}). The highest harvest index was recorded from the combination of I_1V_6 (48.51%), whereas the lowest from I_1V_9 (39.20%).

5.1.2 Experiment-2: Yield Performance of Selected Aus Rice Varieties under Irrigated and Non-irrigated Condition

The experiment was conducted during the period of April to August, 2016 to find out the yield performance of selected Aus rice varieties under irrigated and non-irrigated condition. The experiment comprised of two factors. Factor A: Irrigation (2 levels): I_0: No irrigation and I_1: Supplemental irrigation; and Factor B: Rice varieties (4 varieties): V_1: BR-14, V_2: BRRI dhan48, V_3: BRRI dhan55 and V_4: BRRI dhan65. The two factors experiment was laid out in split-plot design with three replications. Data were recorded on different growth characters, yield components and yield of rice and statistically significant variation was recorded for different treatment.

For different levels of irrigation, At ETS, MTS, FS, GFS and MS, the taller plant (41.85, 84.94, 109.20, 115.18 and 113.31 cm, respectively) was observed from I_1, whereas the shorter plants (35.76, 75.08, 94.14, 103.36 and 101.46 cm, respectively) from I_0. At ETS, MTS, FS and GFS, the maximum number of tiller hill^{-1} (6.52, 14.72, 16.62 and 16.25, respectively) was observed from I_1, while the minimum number (5.65, 13.82, 14.40 and 14.03, respectively) from I_0. At ETS, MTS, FS and GFS, the highest leaf area index (1.49, 3.05, 5.05 and 4.07, respectively) was observed from I_1, while the lowest (1.29, 2.52, 4.36 and 3.43, respectively) from I_0. The maximum crop duration (116.67 days) was observed from I_1, while the minimum (103.50 days) from I_0. The maximum number of effective tillers hill^{-1} (15.05) was observed from I_1, while the minimum number (12.10) from I_0. The minimum number of non-effective tillers hill^{-1} (2.75) was observed from I_0, while the maximum number (2.03) from I_1. The maximum number of total tillers hill^{-1} (17.08) was found from I_1, whereas the minimum number (14.85) from I_0. The longest panicle (24.58 cm) was recorded from I_1 and the shortest panicle (21.93 cm) from I_0. The maximum number of filled grains panicle^{-1} (120.72) was observed from I_1, whereas the minimum number (107.32) from I_0. The minimum number of unfilled grains panicle^{-1} (7.40) was recorded from I_1 and the maximum number (8.43) from I_0. The maximum number of total grains panicle^{-1} (128.12) was observed from I_1, while the minimum number (115.75) from I_0. The highest weight of 1000 grains (25.32 g) was found from I_1, while the lowest weight (23.81 g) from I_0. The highest grain yield (5.17 t ha^{-1}) was recorded from I_1, while the lowest (4.44 t ha^{-1}) from I_0. The highest straw yield (5.97 t ha^{-1}) was observed from I_1, while the lowest (5.24 t ha^{-1}) from I_0. The highest biological yield (11.14 t ha^{-1}) was recorded from I_1 and the lowest (9.68 t ha^{-1}) from I_0. The highest harvest index (46.25%) was found from I_1, while the lowest (45.75%) from I_0.

Due to different rice varieties, at ETS, MTS, FS, GFS and MS, the tallest plant (41.36, 84.97, 114.47, 120.41 and 118.51 cm, respectively) was found from V_1, while the shortest plant (36.51, 76.64, 93.97, 101.58 and 100.51 cm, respectively) from V_4. At ETS, MTS, FS and GFS, the maximum number of tiller hill^{-1} (6.53, 15.17, 16.50 and 16.27, respectively) was found from V_2, whereas the minimum number (5.63, 13.40, 14.63 and 14.13, respectively) from V_4. At ETS, MTS, FS and GFS, the highest leaf area index (1.52, 3.24, 4.92 and 4.25, respectively) was found from V_2, whereas the lowest (1.25, 2.29, 4.32 and 3.19, respectively) from V_4. The maximum crop duration (120.33 days) was found from V_1, whereas the minimum (103.00 days) from V_4. The maximum number of effective tillers hill^{-1} (14.80) was found from V_2, whereas the (12.27) from V_4. The minimum number of non-effective tillers hill^{-1} (2.07) was found from V_2, whereas the maximum number (2.67) from V_4. The maximum number of total tillers hill^{-1} (16.87) was recorded from V_2, while the minimum number (14.93) from V_4. The longest panicle (24.35 cm) was recorded from V_2, whereas the shortest panicle (22.00 cm) from V_4. The maximum number of filled grains panicle^{-1} (119.90) was found from V_2, while the minimum number (107.50) from V_4. The minimum number of unfilled grains panicle^{-1} (7.10) was found from V_2, whereas the maximum number (9.00) from V_4. The maximum number of total grains panicle^{-1} (127.00) was recorded from V_2, whereas the minimum number (116.50) from V_4. The highest weight of 1000 grains (25.82 g) was found from V_3, while the lowest weight (23.05 g) from V_4. The highest grain yield (5.30 t ha^{-1}) was observed from V_2, whereas the lowest (3.90 t ha^{-1}) from V_4. The highest straw yield (5.89 t ha^{-1}) was found from V_1, whereas the lowest (5.13 t ha^{-1}) from V_4. The highest biological yield (10.97 t ha^{-1}) was observed from V_1, while the lowest (9.02 t ha^{-1}) from V_4. The highest harvest index (48.31%) was found from V_2, whereas the lowest (43.26%) from V_4.

In case of combined effect of different levels of irrigation and rice varieties, at ETS, MTS, FS, GFS and MS, the tallest plant (46.84, 92.75, 126.73, 130.82 and 128.36 cm, respectively) was observed from the combination of I_1V_1, whereas the shortest plant (34.97, 72.21, 89.49, 100.29 and 97.59 cm, respectively) from I_0V_4. At ETS, MTS, FS and GFS, the maximum number of tiller hill^{-1} (6.67, 15.20, 18.47 and 18.33, respectively) was observed from the combination of I_1V_2 and the minimum number (5.07, 12.40, 14.13 and 13.67, respectively) from I_0V_4. At ETS, MTS, FS and GFS, the highest leaf area index (1.68, 3.58, 5.39 and 4.55, respectively) was observed from the combination of I_1V_2 and the lowest (1.20, 2.21, 4.32 and 3.10, respectively) from I_0V_4. The maximum crop duration (131.67 days) was observed from the combination of I_1V_1 and the minimum crop duration (101.67 days) from I_0V_4. The maximum number of effective tillers hill^{-1} (16.93) was observed from I_1V_2 and the minimum number (11.47) from I_0V_4. The minimum number of non-effective tillers hill^{-1} (1.73) was found from the combination of I_1V_3 and the maximum number (3.00) from I_0V_1 and I_0V_3. The maximum number of total tillers hill^{-1} (18.87) was found from the combination of I_1V_2 and the minimum number (14.27) from I_0V_4. The longest panicle (25.70 cm) was observed from I_1V_2, while the shortest panicle (21.17 cm) from I_0V_4. The maximum number of filled grains panicle^{-1} (129.80) was found from I_1V_2 and the minimum number (101.00) from I_0V_4. The minimum number of unfilled grains panicle^{-1} (6.13) was found from the combination of I_1V_2, while the maximum number (9.93) from I_0V_4. The maximum number of total grains panicle^{-1} (135.93) was found from I_1V_2 and the minimum number (110.93) from I_0V_4. The highest weight of 1000 grains (26.77 g) was observed from the combination of I_1V_3, whereas the lowest weight (23.00 g) from I_0V_4. The highest grain yield (5.69 t ha^{-1}) from I_1V_2 and the lowest (3.59 t ha^{-1}) from I_0V_4. The highest straw yield (6.34 t ha^{-1}) was observed from I_1V_1 and the lowest (4.58 t ha^{-1} from I_0V_4. The highest biological yield (11.97 t ha^{-1}) was recorded from the combination of I_1V_1, whereas the lowest (8.17 t ha^{-1}) from I_0V_1. The highest harvest index (49.03%) was found from the combination of I_1V_2 and the lowest (42.61%) from I_1V_4.

5.1.3 Experiment-3: Productivity of Aus Rice Varieties Under Different Fertility Regime

The experiment was conducted during the period of April to August, 2016 to find out the productivity of Aus rice varieties under different fertility regime. The experiment comprised of two factors as Factor A: Fertilizer (3 levels): F_1:

Recommended fertilizer dose-RFD, F_2: 20% added with RFD and F_3: 20% less with RFD; and Factor B: Rice variety (4 varieties): V_1: BR-14, V_2: BRRI dhan48, V_3: BRRI dhan55 and V_4: BRRI dhan65. The two factors experiment was laid out in split-plot design with three replications. Data were recorded on different growth characters, yield components and yield of rice and statistically significant variation was recorded for different treatment.

In case of fertility regime, at ETS, MTS, FS, GFS and MS, the tallest plant (41.78, 83.84, 104.95, 116.40 and 112.80 cm, respectively) was recorded from F_1, whereas the shortest plants (37.30, 77.04, 96.29, 107.49 and 106.02 cm, respectively) from F_3. At ETS, MTS, FS and GFS, the maximum number of tiller hill^{-1} (6.70, 14.98, 16.67 and 16.37, respectively) was found from F_1, while the minimum number (6.02, 13.05, 13.75 and 13.47, respectively) from F_3. At ETS, MTS, FS and GFS, the highest total dry matter (169.48, 526.06, 668.71 and 819.09 g m^{-2}, respectively) was observed from F_1, while the lowest (150.31, 462.79, 530.72 and 676.65 g m^{-2}, respectively) from F_3. The maximum crop duration (116.92 days) was observed from F_2 and the minimum crop duration (106.50 days) from F_1. The maximum number of effective tillers hill^{-1} (14.42) was found from F_1, while the minimum number (11.55) from F_3. The minimum number of non-effective tillers hill^{-1} (1.90) was observed from F_1, whereas the maximum number (2.50) from F_2. The maximum number of total tillers hill^{-1} (16.32) was observed from F_1 and the minimum number (13.68) from F_3. The longest panicle (24.44 cm) was recorded from F_1, while the shortest panicle (22.70 cm) from F_3. The maximum number of filled grains panicle^{-1} (122.33) from F_1 and the minimum number (110.78) from F_3. The minimum number of unfilled grains panicle^{-1} (7.52) was observed from F_1, while the maximum number (9.03) from F_3. The maximum number of total grains panicle^{-1} (129.85) was recorded from F_1 and the minimum number (119.82) from F_3. The highest weight of 1000 grains (25.27 g) was observed from F_1, while the lowest (24.34 g) from F_3. The highest grain yield (5.23 t ha^{-1}) was recorded from F_1, while the lowest (4.41 t ha^{-1}) from F_3. The highest straw yield (6.09 t ha^{-1}) was observed from F_1, while the lowest (5.04 t ha^{-1}) from

F_3. The highest biological yield (11.32 t ha^{-1}) was found from F_1 and the lowest (9.46 t ha^{-1}) from F_3. The highest harvest index (46.56%) was observed from F_3 and the lowest (45.86%) from F_2.

For different rice varieties, at ETS, MTS, FS, GFS and MS, the tallest plant (41.73, 86.49, 111.64, 123.72 and 120.71 cm, respectively) was observed from V_1, while the shortest plant (37.00, 75.84, 90.69, 103.78 and 101.68 cm, respectively) from V_4. At ETS, MTS, FS and GFS, the maximum number of tiller $hill^{-1}$ (6.71, 14.76, 16.02 and 15.60, respectively) was recorded from V_2, whereas the minimum number (5.69, 13.24, 14.31 and 14.09, respectively) from V_4. At ETS, MTS, FS and GFS, the highest total dry matter (168.61, 533.68, 696.65 and 805.66 g m^{-2}, respectively) was found from V_2, whereas the lowest (149.98, 462.30, 557.53 and 731.17 g m^{-2}, respectively) from V_4. The maximum crop duration (121.00 days) was found from V_1, whereas the minimum crop duration (103.78 days) from V_4. The maximum number of effective tillers $hill^{-1}$ (13.62) was observed from V_2, whereas the minimum number (11.82) from V_4. The minimum number of non-effective tillers $hill^{-1}$ (2.00) was found from V_2, while the maximum number (2.33) from V_4. The maximum number of total tillers $hill^{-1}$ (15.62) was found from V_2 and the minimum number (14.16) from V_4. The longest panicle (24.33 cm) was observed from V_2, whereas the shortest panicle (22.56 cm) from V_4. The maximum number of filled grains $panicle^{-1}$ (123.09) was found from V_2, while the minimum number (111.00) from V_4. The minimum number of unfilled grains $panicle^{-1}$ (7.89) was found from V_4, whereas the maximum number (8.60) from V_2. The maximum number of total grains $panicle^{-1}$ (131.69) was found from V_2, while the minimum number (118.89) from V_4. The highest weight of 1000 grains (26.10 g) was found from V_3, whereas the lowest weight (23.68 g) from V_4. The highest grain yield (5.40 t ha^{-1}) was observed from V_2, whereas the lowest (3.95 t ha^{-1}) from V_4. The highest straw yield (5.91 t ha^{-1}) was found from V_1, whereas the lowest (5.16 t ha^{-1}) from V_4. The highest biological yield (11.10 t ha^{-1}) was observed from V_2, whereas the lowest (9.11 t ha^{-1}) from V_4. The highest harvest index (48.59%) was recorded from V_2 and the lowest (43.43%) from V_4.

Due to the combined effect of different fertility regime and rice varieties at ETS, MTS, FS, GFS and MS, the tallest plant (44.02, 89.59, 113.39, 129.05 and 124.49 cm, respectively) was found from the combination of F_1V_1, whereas the shortest plant (33.86, 71.11, 84.44, 100.48 and 100.03 cm, respectively) from F_3V_4. At ETS, MTS, FS and GFS, the maximum number of tiller hill^{-1} (7.47, 15.80, 17.53 and 17.20, respectively) was observed from F_1V_2 and the minimum number (5.60, 12.00, 12.33 and 12.13, respectively) from F_3V_4. At ETS, MTS, FS and GFS, the highest total dry matter (185.02, 552.38, 746.27 and 878.23 g m^{-2}, respectively) was observed from F_1V_2 and the lowest (133.86, 422.69, 453.87 and 568.75 g m^{-2}, respectively) from F_2V_4. The maximum crop duration (124.67 days) was observed from the combination of F_2V_1 and the minimum (100.67 days) from F_2V_3. The maximum number of effective tillers hill^{-1} (15.33) was recorded from the combination of F_1V_2 and the minimum number (10.27) from F_3V_4. The minimum number of non-effective tillers hill^{-1} (1.67) was found from the combination of F_1V_2, whereas the maximum number (3.20) from F_2V_4. The maximum number of total tillers hill^{-1} (17.00) was observed from F_1V_2 and the minimum number (12.20) from F_3V_4. The longest panicle (25.78 cm) was observed from F_1V_2, while the shortest panicle (21.71 cm) from F_3V_4. The maximum number of filled grains panicle^{-1} (129.40) was observed from F_1V_2, whereas the minimum number (101.53) from F_3V_4. The minimum number of unfilled grains panicle^{-1} (6.53) was found from F_1V_4 and the maximum number (9.47) from F_2V_1. The maximum number of total grains panicle^{-1} (137.47) was observed from F_1V_2, whereas the minimum number (110.13) from F_3V_4. The highest weight of 1000 grains (26.40 g) from F_1V_3 and the lowest weight (21.79 g) from F_3V_4. The highest grain yield (5.85 t ha^{-1}) was found from of F_1V_2 and the lowest (3.49 t ha^{-1}) from F_3V_4. The highest straw yield (6.71 t ha^{-1}) was observed from F_1V_3 and the lowest (4.34 t ha^{-1}) from F_3V_4. The highest biological yield (12.20 t ha^{-1}) was found from the combination of F_1V_3 and the lowest (7.34 t ha^{-1}) from F_3V_4. The highest harvest index (49.26%) was observed from the combination of F_1V_2, whereas the lowest (42.01%) from F_2V_4.

5.1.4 Experiment-4: Effect of Weed Management on the Yield Attributes and Yield of Different Aus Rice Varieties

The experiment was conducted during the period of April to August, 2016 to find out the effect of weed management on the yield attributes and yield of different Aus rice varieties. The experiment comprised of two factors as Factor A: Weed management (2 levels): W_0: Control, W_1: Hand weeding at 20 and 40 DAT; and Factor B: Rice varieties (4 varieties): V_1: BR-14, V_2: BRRI dhan48, V_3: BRRI dhan55 and V_4: BRRI dhan65. The two factorial experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Data were recorded on weed population, different growth characters, yield components and yield of rice and statistically significant variation was recorded for different treatment.

Due to different weed management, at ETS, MTS, FS and GFS, the higher weed population (19.25, 25.00, 14.17 and 10.92, respectively) was found from W_0, whereas the lower weed population (15.17, 17.75, 8.16 and 4.42, respectively) from W_1. At ETS, MTS, FS, GFS and MS, the taller plant (39.92, 82.51, 106.06, 113.99 and 111.50 cm, respectively) was recorded from W_1, while the shorter plants (35.96, 75.12, 96.10, 104.06 and 102.50 cm, respectively) from W_0. At ETS, MTS, FS and GFS, the maximum number of tiller hill^{-1} (6.65, 14.47, 16.60 and 16.15, respectively) was observed from W_1, while the minimum number (6.05, 13.25, 14.57 and 14.08, respectively) from W_0. The maximum crop duration (113.58 days) was found from W_1 and the minimum crop duration (109.17 days) from W_0. The maximum number of effective tillers hill^{-1} (13.63) was recorded from W_1, whereas the minimum number (11.72) from W_0. The minimum number of non-effective tillers hill^{-1} (1.78) was observed from W_1, while the maximum number (2.90) from W_0. The maximum number of total tillers hill^{-1} (15.42) was recorded from W_1, while the minimum number (14.62) from W_0. The longest panicle (24.04 cm) was found from W_1, whereas the shortest panicle (22.64 cm) from W_0. The maximum number of filled grains panicle^{-1} (121.52) was recorded from W_1, while the minimum number (112.88) from W_0. The minimum number of unfilled grains panicle^{-1} (7.32) was observed from W_1, while the maximum number (9.12) from W_0. The maximum number of total grains panicle^{-1} (128.83) was found from W_1, whereas the minimum number (122.00) from W_0. The highest weight of 1000 grains (25.12 g) was observed from W_1 and the lowest weight (24.07 g) from W_0. The highest grain yield (5.18 t ha^{-1}) was found from W_1, whereas the lowest (4.66 t ha^{-1}) from W_0. The highest straw yield (5.99 t ha^{-1}) was observed from W_1 and the lowest (5.38 t ha^{-1}) from W_0. The highest biological yield (11.17 t ha^{-1}) was observed from W_1, while the lowest (10.04 t ha^{-1}) from W_0. The highest harvest index (46.29%) was found from W_1, while the lowest (46.24%) from W_0.

In case of different rice varieties, at ETS, MTS, FS and GFS, the highest weed population (17.83, 22.17, 11.50 and 7.83, respectively) was found from V_1, while the lowest weed population (16.67, 20.83, 10.67 and 7.50, respectively) from V_4. At ETS, MTS, FS, GFS and MS, the tallest plant (40.68, 86.72, 113.93, 119.93 and 117.83 cm, respectively) was found from V_1, whereas the shortest plant (35.36, 70.71, 94.09, 102.28 and 100.31 cm, respectively) from V_4. At ETS, MTS, FS and GFS, the maximum number of tiller hill^{-1} (6.87, 14.97, 16.87 and 16.33, respectively) was recorded from V_2, whereas the minimum number (6.03, 13.07, 14.43 and 14.00, respectively) from V_4. The maximum crop duration (120.67 days) was found from V_1, whereas the minimum crop duration (102.17 days) from V_4. The maximum number of effective tillers hill^{-1} (14.07) was recorded from V_2 and the minimum number (11.90) from V_4. The minimum number of non-effective tillers hill^{-1} (2.67) was recorded from V_4, whereas the maximum number (2.03) from V_2. The maximum number of total tillers hill^{-1} (16.10) was found from V_2 and the minimum number (14.57) from V_4. The longest panicle (23.93 cm) was recorded from V_2, while the shortest panicle (22.35 cm) from V_4. The maximum number of filled grains panicle^{-1} (123.23) was found from V_2 and the minimum number (113.00) from V_1. The minimum number of unfilled grains panicle^{-1} (7.17) was found from V_2 and the maximum number (9.27) from V_4. The maximum number of total grains panicle^{-1} (130.40) was found from V_2, while the minimum number (121.57) from V_1. The highest weight of 1000 grains (26.24 g) was recorded from V_3, whereas the lowest weight (23.18 g) from V_4. The highest harvest index (48.72%) was observed from V_2 which was followed (46.46% and 46.33%) by V_1 and V_3, respectively, whereas the lowest harvest index (43.56%) was found from V_4. The highest grain yield (5.47 t ha^{-1}) was recorded from V_2, while the lowest (3.98 t ha^{-1}) from V_4. The highest straw yield 5.95 t ha^{-1}) was observed from V_1, whereas the lowest (5.19 t ha^{-1}) from V_4. The highest biological yield (11.23 t ha^{-1}) was found from V_2, whereas the lowest (9.17 t ha^{-1}) from V_4.

For the combined effect of different weed management and rice varieties, at ETS, MTS, FS and GFS, the highest weed population (21.33, 26.00, 15.00 and 11.33, respectively) was observed from the combination of W_0V_2, whereas the lowest weed population (13.67, 15.67, 7.67 and 4.00, respectively) from W_1V_2. At ETS, MTS, FS, GFS and MS, the tallest plant (41.27, 87.93, 116.44, 121.13 and 118.78 cm, respectively) was found from the combination of W_1V_1 and the shortest plant (32.26, 64.86, 80.33, 90.12 and 88.42 cm, respectively) from W_0V_4. At ETS, MTS, FS and GFS, the maximum number of tiller hill^{-1} (7.13, 15.40, 17.73 and 17.40, respectively) was recorded from the combination of W_1V_2 and the minimum number (5.40, 11.73, 12.73 and 12.27, respectively) from W_0V_4. The maximum crop duration (123.33 days) was observed from the combination of W_1V_1, while the minimum crop duration (100.33 days) from W_0V_4. The maximum number of effective tillers hill^{-1} (14.53) was observed from the combination of W_1V_2, while minimum number (10.07) from W_0V_4. The minimum number of non-effective tillers hill^{-1} (1.47) was found from the combination of W_1V_1 and the maximum number (3.47) from W_0V_1. The maximum number of total tillers hill^{-1} (16.13) was observed from the combination of W_1V_2 and the minimum number (13.20) from W_0V_4. The longest panicle (25.24 cm) was attained from the combination of W_1V_2, whereas the shortest panicle (22.24 cm) from W_0V_4. The maximum number of filled grains panicle^{-1} (128.33) was found from the combination of W_1V_2 and the minimum number (109.07) from W_0V_4. The minimum number of unfilled grains panicle^{-1} (6.20) was observed from the combination of W_1V_2 and the maximum number (9.80) from W_0V_1. The maximum number of total grains panicle^{-1} (134.53) was observed from the combination of W_1V_2 and the minimum number (118.80) from W_0V_4. The highest weight of 1000 grains (26.56 g) was found from the combination of W_1V_3, while the lowest weight (21.40 g) from W_0V_4. The highest grain yield (5.73 t ha^{-1}) was observed from the combination of W_1V_2 and the lowest (3.64 t ha^{-1}) from W_0V_4. The highest straw yield (6.19 t ha^{-1}) was observed from the combination of W_1V_3 and the lowest (4.54 t ha^{-1}) from W_0V_4. The highest biological yield (11.63 t ha^{-1}) was observed from the combination of W_1V_3 and the lowest (8.19 t ha^{-1}) from W_0V_4. The highest harvest index (49.53%) was recorded from the combination of W_1V_2 and the lowest (42.59%) from W_1V_4.

5.1.5 Experiment-5: Performance of Aus Rice Under Varying Irrigation Regime, Fertilizer Dose and Weeding Method

The experiment was conducted during the period of April to August, 2017 to find out the performance of Aus rice under varying irrigation regime, fertilizer dose and weeding method. The experiment comprised of three factors as Factor A: Irrigation (2 levels): I_0: No irrigation and I_1: Supplemental irrigation; Factor B: Fertilizer (2 levels): F_1: Recommended fertilizer dose-RFD and F_2: 20% added with RFD; and Factor C: Weed management (3 levels): W_1: Hand weeding at 20 and 40 DAT; W_2: Use of pre emergence herbicide at 4 DAT and W_3: Weeding by BRRI hand weeder at 20 and 40 DAT. The three factors experiment was laid out in split-split-plot design with three replications. Data were recorded on weed population, different growth characters, yield components and yield of rice and statistically significant variation was recorded for different treatment.

In case of different irrigation regime, at ETS, MTS, FS and GFS, the higher number of weed population (12.11, 15.85, 10.22 and 5.78, respectively) was recorded from I_0, while the lower weed population (10.44, 9.56, 6.11 and 3.83, respectively) from I_1. At ETS, MTS, FS, GFS and MS the longer plant (33.54, 77.88, 92.76, 103.17 and 101.87 cm, respectively) was observed from I_1, whereas the shorter plant (31.11, 73.51, 89.74, 95.29 and 94.03 cm, respectively) from I_0. At ETS, MTS, FS and GFS the maximum number of tillers hill^{-1} (6.36, 13.47, 14.70 and 14.47, respectively) was found from I_1, while the minimum number (5.97, 12.32, 13.48 and 13.26, respectively) from I_0. At ETS, MTS, FS and GFS the highest leaf area index (1.46, 3.18, 4.50 and 4.30, respectively) was found from I_1, whereas the lowest (1.37, 2.59, 3.28 and 3.00, respectively) from I_0. At ETS, MTS, FS and GFS the highest TDM (174.32, 471.00, 646.85 and 779.14 g m^{-2}, respectively) was recorded from I_1, whereas the lowest TDM (160.37, 428.87, 591.45 and 704.05 g m^{-2}, respectively) from I_0. At ETS to MTS, MTS to FS and FS to GFS the highest CGR (19.78, 11.72 and 8.82 g m^{-2}day^{-1}, respectively) was recorded from I_1 and the lowest CGR (17.90, 10.84 and 7.51 g m^{-2}day^{-1}, respectively) from I_0. At ETS to MTS, MTS to FS and FS to GFS the highest RGR (28.76, 9.31 and 5.35 mg g^{-1}day^{-1}, respectively) was observed from I_1, whereas the lowest RGR (28.47, 9.19 and 5.03 mg g^{-1}day^{-1}, respectively) from I_0. At ETS to MTS, MTS to FS and FS to GFS the highest NAR (7.96, 1.60 and 0.80 g m^{-2} day^{-1}, respectively) was observed from I_1, whereas the lowest NAR (7.82, 1.58 and 0.74 g m^{-2}day^{-1}, respectively) from I_0.

The highest crop duration (111.94 days) was found from I_1 and the lowest crop duration (105.95 days) from I_0. The maximum number of effective tillers hill^{-1} (13.40) was observed from I_1, whereas the minimum number (12.21) from I_0. The minimum number of non-effective tillers hill^{-1} (2.12) was observed from I_1, whereas the maximum number (2.30) from I_0. The maximum number of total tillers hill^{-1} (15.56) was observed from I_1, whereas the minimum number (14.51) from I_0. The longest panicle (23.59 cm) was observed from I_1, whereas the shortest panicle (22.07 cm) from I_0. The maximum number of filled grains panicle^{-1} (118.07) was observed from I_1 and the minimum number (108.14) from I_0. The minimum number of unfilled grains panicle^{-1} (6.56) was observed from I_1, whereas the maximum number (7.07) from I_0. The maximum number of total grains panicle^{-1} (124.62) was found from I_1, whereas the minimum number (115.20) from I_0. The highest weight of 1000 grains (23.56 g) was observed from

I_1, whereas the lowest weight (21.70 g) from I_0. The highest grain yield (5.17 t ha^{-1}) was recorded from I_1, whereas the lowest (4.71 t ha^{-1}) from I_0. The highest straw yield (5.46 t ha^{-1}) was observed from I_1, whereas the lowest (5.02 t ha^{-1}) from I_0. The highest biological yield (10.63 t ha^{-1}) was found from I_1, whereas the lowest (9.73 t ha^{-1}) from I_0. The highest harvest index (48.63%) was found from I_1, whereas the lowest (48.40%) from I_0.

For different fertilizer doses, at ETS, MTS, FS and GFS, the highest weed population (11.83, 13.63, 8.67 and 5.22, respectively) was observed from F_2, whereas the lowest weed population (10.72, 11.78, 7.67 and 4.39, respectively) from F_1. At ETS, MTS, FS, GFS and MS the longest plant (33.84, 79.11, 93.39, 102.46 and 100.79 cm, respectively) was found from F_1, while the shorter plant (30.81, 72.28, 89.11, 96.00 and 95.11 cm, respectively) from F_2. At ETS, MTS, FS and GFS the maximum number of tillers $hill^{-1}$ (6.33, 13.46, 14.64 and 14.40, respectively) was recorded from F_1, while the minimum number (5.99, 12.33, 13.53 and 13.32, respectively) from F_2. At ETS, MTS, FS and GFS the highest leaf area index (1.46, 3.15, 4.42 and 4.23, respectively) was recorded from F_1, while the lowest (1.37, 2.61, 3.36 and 3.07, respectively) from F_2. At ETS, MTS, FS and GFS the highest TDM (173.38, 466.59, 641.56 and 773.81 g m^{-2}, respectively) was found from F_1, while the lowest TDM (161.30, 433.29, 596.74 and 709.38 g m^{-2}, respectively) from F_2. At ETS to MTS, MTS to FS and FS to GFS the highest CGR (19.55, 11.66 and 8.82 g $m^{-2}day^{-1}$, respectively) was observed from F_1, while the lowest CGR (18.13, 10.90 and 7.51 g $m^{-2}day^{-1}$, respectively) from F_2. At ETS to MTS, MTS to FS and FS to GFS the highest RGR (28.62, 9.27 and 5.39 mg $g^{-1}day^{-1}$, respectively) was found from F_1, while the lowest RGR (28.61, 9.24 and 4.99 mg $g^{-1}day^{-1}$, respectively) from F_2. At ETS to MTS, MTS to FS and FS to GFS the highest NAR (7.90, 1.60 and 0.80 g $m^{-2}day^{-1}$, respectively) was found from F_1, while the lowest NAR (7.88, 1.58 and 0.74 g $m^{-2}day^{-1}$, respectively) from F_2.

The highest crop duration (112.17 days) was recorded from F_2, while the lowest (105.72 days) from F_2. The maximum number of effective tillers hill^{-1} (13.69) was recorded from F_1, while the minimum number (11.92) from F_2. The minimum number of non-effective tillers hill^{-1} (2.01) was recorded from F_1, while the maximum number (2.41) from F_2. The maximum number of total tillers hill^{-1} (15.73) was recorded from F_1, while the minimum number (14.33) from F_2. The longest panicle (23.48 cm) was found from F_1, while the shortest panicle (22.18 cm) from F_2. The maximum number of filled grains panicle^{-1} (117.37) was found from F_1, whereas the minimum number (108.83) from F_2. The minimum number of filled grains panicle^{-1} (6.54) was recorded from F_1, while the maximum number (7.08) from F_2. The maximum number of total grains panicle^{-1} (123.92) was recorded from F_1, while the minimum number (115.91) from F_2. The highest weight of 1000 grains (23.53 g) was found from F_1 and the lowest weight (21.73 g) from F_2. The highest grain yield (5.16 t ha^{-1}) was observed from F_1 and the lowest (4.71 t ha^{-1}) from F_2. The highest straw yield (5.49 t ha^{-1}) was found from F_1, while the lowest (5.00 t ha^{-1}) from F_2. The highest biological yield (10.65 t ha^{-1}) was found from F_1, while the lowest (9.71 t ha^{-1}) from F_2. The highest harvest index (48.53%) was recorded from F_1 and the lowest (48.50%) from F_2.

Due to different weeding methods, at ETS, MTS, FS and GFS, the highest weed population (16.67, 18.44, 12.42 and 6.50, respectively) was recorded from W_1, while the lowest weed population (1.42, 1.92, 2.25 and 2.50, respectively) from W_2. At ETS, MTS, FS, GFS and MS the longest plant (33.57, 77.79, 92.47, 101.81 and 99.98 cm, respectively) was found from W_2, while the shortest plant (30.64, 72.66, 88.20, 96.15 and 94.98 cm, respectively) from W_1. 3. At ETS, MTS, FS and GFS the maximum number of tillers hill^{-1} (6.38, 13.25, 14.47 and 14.23, respectively) was recorded from W_2, while the minimum number (5.95, 12.35, 13.43 and 13.22, respectively) from W_1. At ETS, MTS, FS and GFS the highest leaf area index (1.45, 3.02, 4.22 and 3.96, respectively) was found from W_2, while the lowest (1.36, 2.67, 3.43 and 3.16, respectively) from W_1. At ETS, MTS, FS and GFS the highest TDM (171.18, 460.88, 633.98 and 762.92 g m^{-2}, respectively) was found from W_2, while the lowest TDM (162.87, 437.62, 601.93 and 716.05 g m^{-2}, respectively) from W_1. At ETS to MTS, MTS to FS and FS to GFS the highest CGR (19.31, 11.54 and 8.60 g $m^{-2}day^{-1}$, respectively) was recorded from W_2, while the lowest CGR (18.32, 10.95 and 7.61 g $m^{-2}day^{-1}$, respectively) from W_1. At ETS to MTS, MTS to FS and FS to GFS the highest RGR (28.64, 9.27 and 5.33 mg $g^{-1}day^{-1}$, respectively) from W_2, while the lowest RGR (28.60, 9.24 and 4.98 mg $g^{-1}day^{-1}$, respectively) from W_1. At ETS to MTS, MTS to FS and FS to GFS the highest NAR (7.93, 1.60 and 0.79 g $m^{-2}day^{-1}$, respectively) was found from W_2, while the lowest NAR (7.82, 1.58 and 0.74 g $m^{-2}day^{-1}$, respectively) from W_1.

The highest crop duration (110.17 days) was found from W_1, while the lowest (107.83 days) from W_1. The maximum number of effective tillers $hill^{-1}$ (13.28) was found from W_2, while the minimum number (12.10) from W_1. The minimum number of non-effective tillers $hill^{-1}$ (2.12) was found from W_2 and the maximum number (2.35) from W_1. The maximum number of total tillers $hill^{-1}$ (15.45) was found from W_2, whereas the minimum number (14.45) from W_1. The longest panicle (23.19 cm) was found from W_2, while the shortest panicle (22.21 cm) from W_1. The maximum number of filled grains $panicle^{-1}$ (116.08) was recorded from W_2, while the minimum number (109.57) from W_1. The minimum number of unfilled grains $panicle^{-1}$ (6.67) was found from W_2, while the maximum number (7.07) from W_1. The maximum number of total grains $panicle^{-1}$ (122.75) was observed from W_2, while the minimum number (116.64) from W_1. The highest weight of 1000 grains (22.92 g) was found from W_2, while the lowest weight (22.48 g) from W_3. The highest grain yield (5.06 t ha^{-1}) was recorded from W_2 and the lowest grain yield (4.77 t ha^{-1}) from W_1. The highest straw yield (5.35 t ha^{-1}) was found from W_2, while the lowest (5.07 t ha^{-1}) from W_1. The highest biological yield (10.40 t ha^{-1}) was recorded from W_2, while the lowest (9.84 t ha^{-1}) was observed from W_1. The highest harvest index (48.61%) was observed from W_2, while the lowest (48.41%) from W_3.

For the combined effect of different irrigation regime and fertilizer doses, at ETS, MTS, FS and GFS, the highest weed population (12.33, 16.37, 10.33 and 6.00, respectively) was found from the combination of I_0F_2 and the lowest weed population (9.56, 8.22, 5.22 and 3.22, respectively) from I_1F_1. At ETS, MTS, FS, GFS and MS the longest plant (36.25, 83.43, 94.96, 108.60 and 106.52 cm, respectively) was observed from the combination of I_1F_1, whereas the shortest plant (30.78, 72.23, 87.66, 94.25 and 92.99 cm, respectively) from I_0F_2. At ETS, MTS, FS and GFS the maximum number of tillers hill^{-1} (6.69, 14.38, 15.47 and 15.20, respectively) was recorded from the combination of I_1F_1, whereas the minimum number (5.96, 12.11, 13.13 and 12.91, respectively) from I_0F_2. At ETS, MTS, FS and GFS the highest leaf area index (1.55, 3.74, 4.51 and 4.49, respectively) was found from the combination of I_1F_1, whereas the lowest (1.36, 2.57, 3.23 and 2.98, respectively) from I_0F_2. At ETS, MTS, FS and GFS the highest TDM (186.80, 506.48, 694.17 and 845.60 g m^{-2}, respectively) was observed from the combination of I_1F_1, whereas the lowest TDM (159.97, 426.69, 588.95 and 702.01 g m^{-2}, respectively) from I_0F_2. At ETS to MTS, MTS to FS and FS to GFS the highest CGR (21.31, 12.51 and 10.10 g m^{-2}day^{-1}, respectively) was observed from the combination of I_1F_1, whereas the lowest CGR (17.78, 10.82 and 7.48 g m^{-2}day^{-1}, respectively) from I_0F_2. At ETS to MTS, MTS to FS and FS to GFS the highest RGR (28.86, 9.34 and 5.71 mg g^{-1}day^{-1}, respectively) was observed from the combination of I_1F_1, whereas the lowest RGR (28.38, 9.13 and 4.98 mg g^{-1}day^{-1}, respectively) from I_0F_2. At ETS to MTS, MTS to FS and FS to GFS the highest NAR (8.01, 1.61 and 0.86 g m^{-2}day^{-1}, respectively) was observed from the combination of I_1F_1, whereas the lowest NAR (7.75, 1.57 and 0.73 g m^{-2}day^{-1}, respectively) from I_0F_2.

The highest crop duration (118.11 days) was observed from the combination of I_1F_2, while the lowest (105.67 days) from I_0F_1. The maximum number of effective tillers hill^{-1} (14.96) was observed from the combination of I_1F_1, whereas the minimum number (11.84) from I_1F_2. The minimum number of non-effective tillers hill^{-1} (1.78) was found from the combination of I_1F_1, whereas the maximum number (2.47) from I_1F_2. The maximum number of total tillers hill^{-1} (16.80) was found from the combination of I_1F_1, whereas the minimum number (14.31) from I_1F_2. The longest panicle (24.88 cm) was observed from the combination of I_1F_1, whereas the shortest panicle (22.06 cm) from I_0F_2. The maximum number of filled grains panicle^{-1} (127.04) was found from the combination of I_1F_1, whereas the minimum number (107.70) from I_0F_1. The minimum number of unfilled grains panicle^{-1} (6.07) from I_1F_1, whereas the maximum number (7.11) was recorded from the combination of I_0F_2. The maximum number of total grains panicle^{-1} (133.11) was observed from the combination of I_1F_1, whereas the minimum number (114.72) from I_0F_1. The highest weight of 1000 grains (25.35 g) was found from the combination of I_1F_1 and the lowest weight (21.69 g) from I_0F_2. The highest grain yield (5.59 t ha^{-1}) was found from the combination of I_1F_1, whereas the lowest (4.68 t ha^{-1}) from I_0F_2. The highest straw yield (5.94 t ha^{-1}) was observed from the combination of I_1F_1, whereas the lowest (4.99 t ha^{-1}) from I_1F_2. The highest biological yield (11.53 t ha^{-1}) was found from the combination of I_1F_1, whereas the lowest (9.69 t ha^{-1}) from I_0F_2. The highest harvest index (48.74%) was found from the combination of I_1F_2, whereas the lowest (48.32%) from I_0F_2.

In case of the combined effect of different irrigation regime and weeding methods, at ETS, MTS, FS and GFS, the highest weed population (17.50, 23.88, 15.00 and 7.50, respectively) was found from the combination of I_0W_1, whereas the lowest weed population (1.17, 1.83, 2.17 and 2.33, respectively) from I_1W_2. At ETS, MTS, FS, GFS and MS the longest plant (34.11, 78.12, 93.46, 104.06 and 102.56 cm, respectively) was observed from the combination of I_1W_2, whereas the shortest plant (28.09, 67.71, 82.93, 89.16 and 87.39 cm, respectively) from I_0W_1. At ETS, MTS, FS and GFS the maximum number of tillers hill^{-1} (6.47, 13.50, 14.77 and 14.53, respectively) was found from the combination of I_1W_2, while the minimum number (5.60, 11.20, 12.13 and 11.90, respectively) from I_0W_1. At ETS, MTS, FS and GFS the highest leaf area index (1.47, 3.26, 4.72 and 4.47, respectively) was observed from the combination of I_1W_1, whereas the lowest (1.27, 2.07, 2.13 and 1.86, respectively) from I_0W_1. At ETS, MTS, FS and GFS the highest TDM (175.47, 472.96, 649.55 and 783.54 g m^{-2}, respectively) was found from the combination of I_1W_2, whereas the lowest TDM (150.26, 402.28, 554.32 and 648.56 g m^{-2}, respectively) from I_0W_1. At ETS to MTS, MTS to FS and FS to GFS the highest CGR (g $m^{-2}day^{-1}$, respectively) was observed from the combination of I_1W_2, whereas the lowest CGR (g $m^{-2}day^{-1}$, respectively) from I_0W_1. At ETS to MTS, MTS to FS and FS to GFS the highest RGR (28.82, 9.33 and 5.42 mg $g^{-1}day^{-1}$, respectively) was observed from the combination of I_1W_2, whereas the lowest RGR (28.44, 9.18 and 4.54 mg $g^{-1}day^{-1}$, respectively) from I_0W_1. At ETS to MTS, MTS to FS and FS to GFS the highest NAR (8.05, 1.62 and 0.81 g $m^{-2}day^{-1}$, respectively) was observed from the combination of I_1W_2, whereas the lowest NAR (7.74, 1.56 and 0.67 g $m^{-2}day^{-1}$, respectively) from I_0W_1.

The highest crop duration (109.83 days) was found from the combination of I_0W_1, whereas the lowest (103.33 days) from I_0W_2. The maximum number of effective tillers $hill^{-1}$ (13.47) was found from the combination of I_1W_1 and I_1W_3, whereas the minimum number (10.73) from I_0W_1. The minimum number of non-effective tillers $hill^{-1}$ (2.03) was found from the combination of I_0W_2 and I_1W_1, whereas the maximum number (2.67) from I_0W_1. The maximum number of total tillers $hill^{-1}$ (15.60) was observed from the combination of I_1W_3, whereas the minimum number (13.40) from I_0W_1. The longest panicle (23.92 cm) was observed from the combination of I_1W_1 and the shortest panicle (20.50 cm) from I_0W_1. The maximum number of filled grains $panicle^{-1}$ (118.47) was observed from I_1W_2, whereas the minimum number (100.88) from I_0W_1. The minimum number of unfilled grains $panicle^{-1}$ (6.50) was found from the combination of I_1W_1, whereas the maximum number (7.63) from I_0W_1. The maximum number of total grains $panicle^{-1}$ (125.10) was observed from the combination of I_1W_2, whereas the minimum number (108.51) from I_0W_1. The highest weight of 1000 grains (24.26 g) was observed from the combination of I_1W_1, whereas the lowest weight (20.73 g) from I_0W_1. The highest grain yield (5.18 t ha^{-1}) was recorded from the combination of I_1W_1, whereas the lowest (4.36 t ha^{-1}) from I_0W_1. The highest straw yield (5.57 t ha^{-1}) was observed from the combination of I_1W_2, whereas the lowest

(4.57 t ha^{-1}) from I_0W_1. The highest biological yield (10.75 t ha^{-1}) was observed from the combination of I_1W_1, whereas the lowest (8.93 t ha^{-1}) from I_0W_1. The highest harvest index (49.06%) was recorded from the combination of I_1W_2, whereas the lowest (48.15%) from I_0W_2.

Due to the combined effect of different fertilizer doses and weeding methods, at ETS, MTS, FS and GFS, the highest weed population (17.17, 19.38, 13.67 and 7.50, respectively) was recorded from the combination of F_2W_1, whereas the lowest weed population (1.17, 1.50, 1.83 and 2.17, respectively) from F_1W_2. At ETS, MTS, FS, GFS and MS the longest plant (36.17, 82.46, 94.80, 106.61 and 104.23 cm, respectively) was observed from the combination of F_1W_2, whereas the shortest plant (29.26, 69.12, 84.55, 93.64 and 92.06 cm, respectively) from F_2W_1. At ETS, MTS, FS and GFS the maximum number of tillers $hill^{-1}$ (6.67, 14.03, 15.17 and 14.97, respectively) was observed from the combination of F_1W_2, whereas the minimum number (5.80, 11.77, 12.70 and 12.50, respectively) from F_2W_1. At ETS, MTS, FS and GFS the highest leaf area index (1.53, 3.49, 5.13 and 4.97, respectively) was found from the combination of F_1W_2, whereas the lowest (1.32, 2.50, 3.05 and 2.78, respectively) from F_2W_1. At ETS, MTS, FS and GFS the highest TDM (182.53, 493.38, 677.17 and 823.39 g m^{-2}, respectively) was recorded from the combination of F_1W_2, while the lowest TDM (159.45, 428.39, 590.78 and 697.78 g m^{-2}, respectively) from F_2W_1. At ETS to MTS, MTS to FS and FS to GFS the highest CGR (19.85, 11.77 and 8.93 g $m^{-2}day^{-1}$, respectively) was observed from the combination of F_1W_2, whereas the lowest CGR (16.80, 10.14 and 6.28 g $m^{-2}day^{-1}$, respectively) from F_2W_1. At ETS to MTS, MTS to FS and FS to GFS the highest RGR (28.74, 9.31 and 5.66 mg $g^{-1}day^{-1}$, respectively) was observed from the combination of F_1W_2, whereas the lowest RGR (28.49, 9.19 and 4.78 mg $g^{-1}day^{-1}$, respectively) from F_2W_1. At ETS to MTS, MTS to FS and FS to GFS the highest NAR (8.04, 1.61 and 0.85 g $m^{-2}day^{-1}$, respectively) was observed from F_1W_2, whereas the lowest NAR (7.81, 1.57 and 0.71 g $m^{-2}day^{-1}$, respectively) from F_2W_1.

The highest crop duration (113.00 days) was recorded from the combination of F_2W_2, whereas the lowest (102.67 days) from F_2W_1. The maximum number of effective tillers hill^{-1} (14.67) was observed from the combination of F_1W_2, whereas the minimum number (11.30) from F_2W_1. The minimum number of non-effective tillers hill^{-1} (1.80) was observed from the combination of F_1W_2, whereas the maximum number (2.57) from F_2W_1. The maximum number of total tillers hill^{-1} (16.57) was observed from the combination of F_1W_2, whereas the minimum number (13.87) from F_2W_1. The longest panicle (24.26 cm) was observed from the combination of F_1W_2, whereas the shortest panicle (21.61 cm) from F_2W_1. The maximum number of filled grains panicle^{-1} (124.30) was observed from the combination of F_1W_2, whereas the minimum number (107.50) from F_2W_1. The minimum number of unfilled grains panicle^{-1} (6.27) was observed from the combination of F_1W_2, whereas the maximum number (7.30) from F_2W_1. The maximum number of total grains panicle^{-1} (130.57) was observed from the combination of F_1W_2, whereas the minimum number (114.80) from F_2W_1. The highest weight of 1000 grains (24.56 g) was found from the combination of F_1W_2, whereas the lowest weight (21.29 g) from F_2W_2. The highest grain yield (5.40 t ha^{-1}) was found from the combination of F_1W_2, whereas the lowest (4.58 t ha^{-1}) from F_2W_1. The highest straw yield (5.73 t ha^{-1}) was observed from the combination of F_1W_2, whereas the lowest (4.84 t ha^{-1}) from F_2W_1. The highest biological yield (11.13 t ha^{-1}) was observed from the combination of F_1W_2, whereas the lowest (9.42 t ha^{-1}) from F_2W_1. The highest harvest index (48.72%) was found from the combination of F_2W_2, whereas the lowest (48.27%) from F_2W_3.

In case of the combined effect of different irrigation regime, fertilizer doses and weeding methods, at ETS, MTS, FS and GFS, the highest weed population (18.33, 24.00, 15.33 and 8.33, respectively) was observed from the combination of $I_0F_2W_1$, whereas the lowest weed population (1.00, 1.33, 1.67 and 2.00, respectively) was found from $I_1F_1W_2$. At ETS, MTS, FS, GFS and MS the longest plant (39.13, 85.46, 95.65, 112.78 and 108.84 cm, respectively) was observed from the combination of $I_1F_1W_2$, whereas the shortest plant (26.35, 64.16, 76.42, 86.14 and 83.56 cm, respectively) from $I_0F_2W_1$. At ETS, MTS, FS and GFS the maximum number of tillers hill^{-1} (6.93, 14.73, 15.87 and 15.67, respectively) was recorded from the combination of $I_1F_1W_2$, whereas the minimum number (5.47, 10.53, 11.07 and 10.80, respectively) from $I_0F_2W_1$. At ETS, MTS, FS and GFS the highest leaf area index (1.62, 3.86, 5.69 and 4.80, respectively) was recorded from the combination of $I_1F_1W_2$, whereas the lowest (1.22, 2.02, 2.19 and 1.72, respectively) from $I_0F_2W_1$. At ETS, MTS, FS and GFS the highest TDM (194.32, 529.67, 724.05 and 886.45 g m^{-2}, respectively) was observed from the combination of $I_1F_1W_2$ and the lowest TDM (149.19, 402.74, 553.67 and 642.82 g m^{-2}, respectively) from $I_0F_2W_1$. At ETS to MTS, MTS to FS and FS to GFS the highest CGR (22.36, 12.96 and 10.83 g m^{-2}day^{-1}, respectively) was observed from the combination of $I_1F_1W_2$, whereas the lowest CGR (16.70, 10.06 and 5.94 g m^{-2}day^{-1}, respectively) from $I_0F_2W_1$. At ETS to MTS, MTS to FS and FS to GFS the highest RGR (29.00, 9.36 and 5.87 mg g^{-1}day^{-1}, respectively) was observed from the combination of $I_1F_1W_2$, whereas the lowest RGR (28.26, 9.15 and 4.32 mg g^{-1}day^{-1}, respectively) from $I_0F_2W_1$. At ETS to MTS, MTS to FS and FS to GFS the highest NAR (8.19, 1.63 and 0.91 g m^{-2}day^{-1}, respectively) was observed from the combination of $I_1F_1W_2$, whereas the lowest NAR (7.73, 1.55 and 0.65 g m^{-2}day^{-1}, respectively) from $I_0F_2W_1$.

The highest crop duration (120.33 days) was found from the combination of $I_1F_2W_3$, whereas the lowest (100.67 days) from $I_0F_1W_2$. The maximum number of effective tillers hill^{-1} (15.53) was observed from the combination of $I_1F_1W_2$, whereas the minimum number (10.07) from $I_0F_2W_1$. The minimum number of non-effective tillers hill^{-1} (1.67) was found from the combination of $I_1F_1W_2$ and the maximum number (2.87) from $I_0F_2W_1$. The maximum number of total tillers hill^{-1} (17.40) was found from the combination of $I_1F_1W_2$, while the minimum number (12.93) from $I_0F_2W_1$. The longest panicle (25.05 cm) was observed from the combination of $I_1F_1W_2$, while the shortest panicle (20.10 cm) from $I_0F_2W_1$. The maximum number of filled grains panicle^{-1} (133.07) was observed from the combination of $I_1F_1W_2$, whereas the minimum number (100.67) from $I_0F_2W_1$. The minimum number of unfilled grains panicle^{-1} (5.93) was observed from the combination of $I_1F_1W_2$, whereas the maximum number (7.87) from $I_0F_2W_1$. The maximum number of total grains panicle^{-1} (139.00) was observed from the combination of $I_1F_1W_2$, whereas the minimum number (108.53) from $I_0F_2W_1$.The highest weight of 1000 grains (26.21 g) was observed from the combination of $I_1F_1W_2$, whereas the lowest weight (20.35 g) from $I_1F_2W_2$. The highest grain yield (5.79 t ha^{-1}) was recorded from the combination of $I_1F_1W_2$, while the lowest (4.23 t ha^{-1}) from $I_0F_2W_1$. The highest straw yield (5.97 t ha^{-1}) was observed from the combination of $I_1F_1W_2$, whereas the lowest (4.45 t ha^{-1}) from $I_0F_2W_1$. The highest biological yield (11.76 t ha^{-1}) was found from the combination of $I_1F_1W_2$, whereas the lowest (8.68 t ha^{-1}) from $I_0F_2W_1$. The highest harvest index (49.22%) was observed from the combination of $I_1F_1W_2$ and the lowest (47.72%) from $I_0F_2W_3$.

5.2 Conclusion

In this study five experiments were carried out each initiating in the month of April and ending in July/August through the year 2015 to 2017 at Shere-e-Bangla Agricultural University to evaluate some of the existing aus rice varieties under varying irrigation, weed control and fertilizer regimes.

In the first experiment, twelve aus rice varieties BR 3, BR 14, BR 16, BRRI dhan27, BRRI dhan42, BRRI dhan48, BRRI dhan55, BRRI dhan65, China (Muladi local), Kali Shait-ta (Muladi local), Benamuri (Muladi local) and Abdul Hye (Jhalkathi local) were tested under two irrigation regimes (no irrigation and supplemental irrigation). Effect of both the irrigation and variety; and that of the interaction were significant. Irrigated plots showed significantly higher seed yields (4.22 t ha^{-1}) compared to that of the non-irrigated ones (3.90 t ha^{-1}). Out of twelve, the local varieties yielded 27% lower (2.90-3.61 with an average of 3.26 t ha^{-1}) than the high yielders (3.85-5.22, average 4.46 t ha^{-1}). Three varieties (BR14, BRRI dhan48 and BRRI dhan55) showed higher seed yields (5.16-5.69 t ha^{-1}). BRRI dhan65 had the earliest maturity (106.50 days) with a good grain yield (3.85

t ha^{-1}). The lowest seed yield was observed with the variety Kali shaita-ta and Benamuri (2.84 and 2.86 t/ha respectively) under non irrigated condition. As the three varieties (BR 14, BRRI dhan48 and BRRI dhan55) gave seed yields which were at par and the BRRI dhan65 had the shortest duration along with a good seed yield have been selected to be evaluated again in the next season. The second experiment was done with two regimes of irrigation (with and without) and four varieties (BR 14, BRRI dhan48, BRRI dhan55 and BRRI dhan65). Results showed that the irrigated plots produced the higher seed yield (5.17 t ha^{-1}), while the non-irrigated ones (4.44 t ha^{-1}). Across the irrigation treatments, the varieties, BR 14, BRRI dhan48 and BRRI dhan55 out yielded (4.95-5.30 t ha^{-1}) the BRRI dhan65 (3.90 t ha^{-1}). But the interaction treatment of varieties BR 14 and BRRI dhan48 with irrigation gave significantly higher grain yields (5.63 and 5.69 t ha^{-1}). The interaction treatment of non-irrigation × BRRI dhan65 showed the lowest grain yield (3.59 t ha^{-1}). In this experiment out of four varieties BR 14, BRRI dhan48 and BRRI dhan55 had identical and significantly higher grain yields (5.16-5.69 t ha^{-1}) than that of the BRRI dhan65 (4.21 t ha^{-1} under irrigated condition). However, it was observed that the variety BRRI dhan65 although produced lower grain yield compared to the other three varieties, it showed the shortest duration both in the Experiment-I and II. So, it was decided to further evaluate this variety in the third year.

In the Experiment-III, three levels of fertilizer (recommended, 20% higher the recommended and 20% lower than recommended) and four varieties (BRRI 14, BRRI dhan48, BRRI dhan55 and BRRI dhan65) were tested. Fertilizer, variety and the combination had significant effect on varying plant characters. The recommended and higher dose had the significantly higher grain yields (5.23 and 4.95 t ha^{-1}) than that of the lower dose (4.41 t ha^{-1}).

Across the varieties, BR 14, BRRI dhan48 and BRRI dhan55 yielded significantly higher (5.01-5.40 t ha^{-1}) than BRRI dhan65 (3.95 t ha^{-1}). But based on the interaction, the three varieties (BR 14, BRRI dhan48 and BRRI dhan55) at recommended while the two varieties (BRRI dhan48 and BRRI dhan55) at the higher dose gave identical higher grain yields (5.85 and 5.49 t ha^{-1}). Significantly the lowest grain yield was obtained with the varieties BRRI dhan55 and BRRI dhan65 under recommended and higher dose respectively (3.49 and 4.21 t ha^{-1}).

In Experiment-IV which was conducted along with the Experiment-III in the same season, the previously selected (in Experiment-I) four varieties (BR 14, BRRI dhan48, BRRI dhan55 and BRRI dhan65) were subjected to weeding treatments (unweeded and hand weeded) and results showed that the weeded plots had significantly higher seed yield (5.18 t ha^{-1}) than the unweeded ones (4.66 t ha^{-1}). Among the varieties, BR 14, BRRI dhan48, BRRI dhan55 showed significantly higher seed yields (5.06, 5.17 and 5.47 t ha^{-1}) than the BRRI dhan65 (3.98 t ha^{-1}). However, the interaction showed that even under unweeded condition, the BRRI dhan48 gave significantly higher grain yields (5.21 t ha^{-1}) over others. But under weeded condition, this variety produced much higher grain yield (5.73 t ha^{-1}) although that was identical with those of other varieties (5.21-5.44 t ha^{-1}).

As coupled with highest productivity potential, it was observed in experiment 4 that BRRI dhan48 had a weed suppression capability than that of other varieties. Considering these two points it was decided to impose this variety to the interaction effect of irrigation, fertilizer and weed control in the 5th experiment in the next season (third year).

In the Experiment-V, BRRI dhan48 was grown under two irrigation regimes (with or without supplemental irrigation), three fertilizer doses (recommended, 20% higher the recommended and 20% lower than recommended) and three weeding methods (hand weeding, pre-emergence herbicide and weeding by BRRI hand weeder). It was revealed that significantly higher grain yield was obtained from irrigated plots (5.17 t ha^{-1}) than that (4.71 t ha^{-1}) under plots having no irrigation. Herbicide application and weeding by weeder out yielded (4.77-5.06 t ha^{-1}) the hand weeding (4.77 t ha^{-1}). But the combination treatment of the irrigation ×

recommended fertilizer × weeding by pre-emergence herbicide out yielded giving 5.79 t ha^{-1} which significantly higher over those of other combination treatments (4.23-5.56 t ha^{-1}). This treatment had also significantly the highest values in number of effective and total tillers per hill (15.53 and 17.40 respectively), panicle length (25.05 cm), total grains per panicle (139 g), filled grains per panicle (133 g), 1000 seed weight (26.21 g), total straw weight (5.97 t ha^{-1}), and Biological yield (11.76 t ha^{-1}), plant height (112.78 cm), leaf area index (17.69), dry matter (886 g m^{-2}), crop growth rate (22.36, 12.96 and 10.83 gcm^{-2}day at early tillering, mid tillering and flowering), net assimilation rate (8.19, 1.63 and 0.91 g m^{-2}day at early tillering, mid tillering and flowering days respectively). The minimum grain yield (4.23 t ha^{-1}) was found with no irrigation × higher dose of fertilizer × hand weeding and likewise mostly all other parameters were also obtained with this treatment.

So, it may be concluded that the aus rice variety BRRI dhan48 may be grown using supplemental irrigation and pre-emergence weedicide under the application of recommended fertilizer dose.

Under the above facts and findings we may concluded that:

- Among the different rice varieties BRRI dhan48 may be considered the best variety in Aus season in relation to the growth characters, yield components and yield;
- In different irrigation regime continuous (supplemental) irrigation is better for rice growing in Aus season;
- Recommended doses of fertilizer is suitable for obtaining higher seed yield in Aus season;
- Use of pre-emergence herbicide (Amichlor 5G) was found to be better in Aus season in relation to having better growth and higher yield of BRRI dhan48.

5.3 Recommendation

1. In this trial the supplemental irrigation gave significantly higher seed yield than that of rainfed condition. So, the trial may be repeated using some more aus rice varieties to find out the varieties which utilizes less amount of irrigation water to produce higher yield.

2. Moreover, some more aus rice have been released which are found to be more drought needing lesser which also need to be included in the next study.

3. Furthermore, this study was made at SAU campus whose environment may not fit to other regions of Bangladesh. So, such study should be repeated to other agro-ecological regions to optimize supplemental irrigation, fertilizer and weeding techniques.

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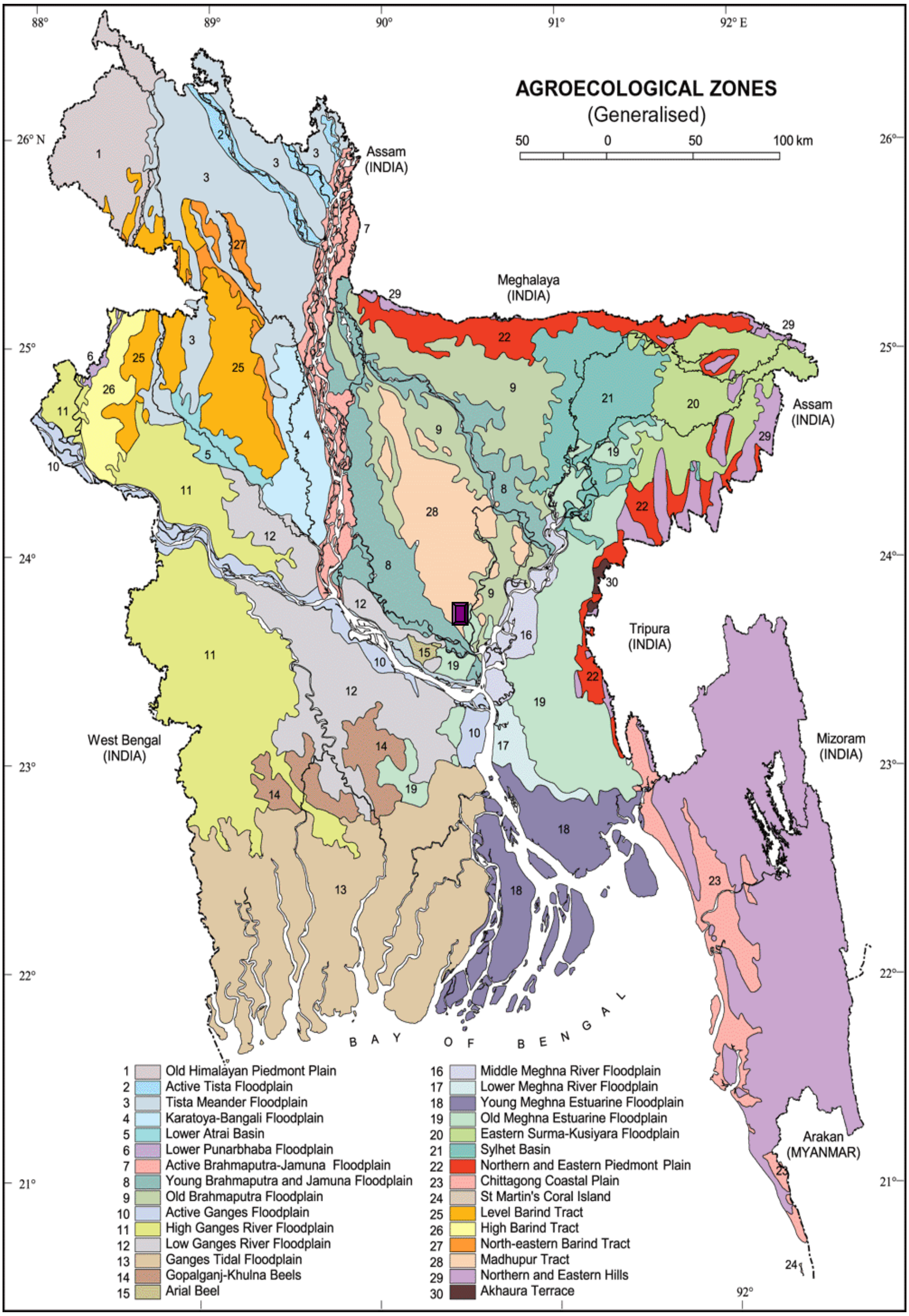
Appendices

APPENDICES

Appendix I. The Map of the experimental site



Appendix II. Characteristics of the soil of experimental field

A. Morphological characteristics of the soil of experimental field

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

B. Physical and chemical properties of the initial soil

Characteristics	Value
% Sand	27
% Silt	43
% Clay	30
Textural class	Silty-clay
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	45

Source: Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka-1212

Appendix III. Monthly record of average relative humidity, average temperature, total rainfall and average sunshine hour of the experimental site during the period from April to August at the year of 2015, 2016 and 2017

Month	Average Relative Humidity (%)			Average Temperature (°C)						Total Rainfall (mm)			Average sunshine (hr)		
				Minimum			Maximum								
	2015	2016	2017	2015	2016	2017	2015	2016	2017	2015	2016	2017	2015	2016	2017
April	67	69	65	23.2	24.4	24.9	33.4	33.8	32.9	78	63	95	6.4	6.6	6.2
May	70	74	76	25.9	25.7	24.2	34.7	35.2	35.6	185	201	187	6.1	6.3	5.9
June	80	79	82	22.5	24.4	25.1	35.4	33.1	36.2	277	312	286	6.3	5.9	6.2
July	83	83	85	24.6	24.6	24.9	36.0	36.0	36.8	563	563	573	5.1	5.7	5.5
August	81	81	87	23.6	23.6	23.3	36.0	36.0	35.2	319	319	303	6.0	6.1	6.2

Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka-1207

Appendix IV. Analysis of variance of the data on plant height of rice at different growth stages in Aus season as influenced by different levels of irrigation and rice varieties

Source of variation	Degrees of freedom	Mean square				
		Plant height (cm) at the stage of				
		Early tillering (ETS)	Maximum tillering (MTS)	Flowering (FS)	Grain filling (GFS)	Maturity (MS)
Replication	2	5.369	0.110	1.381	0.619	0.848
Irrigations (A)	1	273.312*	11.729*	206.790*	112.001*	85.587*
Error	2	13.975	0.329	10.588	4.665	4.108
Varieties (B)	11	40.546**	182.563**	1032.62**	893.941**	813.51**
Interaction (A×B)	11	23.474*	15.732*	36.230*	38.641*	42.618*
Error	44	10.007	7.156	18.102	18.510	17.193

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

Appendix V. Analysis of variance of the data on number of tillers hill^{-1} of rice at different growth stages in Aus season as influenced by different levels of irrigation and rice varieties

Source of variation	Degrees of freedom	Mean square			
		Number of tillers hill^{-1} at the stage of			
		Early tillering (ETS)	Maximum tillering (MTS)	Flowering (FS)	Grain filling (GFS)
Replication	2	0.004	0.041	0.035	0.050
Irrigations (A)	1	2.276*	9.981*	5.896*	2.723*
Error	2	0.094	0.373	0.127	0.071
Varieties (B)	11	2.331**	9.013**	9.814**	9.531**
Interaction (A×B)	11	0.238*	0.715*	0.569*	0.516*
Error	44	0.119	0.336	0.285	0.260

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

Appendix VI. Analysis of variance of the data on crop duration, total, effective and non-effective tillers hill^{-1} of rice in Aus season as influenced by different levels of irrigation and rice varieties

Source of variation	Degrees of freedom	Mean square			
		Crop Duration (Days)	Total tillers hill^{-1} (No.)	Effective tillers hill^{-1} (No.)	Non-effective tillers hill^{-1} (No.)
Replication	2	7.931	0.009	0.011	0.002
Irrigations (A)	1	415.681*	5.553*	2.492*	0.605*
Error	2	17.181	0.136	0.144	0.031
Varieties (B)	11	650.741**	14.942**	26.021**	1.705**
Interaction (A×B)	11	28.074**	0.541*	1.447*	0.368**
Error	44	8.389	0.249	0.324	0.071

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

Appendix VII. Analysis of variance of the data on panicle length, filled, unfilled and total grains panicle^{-1} and weight of 1000 grains of rice in Aus season as influenced by different levels of irrigation and rice varieties

Source of variation	Degrees of freedom	Mean square				
		Panicle length (cm)	Filled grains panicle^{-1} (No.)	Unfilled grains panicle^{-1} (No.)	Total grains panicle^{-1} (No.)	Weights of 1000 grains (g)
Replication	2	0.038	20.023	0.099	19.862	0.225
Irrigations (A)	1	14.534**	777.731*	4.520*	900.761*	0.585
Error	2	0.101	22.255	0.131	23.786	0.707
Varieties (B)	11	6.904**	850.372**	14.389**	667.930**	11.427**
Interaction (A×B)	11	1.484*	93.004*	2.679**	96.756*	1.465*
Error	44	0.756	42.845	0.481	44.670	0.719

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

Appendix VIII. Analysis of variance of the data on grain, straw, biological yield and harvest index of rice in Aus season as influenced by different levels of irrigation and rice varieties

Source of variation	Degrees of freedom	Mean square			
		Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
Replication	2	0.010	0.002	0.017	0.504
Irrigations (A)	1	1.859*	7.907*	17.435*	25.925*
Error	2	0.053	0.321	0.634	0.998
Varieties (B)	11	3.439**	2.259**	10.374**	37.903**
Interaction (A×B)	11	0.098*	1.937**	0.344*	29.519*
Error	44	0.041	0.107	0.184	3.282

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

Appendix IX. Analysis of variance of the data on plant height of rice at different growth stages in Aus season as influenced by different levels of irrigation and selected rice varieties

Source of variation	Degrees of freedom	Mean square				
		Plant height (cm) at the stage of				
		Early tillering (ETS)	Maximum tillering (MTS)	Flowering (FS)	Grain filling (GFS)	Maturity (MS)
Replication	2	0.956	6.256	13.337	3.706	12.464
Irrigations (A)	1	222.650**	583.309*	1359.66*	837.920**	843.602*
Error	2	2.579	28.006	56.168	11.985	17.838
Varieties (B)	3	24.129*	76.471**	510.074**	396.057**	369.014**
Interaction (A×B)	3	24.134*	63.872**	119.490*	148.191*	125.903*
Error	12	5.480	10.775	30.552	34.019	43.823

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

Appendix X. Analysis of variance of the data on number of tillers hill^{-1} of rice at different growth stages in Aus season as influenced by different levels of irrigation and selected rice varieties

Source of variation	Degrees of freedom	Mean square			
		Number of tillers hill^{-1} at the stage of			
		Early tillering (ETS)	Maximum tillering (MTS)	Flowering (FS)	Grain filling (GFS)
Replication	2	0.002	0.027	0.112	0.152
Irrigations (A)	1	4.507**	4.860*	29.482*	29.482*
Error	2	0.022	0.140	1.032	0.772
Varieties (B)	3	0.838**	3.124**	4.579**	5.513**
Interaction (A×B)	3	0.271*	1.060*	2.526*	2.948*
Error	12	0.069	0.272	0.689	0.631

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

Appendix XI. Analysis of variance of the data on leaf area index of rice at different growth stages in Aus season as influenced by different levels of irrigation and selected rice varieties

Source of variation	Degrees of freedom	Mean square			
		Leaf area index at the stage of			
		Early tillering (ETS)	Maximum tillering (MTS)	Flowering (FS)	Grain filling (GFS)
Replication	2	0.0001	0.006	0.002	0.191
Irrigations (A)	1	0.227**	1.695**	28.210*	53.275*
Error	2	0.003	0.011	1.064	1.474
Varieties (B)	3	0.100**	0.968**	6.371**	5.651**
Interaction (A×B)	3	0.013*	0.171*	2.518*	4.263*
Error	12	0.003	0.047	0.691	0.849

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

Appendix XII. Analysis of variance of the data on crop duration, total, effective and non-effective tillers hill^{-1} of rice in Aus season as influenced by different levels of irrigation and selected rice varieties

Source of variation	Degrees of freedom	Mean square			
		Crop Duration (Days)	Total tillers hill^{-1} (No.)	Effective tillers hill^{-1} (No.)	Non-effective tillers hill^{-1} (No.)
Replication	2	14.042	0.042	0.060	0.007
Irrigations (A)	1	1040.167*	29.927*	52.215**	3.082*
Error	2	43.792	1.022	0.740	0.087
Varieties (B)	3	339.278**	4.311**	7.126**	0.375**
Interaction (A×B)	3	125.500**	2.371**	2.099*	0.415**
Error	12	22.806	0.423	0.551	0.040

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

Appendix XIII. Analysis of variance of the data on panicle length, filled, unfilled and total grains panicle^{-1} and weight of 1000 grains of rice in Aus season as influenced by different levels of irrigation and selected rice varieties

Source of variation	Degrees of freedom	Mean square				
		Panicle length (cm)	Filled grains panicle^{-1} (No.)	Unfilled grains panicle^{-1} (No.)	Total grains panicle^{-1} (No.)	Weights of 1000 grains (g)
Replication	2	0.002	3.832	0.087	4.322	0.456
Irrigations (A)	1	42.103*	1077.36*	6.407*	917.608*	13.688*
Error	2	2.081	39.095	0.247	45.452	0.531
Varieties (B)	3	5.642**	167.047**	4.340**	118.173*	7.849**
Interaction (A×B)	3	4.579*	117.920*	1.638**	102.038*	1.488*
Error	12	0.962	27.110	0.149	25.849	0.329

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

Appendix XIV. Analysis of variance of the data on grain, straw, biological yield and harvest index of rice in Aus season as influenced by different levels of irrigation and selected rice varieties

Source of variation	Degrees of freedom	Mean square			
		Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
Replication	2	0.026	0.007	0.024	0.781
Irrigations (A)	1	3.205*	3.234**	12.877*	1.453
Error	2	0.078	0.031	0.199	0.705
Varieties (B)	3	2.318**	0.675**	5.235**	25.878**
Interaction (A×B)	3	0.129*	0.139*	0.364*	12.879*
Error	12	0.034	0.050	0.101	1.314

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

Appendix XV. Analysis of variance of the data on plant height of rice at different growth stages in Aus season as influenced by different fertility regime and selected rice varieties

Source of variation	Degrees of freedom	Mean square				
		Plant height (cm) at the stage of				
		Early tillering (ETS)	Maximum tillering (MTS)	Flowering (FS)	Grain filling (GFS)	Maturity (MS)
Replication	2	0.846	7.871	17.655	0.842	0.403
Fertility regime (A)	2	67.304*	149.602**	256.028*	253.961*	147.955*
Error	4	5.556	8.452	25.313	30.436	19.844
Varieties (B)	3	37.685**	205.689**	819.089**	790.039**	707.335**
Interaction (A×B)	6	9.654*	53.760*	39.850*	86.214*	83.729*
Error	18	3.523	16.052	16.372	31.043	24.006

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

Appendix XVI. Analysis of variance of the data on number of tillers hill^{-1} of rice at different growth stages in Aus season as influenced by different fertility regime and selected rice varieties

Source of variation	Degrees of freedom	Mean square			
		Number of tillers hill^{-1} at the stage of			
		Early tillering (ETS)	Maximum tillering (MTS)	Flowering (FS)	Grain filling (GFS)
Replication	2	0.030	0.173	0.203	0.023
Fertility regime (A)	2	1.523*	12.653*	26.423*	26.670*
Error	4	0.173	1.517	2.412	3.403
Varieties (B)	3	1.714**	3.889**	4.982**	4.084**
Interaction (A×B)	6	0.597*	3.007**	3.489**	3.486**
Error	18	0.177	0.576	0.767	0.872

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

Appendix XVII. Analysis of variance of the data on total dry matter (TDM) m^{-2} of rice at different growth stages in Aus season as influenced by different fertility regime and selected rice varieties

Source of variation	Degrees of freedom	Mean square			
		Total dry matter m^{-2} (g)			
		Early tillering (ETS)	Maximum tillering (MTS)	Flowering (FS)	Grain filling (GFS)
Replication	2	25.276	652.753	686.000	162.401
Fertility regime (A)	2	1128.262*	13989.456*	71182.96**	75377.502**
Error	4	107.951	1697.884	3061.133	1056.544
Varieties (B)	3	571.123**	7834.491**	30078.48**	8516.511**
Interaction (A×B)	6	1132.736**	2269.921**	10784.72**	26620.350**
Error	18	99.728	532.506	1910.172	1509.347

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

Appendix XVIII. Analysis of variance of the data on crop duration, total, effective and non-effective tillers hill^{-1} of rice in Aus season as influenced by different fertility regime and selected rice varieties

Source of variation	Degrees of freedom	Mean square			
		Crop Duration (Days)	Total tillers hill^{-1} (No.)	Effective tillers hill^{-1} (No.)	Non-effective tillers hill^{-1} (No.)
Replication	2	1.028	0.043	0.004	0.028
Fertility regime (A)	2	408.028**	22.493*	29.791*	1.098**
Error	4	14.819	2.967	3.394	0.053
Varieties (B)	3	538.546**	3.823**	5.690**	0.187*
Interaction (A×B)	6	84.102**	3.787**	1.907*	0.422**
Error	18	7.667	0.534	0.598	0.050

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

Appendix XIX. Analysis of variance of the data on panicle length, filled, unfilled and total grains panicle^{-1} and weight of 1000 grains of rice in Aus season as influenced by different fertility regime and selected rice varieties

Source of variation	Degrees of freedom	Mean square				
		Panicle length (cm)	Filled grains panicle^{-1} (No.)	Unfilled grains panicle^{-1} (No.)	Total grains panicle^{-1} (No.)	Weights of 1000 grains (g)
Replication	2	0.133	2.003	0.104	2.655	0.455
Fertility regime (A)	2	9.150*	400.930**	6.963**	303.212**	2.762
Error	4	0.952	7.653	0.122	7.108	4.079
Varieties (B)	3	4.896*	259.142**	0.829*	286.192**	9.133*
Interaction (A×B)	6	4.266*	68.361*	0.638*	77.805*	5.771*
Error	18	1.399	23.465	0.225	22.316	2.127

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

Appendix XX. Analysis of variance of the data on grain, straw, biological yield and harvest index of rice in Aus season as influenced by different fertility regime and selected rice varieties

Source of variation	Degrees of freedom	Mean square			
		Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
Replication	2	0.014	0.003	0.027	0.479
Fertility regime (A)	2	2.061**	3.555**	11.005**	1.550
Error	4	0.065	0.019	0.129	1.116
Varieties (B)	3	3.586**	1.012**	7.959**	40.212**
Interaction (A×B)	6	0.306*	0.596**	1.435**	6.295**
Error	18	0.087	0.097	0.337	0.846

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

Appendix XXI. Analysis of variance of the data on weed population at different growth stages in Aus season as influenced by different weed management and selected rice varieties

Source of variation	Degrees of freedom	Mean square			
		Number of weed populations (m^{-2}) at the stage of			
		Early tillering (ETS)	Maximum tillering (MTS)	Flowering (FS)	Grain filling (GFS)
Replication	2	1.542	0.125	0.292	0.042
Weed management (A)	1	100.042**	315.375**	216.000**	253.500**
Varieties (B)	3	1.819	2.153	0.778	0.111
Interaction (A×B)	3	24.153**	9.264*	1.889**	0.500*
Error	14	1.780	1.982	0.339	0.137

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

Appendix XXII. Analysis of variance of the data on plant height of rice at different growth stages in Aus season as influenced by different weed management and selected rice varieties

Source of variation	Degrees of freedom	Mean square				
		Plant height (cm) at the stage of				
		Early tillering (ETS)	Maximum tillering (MTS)	Flowering (FS)	Grain filling (GFS)	Maturity (MS)
Replication	2	0.945	2.375	17.001	5.802	5.747
Weed management (A)	1	94.19**	327.33**	594.32**	591.53**	486.18**
Varieties (B)	3	30.66**	260.70**	505.84**	373.19**	365.66**
Interaction (A×B)	3	9.426*	54.514*	228.40*	143.89*	149.65*
Error	14	2.448	15.674	58.751	39.343	44.343

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

Appendix XXIII. Analysis of variance of the data on number of tillers hill^{-1} of rice at different growth stages in Aus season as influenced by different weed management and selected rice varieties

Source of variation	Degrees of freedom	Mean square			
		Number of tillers hill^{-1} at the stage of			
		Early tillering (ETS)	Maximum tillering (MTS)	Flowering (FS)	Grain filling (GFS)
Replication	2	0.060	0.122	0.072	0.172
Weed management (A)	1	2.160**	8.882**	24.807**	25.627**
Varieties (B)	3	0.864**	3.882**	6.047**	5.482**
Interaction (A×B)	3	0.324*	1.526*	1.273*	1.520*
Error	14	0.104	0.398	0.369	0.370

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

Appendix XXIV. Analysis of variance of the data on crop duration, total, effective and non-effective tillers hill^{-1} of rice in Aus season as influenced by different weed management and selected rice varieties

Source of variation	Degrees of freedom	Mean square			
		Crop Duration (Days)	Total tillers hill^{-1} (No.)	Effective tillers hill^{-1} (No.)	Non-effective tillers hill^{-1} (No.)
Replication	2	12.500	0.022	0.005	0.007
Weed management (A)	1	117.042*	3.840*	22.042**	7.482**
Varieties (B)	3	361.042**	3.224**	5.739**	0.473**
Interaction (A×B)	3	122.486*	3.067**	2.162*	0.584**
Error	14	18.500	0.585	0.582	0.047

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

Appendix XXV. Analysis of variance of the data on panicle length, filled, unfilled, total grains panicle^{-1} and weight of 1000 grains of rice in Aus season as influenced by different weed management and selected rice varieties

Source of variation	Degrees of freedom	Mean square				
		Panicle length (cm)	Filled grains panicle^{-1} (No.)	Unfilled grains panicle^{-1} (No.)	Total grains panicle^{-1} (No.)	Weights of 1000 grains (g)
Replication	2	0.028	3.860	0.112	4.922	0.258
Weed management (A)	1	11.728**	447.20**	19.438**	280.17**	6.618*
Varieties (B)	3	3.103*	136.11**	4.900**	93.318*	9.526**
Interaction (A×B)	3	4.949**	79.866*	0.609*	87.131*	4.477*
Error	14	0.794	25.944	0.186	25.520	1.033

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

Appendix XXVI. Analysis of variance of the data on grain, straw, biological yield and harvest index of rice in Aus season as influenced by different weed management and selected rice varieties

Source of variation	Degrees of freedom	Mean square			
		Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
Replication	2	0.010	0.019	0.053	0.244
Weed management (A)	1	1.675**	2.209**	7.731**	0.014
Varieties (B)	3	2.533**	0.703**	5.617**	26.819**
Interaction (A×B)	3	1.774*	0.381**	0.736*	16.872**
Error	14	0.076	0.052	0.159	2.308

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

Appendix XXVII. Analysis of variance of the data on weed population at different growth stages of BRRI dhan48 in Aus season as influenced by irrigation, fertilizer and weeding

Source of variation	Degrees of freedom	Mean square			
		Number of weed populations (m^{-2}) at the stage of			
		Early tillering (ETS)	Maximum tillering (MTS)	Flowering (FS)	Grain filling (GFS)
Replication	2	0.111	0.237	0.750	0.028
Irrigation regime (A)	1	25.000**	356.517**	152.111**	34.028*
Error	2	0.333	1.823	2.028	0.694
Fertilizer dose (B)	1	11.111**	30.784**	9.000**	6.250**
Interaction (A×B)	1	4.000**	6.011*	5.444**	1.361*
Error	4	0.056	0.871	0.222	0.139
Weeding methods (C)	2	877.694**	1048.440**	335.083**	51.361**
Interaction (A×C)	2	7.750**	91.441**	37.528**	11.028**
Interaction (B×C)	2	3.361*	4.503*	6.083**	3.583**
Interaction (A×B×C)	2	4.083**	3.809*	2.528*	4.028**
Error	16	0.514	1.212	0.472	0.375

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

Appendix XXVIII. Analysis of variance of the data on plant height of BRRI dhan48 at different growth stages in Aus season as influenced by irrigation, fertilizer and weeding

Source of variation	Degrees of freedom	Mean square				
		Plant height (cm) at the stage of				
		Early tillering (ETS)	Maximum tillering (MTS)	Flowering (FS)	Grain filling (GFS)	Maturity (MS)
Replication	2	0.013	2.886	0.031	0.320	4.406
Irrigation regime (A)	1	53.339*	171.48*	82.084*	559.32**	554.05*
Error	2	2.025	3.281	3.413	0.718	22.962
Fertilizer dose (B)	1	82.810*	419.77**	165.294*	375.71**	290.99**
Interaction (A×B)	1	50.694*	163.80**	184.142*	173.45*	117.25**
Error	4	5.873	0.318	17.545	15.773	2.509
Weeding methods (C)	2	27.417**	86.903**	84.992**	98.444*	83.087*
Interaction (A×C)	2	16.088**	71.570**	132.991**	83.937*	124.75**
Interaction (B×C)	2	12.588*	70.849**	31.135*	122.31*	75.035*
Interaction (A×B×C)	2	24.124**	45.075*	78.996**	117.91*	66.776*
Error	16	2.763	12.858	10.279	24.715	16.676

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

Appendix XXIX. Analysis of variance of the data on number of total tillers hill^{-1} of BRRI dhan48 at different growth stages in Aus season as influenced by irrigation, fertilizer and weeding

Source of variation	Degrees of freedom	Mean square			
		Number of tillers hill^{-1} at the stage of			
		Early tillering (ETS)	Maximum tillering (MTS)	Flowering (FS)	Grain filling (GFS)
Replication	2	0.001	0.071	0.231	0.111
Irrigation regime (A)	1	1.361**	11.787*	13.444*	13.201*
Error	2	0.021	0.338	0.351	0.431
Fertilizer dose (B)	1	1.068*	11.334**	11.111**	10.454**
Interaction (A×B)	1	0.934*	4.410**	1.604*	3.361**
Error	4	0.084	0.022	0.311	0.418
Weeding methods (C)	2	0.564**	2.751**	3.898**	3.768**
Interaction (A×C)	2	0.731*	3.125**	4.484**	4.714**
Interaction (B×C)	2	0.625*	1.658**	0.938*	1.248*
Interaction (A×B×C)	2	0.718*	1.720**	2.751**	3.088**
Error	16	0.103	0.288	0.273	0.326

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

Appendix XXX. Analysis of variance of the data on leaf area index of BRRI dhan48 at different growth stages in Aus season as influenced by irrigation, fertilizer and weeding

Source of variation	Degrees of freedom	Mean square			
		Leaf area index at the stage of			
		Early tillering (ETS)	Maximum tillering (MTS)	Flowering (FS)	Grain filling (GFS)
Replication	2	0.001	0.006	0.172	0.028
Irrigation regime (A)	1	0.078*	3.219*	13.408*	15.244*
Error	2	0.001	0.106	0.415	0.501
Fertilizer dose (B)	1	0.084*	2.623**	10.123**	12.286**
Interaction (A×B)	1	0.060*	2.880**	8.439**	13.279**
Error	4	0.009	0.039	0.194	0.241
Weeding methods (C)	2	0.023*	0.432**	2.041*	2.183*
Interaction (A×C)	2	0.023*	0.932**	4.735**	4.400**
Interaction (B×C)	2	0.017*	0.342*	3.808**	3.607**
Interaction (A×B×C)	2	0.017*	0.268*	3.405*	3.292**
Error	16	0.005	0.078	0.532	0.656

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

Appendix XXXI. Analysis of variance of the data on Total Dry Matter (TDM) m^{-2} of BRRI dhan48at different growth stages in Aus season as influenced by irrigation, fertilizer and weeding

Source of variation	Degrees of freedom	Mean square			
		Total dry matter m^{-2} (g) at the stage of			
		Early tillering (ETS)	Maximum tillering (MTS)	Flowering (FS)	Grain filling (GFS)
Replication	2	2.131	42.689	64.136	49.872
Irrigation regime (A)	1	1751.973*	15976.12*	27622.62*	50743.41*
Error	2	48.277	736.254	1124.497	1438.044
Fertilizer dose (B)	1	1314.206**	9979.96**	18082.71**	37362.67**
Interaction (A×B)	1	1491.795**	12761.32**	22338.22**	42238.21**
Error	4	27.861	338.034	504.820	771.215
Weeding methods (C)	2	210.744*	1640.243*	3131.63*	6751.250**
Interaction (A×C)	2	301.183**	1934.491*	3776.95**	8522.512**
Interaction (B×C)	2	254.285**	2274.536**	3902.26**	7184.796**
Interaction (A×B×C)	2	151.489*	1557.164*	1942.54*	4274.239*
Error	16	39.288	436.833	685.710	1089.728

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

Appendix XXXII. Analysis of variance of the data on Crop Growth Rate (CGR) of BRRI dhan48 at different growth stages in Aus season as influenced by irrigation, fertilizer and weeding

Source of variation	Degrees of freedom	Mean square		
		Crop Growth Rate-CGR (g $m^{-2}day^{-1}$)		
		Early tillering to (ETS) maximum tillering (MTS)	Maximum tillering (MTS) to flowering (FS)	Flowering (FS) to grain filling (GFS)
Replication	2	0.127	0.012	0.040
Irrigation regime (A)	1	31.765	7.042**	15.504*
Error	2	1.854	0.187	0.288
Fertilizer dose (B)	1	18.005**	5.312**	15.378**
Interaction (A×B)	1	24.563**	5.919**	13.967**
Error	4	0.881	0.097	0.651
Weeding methods (C)	2	3.003*	1.069**	3.066*
Interaction (A×C)	2	3.151*	1.358**	4.233**
Interaction (B×C)	2	4.506*	0.976**	2.318*
Interaction (A×B×C)	2	4.316*	0.599*	2.017*
Error	16	1.058	0.143	0.709

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

Appendix XXXIII. Analysis of variance of the data on Relative Growth Rate (RGR) of BRRI dhan48 at different growth stages in Aus season as influenced by irrigation, fertilizer and weeding

Source of variation	Degrees of freedom	Mean square		
		Relative Growth Rate-RGR (mg $g^{-1}day^{-1}$)		
		Early tillering to (ETS) maximum tillering (MTS)	Maximum tillering (MTS) to flowering (FS)	Flowering (FS) to grain filling (GFS)
Replication	2	0.059	0.004	0.014
Irrigation regime (A)	1	0.761	0.121	0.955
Error	2	0.352	0.030	0.079
Fertilizer dose (B)	1	0.001	0.009	1.467
Interaction (A×B)	1	0.334	0.073	0.860
Error	4	0.361	0.032	0.197
Weeding methods (C)	2	0.007	0.004	0.407
Interaction (A×C)	2	0.018	0.001	0.732
Interaction (B×C)	2	0.153	0.023	0.197
Interaction (A×B×C)	2	0.008	0.003	0.251
Error	16	0.319	0.026	0.204

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

Appendix XXXIV. Analysis of variance of the data on Net Assimilation Rate (NAR) of BRRI dhan48 at different growth stages in Aus season as influenced by irrigation, fertilizer and weeding

Source of variation	Degrees of freedom	Mean square		
		Net Assimilation Rate-NAR (g $m^{-2}day^{-1}$)		
		Early tillering to (ETS) maximum tillering (MTS)	Maximum tillering (MTS) to flowering (FS)	Flowering (FS) to grain filling (GFS)
Replication	2	0.016	0.0001	0.0001
Irrigation regime (A)	1	0.199	0.002	0.030
Error	2	0.163	0.0001	0.002
Fertilizer dose (B)	1	0.001	0.003**	0.036*
Interaction (A×B)	1	0.110	0.002**	0.031*
Error	4	0.179	0.0001	0.004
Weeding methods (C)	2	0.043	0.001	0.010
Interaction (A×C)	2	0.057	0.005**	0.012
Interaction (B×C)	2	0.108	0.0001	0.007
Interaction (A×B×C)	2	0.017	0.001	0.008
Error	16	0.093	0.001	0.005

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

Appendix XXXV. Analysis of variance of the data on crop duration, effective, non-effective and total tillers hill^{-1} and panicle length of BRRI dhan48 in Aus season as influenced by irrigation, fertilizer and weeding

Source of variation	Degrees of freedom	Mean square				
		Crop duration (days)	Effective tillers hill^{-1} (No.)	Non-effective tillers hill^{-1} (No.)	Total tillers hill^{-1} (No.)	Panicle length (cm)
Replication	2	1.361	0.415	0.001	0.430	0.123
Irrigation regime (A)	1	324.00*	12.73*	0.284*	9.82*	20.82*
Error	2	12.583	0.601	0.008	0.474	0.795
Fertilizer dose (B)	1	373.78**	28.10**	1.440**	17.64**	15.16*
Interaction (A×B)	1	312.11**	16.26**	0.751**	10.67**	14.72*
Error	4	4.528	0.132	0.016	0.159	1.367
Weeding methods (C)	2	16.44	4.67**	0.181**	3.25**	3.451*
Interaction (A×C)	2	64.33*	5.97**	0.508**	2.75*	9.094**
Interaction (B×C)	2	88.11*	2.58*	0.190**	1.66*	3.485*
Interaction (A×B×C)	2	73.11*	2.65*	0.148*	1.67*	3.807*
Error	16	15.250	0.565	0.032	0.546	0.837

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

Appendix XXXVI. Analysis of variance of the data on filled and unfilled and total grains and weight of 1000 grains of BRRI dhan48 in Aus season as influenced by irrigation, fertilizer and weeding

Source of variation	Degrees of freedom	Mean square			
		Filled grains panicle^{-1} (No.)	Unfilled grains panicle^{-1} (No.)	Total grains panicle^{-1} (No.)	Weights of 1000 grains (g)
Replication	2	2.002	0.034	1.542	0.212
Irrigation regime (A)	1	887.246*	2.351*	798.251*	31.003**
Error	2	21.852	0.041	23.032	0.508
Fertilizer dose (B)	1	656.043**	2.560**	576.640**	29.242**
Interaction (A×B)	1	798.250**	1.778**	724.686**	28.362**
Error	4	9.453	0.042	10.119	0.662
Weeding methods (C)	2	129.841**	0.591*	113.712**	5.757
Interaction (A×C)	2	131.305**	0.924**	110.201**	6.560*
Interaction (B×C)	2	140.854**	0.674*	131.730**	4.901*
Interaction (A×B×C)	2	73.796*	0.458*	63.058*	9.014*
Error	16	19.517	0.138	18.983	1.593

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

Appendix XXXVII. Analysis of variance of the data on grain, straw and biological yield and harvest index of BRRI dhan48 in Aus season as influenced by irrigation, fertilizer and weeding

Source of variation	Degrees of freedom	Mean square			
		Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
Replication	2	0.011	0.008	0.039	0.063
Irrigation regime (A)	1	1.903*	1.749**	7.301*	0.464
Error	2	0.074	0.020	0.171	0.394
Fertilizer dose (B)	1	1.832**	2.137**	7.927**	0.009
Interaction (A×B)	1	1.463**	1.944**	6.781**	0.356
Error	4	0.045	0.016	0.095	0.578
Weeding methods (C)	2	0.268**	0.275*	1.081**	0.118
Interaction (A×C)	2	0.306**	0.765**	2.038**	1.759
Interaction (B×C)	2	0.138*	0.209*	0.682*	0.226
Interaction (A×B×C)	2	0.181*	0.176*	0.655*	1.279
Error	16	0.043	0.055	0.166	0.653

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability