GROWTH AND YIELD PERFORMANCE OF BRRI dhan28 UNDER IRRIGATION AND WEED MANAGEMENT

MD. ABDUL MOMIN

DEPARTMENT OF AGRONOMY
SHER-E-BANGLA AGRICULTURAL UNIVERSITY
DHAKA-1207

JUNE 2014

GROWTH AND YIELD PERFORMANCE OF BRRI dhan28 UNDER IRRIGATION AND WEED MANAGEMENT

BY

MD. ABDUL MOMIN

REG. NO. : 07-02492

A Thesis
Submitted to the Faculty of Agriculture
Sher-e-Bangla Agricultural University, Dhaka
in partial fulfilment of the requirements
for the degree
of

MASTER OF SCIENCE (MS)
IN
AGRONOMY

SEMESTER: JANUARY-JUNE, 2014

APPROVED BY:

(Dr. Md. Jafar Ullah) Professor Supervisor	**(Dr. Md. Fazlul Karim)** Professor Co-Supervisor

(Prof. Dr. H. M. M. Tariq Hossain)
Chairman
Examination Committee
Department of Agronomy

DEDICATED

TO

MY BELOVED PARENTS

DEPARTMENT OF AGRONOMY

Sher-e-Bangla Agricultural University

Sher-e-Bangla Nagar, Dhaka-1207

CERTIFICATE

This is to certify that the thesis entitled **'Growth and Yield Performance of BRRI dhan28 under Irrigation and Weed Management'** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of **Master of Science** in **Agronomy**, embodies the result of a piece of bonafide research work carried out by **Md. Abdul Momin**, Registration number: **07-02492** 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.

Dated:
Dhaka, Bangladesh

Prof. Dr. Md. Jafar Ullah
Department of Agronomy
Sher-e-Bangla Agricultural University
Dhaka-1207

ACKNOWLEDGEMENTS

All praises are due to the Omnipotent Allah, the Supreme Ruler of the universe who enables the author to complete this present piece of work. The author deems it a great pleasure to express his profound gratefulness to his respected parents, who entiled much hardship inspiring for prosecuting his studies, receiving proper education.

The author feels proud to express his heartiest sence of gratitude, sincere appreciation and immense indebtedness to his Supervisor Professor Dr. Md. Jafar Ullah, Department of Agronomy, Sher-e-Bangla Agricultural University (SAU), Dhaka, for his continuous scholastic and intellectual guidance, cooperation, constructive criticism and suggestions in carrying out the research work and preparation of thesis, without his intense co-operation this work would not have been possible.

The author feels proud to express his deepest respect, sincere appreciation and immense indebtedness to his Co-Supervisor Professor Dr. Md. Fazlul Karim, Department of Agronomy, SAU, Dhaka, for his scholastic and continuous guidance, constructive criticism and valuable suggestions during the entire period of course and research work and preparation of this thesis.

The author expresses his sincere respect and sence of gratitude to Chairman Professor Dr. H. M. M. Tariq Hossain, Departement of Agronomy, SAU, Dhaka for valuable suggestions and cooperation during the study period. The author also expresses his heartfelt thanks to all the teachers of the Department of Agronomy, SAU, for their valuable teaching, suggestions and encouragement during the period of the study.

The author expresses his sincere appreciation to his relatives, well wishers and friends for their inspiration, help and encouragement throughout the study.

GROWTH AND YIELD PERFORMANCE OF BRRI dhan28 UNDER IRRIGATION AND WEED MANAGEMENT

BY

MD. ABDUL MOMIN

ABSTRACT

The experiment was conducted in the experimental area Agronomy Farm of Sher-e-Bangla Agricultural University, Dhaka during the period from November 2012 to April, 2013 in *Boro* season to study the effect of irrigation and weed management of BRRI dhan28. The experiment comprised of five levels of irrigation *viz.* I_1: All time available water; I_2: Irrigation at 2 days after field drying; I_3: Irrigation at 4 days after field drying; I_4: Irrigation at 6 days after field drying and I_5: Irrigation at 8 days after field drying and three levels of weed management *viz.* W_0: No weeding, W_1: Weeding at tillering stage and W_2: Weeding at flag leaf initiation stage. The experiment was laid out in split plot design with three replications. Data on weed population, different growth parameter and yield of rice was recorded and significant variation was observed for different treatments. The highest grain yield (5.90 t ha^{-1}) was observed from I_2, whereas the lowest (4.94 t ha^{-1}) was recorded from I_5. The highest grain yield (5.69 t ha^{-1}) was recorded from W_1, while the lowest (4.80 t ha^{-1}) was found from W_0. The highest grain yield (6.44 t ha^{-1}) was observed from I_2W_1 and the lowest (3.59 t ha^{-1}) was found from I_5W_0 treatment combination. The increased yield of I_2W_1 was attributed due to the greater plant growth and number of field grain per panicle.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

CHAPTER I

INTRODUCTION

Rice (*Oryza sativa* L.) is the most important food in tropical and subtropical regions (Singh *et al*., 2012). It is the staple food of more than three billion people in the world, most of who live in Asia (IRRI, 2009). It is the staple food of not only Bangladesh but also for South Asia (Hien *et al.*, 2006). Rice production and consumption is concentrated in Asia, where more than 90% of all rice is consumed (FAO, 2006). In Bangladesh, the geographical, climatic and edaphic conditions are favorable for year round rice cultivation. The slogan 'Rice is life' is most appropriate for Bangladesh as this crop plays a vital role in our food security and is a means of livelihood for millions of rural peoples. About 84.67% of cropped area of Bangladesh is used for rice production, with annual production of 30.42 million tons from 10.4 million hectare of land (BBS, 2013).

Agriculture in Bangladesh is dominated by intensive rice cultivation covering 80% of arable land. The population of Bangladesh is increasing at an alarming rate and the cultivable land is reducing due to urbanization and industrialization resulting in more shortage of food. As it is not possible to have horizontal expansion of rice area so, rice yield unit^{-1} area should be increased to meet this ever-increasing demand of food. Rice and rice based cropping system have important role in the Eastern Indo Gangetic Plain to increase food production for a rapidly growing population. Rice yields are either decelerating/stagnating /declining in post green revolution era mainly due to imbalance in fertilizer use, soil degradation, irrigation and weeding schedule, type of cropping system practiced, lack of suitable rice genotypes/variety for low moisture adaptability and disease resistance (Prakash, 2010). The average yield of rice in Bangladesh is about 2.92 t ha^{-1} (BBS, 2013). However, the national average of rice yield in Bangladesh is very low compared to other rice growing countries, like China (6.30 t ha^{-1}), Japan (6.60 t ha^{-1}) and Korea (6.30 t ha^{-1}) (FAO, 2009).

Rice is grown in Bangladesh under diverse ecosystems like irrigated, rainfed and deep water conditions in three distinct seasons namely *Aus*, *Aman* and *Boro*. The production efficiency of rice depends on the favorable climatic conditions particularly temperature, soil moisture level and sunshine hours. Successful crop cultivation largely depends on proper water management along the greater part of the growth period of the crop. Water plays a vital role in growth, yield and nutrient uptake of rice plant. Insufficient water vigorously affects the germination of seed, cell division, tillering and nutrient uptake of the plants. Nutrients from the soil reach the surface of roots by mass flow and diffusion processes. Mass flow and diffusion processes are again positively correlated with moisture content of the soil. Movement of nutrients through the plant body is also associated with soil water contents. So, optimum supply of water is one of the most important factors in rice production. Rice plants need adequate moisture throughout of its life cycle. In tropical Asia on average a total of 1245 mm of water required for the complete growth cycle of rice. This total can be split into 40 mm for seedling nursery, 200 mm for land preparation and 1000 mm for satisfying the need during the whole growing period (Sattar, 2004).

Among the various factors reducing the rice yield weeds are considered as a major constraint. Weed is one of the most important agricultural pests. 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 varieties (winter rice) (BRRI, 2008). Weeds are the major biotic constraint to increased rice production worldwide. Among the various factors, severe weed infestation is the most important for such low yield. Many investigators have reported a great loss in the rice yield due to weed infestation from different parts of the world (Nandal and Singh, 1994). Weeds, besides harboring insects, compete with crop for water, light and plant nutrients and adversely affect the micro-climate around the plant (Behera *et al.*, 1996; Nojavan, 2001 and Yaghobi *et al.*, 2008). The climatic and edaphic conditions of Bangladesh are favorable for the growth of numerous noxious weed species.

Appropriate irrigation schedule and weed population greatly influences the growth and yield of rice. Weed infestation in rice crop may reduce the grain yield by 68-100% for direct seeded Aus rice, 14-48% for *Aman* Rice and 22.36% for modern *Boro* Rice (IRRI, 1998). However, yield loss due to weeds depends upon some variables like magnitude of weed infestation, type of weed species, time of association with crop and irrigation scheduling (Moody and De Detta, 1998). Therefore, proper irrigation scheduling and weed management is essential for satisfactory rice production in Bangladesh. Weed free condition during the critical period of competition is essential for obtaining optimum rice yield. Subsistence farmers in Bangladesh spend more time and energy on weed control than any other aspects of rice cultivation. A number of studies showed that weed control through both traditional and chemical methods influence crop growth and yield attributes of rice (Mandal *et al.*, 1995; Gill *et al.*, 1992; Panwar *et al.*, 1992). Thus, the appropriate irrigation scheduling and weeding practices need to be adopted by the farmers for maximizing rice yield.

Keeping in the view of the importance of rice and role of irrigation and weed management, therefore, the present research work has been undertaken in *Boro* season with the following objectives:

- To find out the optimum time of irrigation in *Boro* rice for maximum growth and yield;
- To observe the suitable growth stage of weeding in *Boro* rice for maximum growth and yield;
- To find out the interaction effect of irrigation and weeding in *Boro* rice for maximum growth and yield.

CHAPTER 2

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

Rice is the main food crop of the people of Bangladesh. Research on this crop is going on various aspects in increase its potential yield including management practices like irrigation and weeding. An attempt is made to review the available literature that are related to the effect of irrigation and weeding on the yield and yield attributes of rice as below under the following headings-

2.1 Effect of irrigation on yield attributes and yield of rice

An experiment was carried out by Karim *et al*. (2014) in Bangladesh Agricultural Research Institute (BARI) to evaluate yield and resource use efficiency of transplanted boro rice under two tillage and three irrigation methods. Two tillage methods and three irrigation methods viz., sprinkler irrigation, alternate wetting and drying (AWD) and flood irrigation were used as treatment variables. Grain yield was 7.62% higher in sprinkler and 4.72% higher in AWD irrigation method over flood irrigation method. Irrespective of tillage methods, reduced tillage method holds 4.62% higher yield production over conventional tillage method. Water use efficiency was found highest in sprinkler irrigation method (0.83 kg m^{-3}) and in reduced tillage method (0.773 kg m^{-3}). Labour required for land preparation was 15 md ha^{-1} in reduced tillage, whereas it was 38 md ha^{-1} in conventional tillage method. Irrigation and total cost of production was 7753 Tk. Ha^{-1} and 69972 Tk. Ha^{-1} in Sprinkler × RT method. Benefit cost ratio was also higher in sprinkler irrigation (1.81) and reduced tillage method (1.82).

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

Shamsuzzaman (2007) an experiment was conducted at the Field laboratory of the Department of Soil Science, Bangladesh Agricultural University (BAU), Mymensingh during aman season to find out the yield performance of T. aman rice varieties viz. V_1: BR11, V_2: BRRI dhan41, V_3: BRRI dhan31, V_4: BRRI dhan40 and V_5: BRRI dhan30 under two conditions rainfed and supplemental irrigation. The sequence of varitals performance was $V_2>V_4>V_3>V_5>V_1$. The highest plant height (125.29 cm), grain yield (5.06 t ha^{-1}) and biological yield (11.67 t ha^{-1}) were obtained in BRRI dhan41 and harvest index (44.76%) in BRRI Dhan31. The rate of increase occurred in each yield contributing components and yields especially panicle length by 5.86% < grain yield 7.67%, straw yield 1.14%, biological yield 3.77% and The harvest index 3.76% in supplemental irrigated plots over rainfed conditioned plots.

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

Torres and Valle (2006) established a demonstration plot in southern Campeche, Mexico using supplementary irrigation from deep tubewells with the aim to increase productivity during two consecutive spring-summer cycles on 60 and 100 hectors using Campeche A-80 (non-irrigated) and Philippine Miracle (irrigated) varieties. Results of both cycles showed the superiority in yield with irrigation; 5.89 and 5.63 t ha^{-1} were harvested in the 1989 and 1990 cycles, respectively. In

1989, no yield was obtained in the non-irrigated plot due to drought while in 1990. 3.1 t ha^{-1} was obtained.

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

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

Yang *et al*. (2005) carried out an experiment with aerobic rice varieties 1-11/502 and HD297 and lowland rice variety JD305 were conducted under aerobic and flooded conditions. Under flooded conditions JD305 yielded up to 8.8 t ha^{-1}, I ID502 up to 6.8 t ha^{-1} and 11D297 up to 5.4 t ha^{-1} compared to the flooded conditions.

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

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

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

Tomar *et al*. (2000) conducted multilocation yield trials to ascertain the degree of stability of rice genotypes suitable for rainfed condition. Nine medium duration rice genotypes (Mahamaya, Chapti Gurmatiya, HRI 134, IET 14100, IET 15178, R1057-1632-1-1, R1097-44-1, IET 15163 and Swarna) were grown at four different locations in Raigarh, Madhya Pradesh, India. All genotypes other than Chapti Gurmatiya and IET 15178 showed average response. Swarna with the highest mean yield, average response and significant value of S^2di showed its stable behaviour and suitability for that environment.

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

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

mm). The highest amylose content (23.90 and 23.82%) was obtained with 12 and II in 1998 and 1999, respectively while the highest head rice recovery (34.99 and 37.61%) was obtained with I1 in 1998 and 1999, respectively.

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

Sujit and Sarker (2003) conducted an experiment in Giridih, Jharkhand, India to evaluate the drought tolerance of upland rice cultivars Brown Gora, RR-167-982, Kalinga-3, RR-151-3, RR-51-1, RR-50-5, RR-2-6 and Birsa-101 under rainfed condition. Among the 8 short duration cultivars, 6 were drought-tolerant with sustainable yield potentials of 10.90, 8.51, 10.90, 14.70, 10.10 and 10.80 q ha^{-1}, respectively during the stress/drought year while the respective mean yield during the normal years were 12.75, 10.71, 15.90, 20.54, 14.46 and 17.26 q ha^{-1}, respectively.

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

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

Babu *et al*. (2000) conducted a field study at the upland block of Hebbal tank area (Karnataka, India) to determine the performance of rainfed lowland rice cultivars Rasi and hybrid KRH 1. The crop was raised under rainfed conditions up to 33 days after sowing and later the field was flooded with stored rain water in the Hebbal tank. KRH 1 recorded a higher yield (3.27 vs. 2.77 t ha^{-1}), longer and heavier panicles and heavier grain weight than Rasi. KRH 1 also produced a higher straw yield (6.52 t ha^{-1}) than Rasi (6.26 t ha^{-1}).

Bhandari *et al*. (2000) on-farm research were conducted in 127 locations (78 irrigated and 49 rainfed conditions) in 3 districts of Punjab to increase the crop productivity of different cropping sequences over a period of time. It was concluded that under irrigated conditions, it is advisable to grow rice-gobhi, mungbean/rice-wheatmaize fodder crops in sequence to get the highest economic yields while under rainfed conditions, green manure followed by wheat/raya/black gram are the only alternatives of increasing and sustaining the productivity over a longer period of time.

Tomar *et al*. (2000) a field experiment was conducted on a deep Vertisol of Jabalpur, Madhya Pradesh, India. Favorable soil water regime was established during rainy season and excess runoff water was canalized to a farm pond to provide supplemental irrigation for the Rabi crops cropping. Tabulated results showed that the average yield of rice was 2.54 t ha^{-1}.

Chaulian *et al*. (1999) found in a field trial that two rice varieties cv. Browngara and Vandana were subjected to water stress at booting and anthisis stage. Water stress at both stages reduced plant height, total tillers and total dry matter.

RRDI (1999) observed that rice is most susceptible to water stress during reproductive stage. They found that water stress during vegetative stage reduces plant height and tiller number. Hirsawa (1998) observed that moisture depletion causes severe injury to panicle in the critical stages. Significant differences in root system development and drought have been observed among rice cultivars. Water uptake capacity might depend on root system development and root hydraulic conductivity.

Yang *et al*. (1994) reported that water deficit at the vegetative stage of the crop, decreased tiller number per plant. Water deficit at the reproductive stage has the reduction number of spikelets panicle^{-1}, percentage of filled spikelets and 1000-grain weight.

Islam and Salam (1994a) conducted a pot experiment at Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh to observe the growth and yield performance of 4 aus rice genotypes grown under soil moisture stress. Moisture stress resulted in reduced total dry matter. These characters also varied with the severity of stress.

Islam *et al*. (1994b) observed the effect of drought on the growth and yield of rice at tillering, booting and flowering stages in aus season. They concluded that water stress showed the maximum adverse effect at tillering stage. The highest yield reduction was 68.6% due to water stress observed at booting followed by grain filling stage produced lower harvest index values than the control but the size and weight of the remained grains became higher. Stress at flowering stage produced the lowest 1000-grain weight. Ingram *et al*. (1993) showed that yield losses resulting from moisture deficit were particularly severely stroked at the booting stage.

BRRI (1992) studied the effect of water deficits for monsoon (transplanted aman) rice cultivation and reported that if rainfall continued till November there was no need for supplemental irrigation in the case of late transplanting. However, if it cases in the first week of October late transplanted rice will suffer from drought and percentage filled grain will be decreased conspicuously.

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

Weed management plays an important role on the performance of rice crop. Thus, the best weed management needs to be resorted to reduce weed infestation and maximum rice yield. Zaman *et al.* (2013) conducted an experiment to evaluate the best option of weed control for the farmers. They found that herbicide Sirius 10WP and one hand weeding at 20 DAS produced the highest grain yield whereas no weeding condition produced the lowest yield contributing characters, grain yield and straw yield. Pasha *et al.* (2012) carried out an experiment to study the effects of several weed control methods on yield and yield components of rice in Northern part of Iran. They worked with seven treatments including hand weeding twice (T_1), powered weeding twice (T_2), powered weeding + hand weeding once (3), cono-weeder weeding twice (T_4), herbicide application + hand weeding once (T_5), control treatment (T_6) and herbicide application once (T_7). Among treatments, herbicide application + hand weeding once (T_5) had the highest grain yield (4584 kg ha^{-1}), while control treatment (T_6) because of the high unfilled grain per panicle and less panicle number per square meter had the lowest grain yield (2505 kg ha^{-1}).

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

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

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

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

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

Pandey (2009) worked with eight weed treatments and two rice variety in SRI system and reported that among weed control treatments, three soil-aerating weedings at 14, 28 and 42 DAT was best for controlling weeds which contributed to the highest plant height and also higher number of tillers per plant and moderately higher leaf area index, higher number of effective tillers per square meter (282.67), panicle weight (3.92 gm), number of grains per panicle (184.54), lower sterility (7.36%), and higher grain yield (6.53 t ha^{-1}). Singh *et al*. (2009) reported that weeds competed for moisture, nutrients, light and space and as a consequence, weeds infestation in Dry Seeded Rice resulted in yield losses in the range to 30 to 90%, reduced grain quality and enhanced the cost of production.

Mahajan *et al*. (2009) reported that sequential spray of pre-emergence application of pendimethalin (1 kg ha^{-1}) followed by bispyribac sodium (30 g ha^{-1}) at 15 days after sowing was found best for the control of weeds. Singh (2008) reported that the effective period of weed-crop competition in DSR occurs in two phases; i.e. between 15-30 days, and 45-60 days after seeding. The competition beyond 15 days after seeding may cause significant reduction in the grain yield. However, competition for the first 15 days only may not have much adverse effect on crop.

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

Mukherjee and Malty (2007) conducted an experiment on the transplanted rice, with Butachlor 1 kg ha^{-1} at three days after transplanting + almix 20 WP 4 g ha^{-1} at 20 days after transplanting registered higher weed control efficiency and grain yield (3.17 and 3.5 t ha^{-1}) comparable with season long weed control weed-free condition. Rahman *et al.* (2007) worked for an economic study of different levels of herbicide used and hand weeding method in controlling weeds in transplanted *Aman* rice. The highest grain yield (5.35 t ha^{-1}) was obtained with the application of Rifit 500 EC at 1 litre ha^{-1}, which was similar to hand weeding (5.16 t ha^{-1}). The application of Rifit 500EC at 1.1 litre ha^{-1} maximized the profit and its benefit-cost ratio was the highest (1.55) among the treatments.

Rao *et al*. (2007) reported that herbicides that are found effective in DSR are pyrazosulfuron and oxadiragyl as pre-emergence and azimsulfuron, penoxsulam, cyhalopfop-butyl, and ethoxysulfuron as post-emergence. Aktaruzzaman (2007) reported that weeding regimes exerted significance influence on all the crop characters studied except panicle length and highest grain yield was obtained from weed free treatment and the lowest value was obtained from no weeding treatment.

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

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

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

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

was obtained with the application of butachlor @ 1.5 kg ha^{-1} supplemented with two hand weeding in rice.

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

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

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

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

Gul-Hasan *et al*. (2002) found that grain yields were highest in hand weeding and Basagran EC (post emergence) treated plots (2560 and 3256 kg ha^{-1}), respectively. Jayadeva and Bhairappanavar (2002) reported that pendimethalin, thiobencarb, and anilofos have been found more effective and safer for direct seeded rice. Pendimethalin at 1.0 kg ha^{-1} as preemergence has been quite effective and economical for dry-seeded rice.

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

Nair *et al.* (2002) observed that application of Butachlor @ 1.25 kg ha^{-1} along with one hand weeding at 40 DAT recorded higher panicle m^{-2}, panicle length, grains $panicle^{-1}$ and 1000 grain weight and which ultimately increased the grain yield of rice. Chandra and Pandy (2001) observed that hand weeding was most effective in mitigating the dry matter accumulation and N depletion and also reported that higher grain and straw yields was obtained from hand weeding with 120 kg N ha^{-1}.

Pathak *et al.* (2001) conducted an experiment on upland rice cv. IR50, which was recommended for the aus season, in Assam, India during March-July 1991 to assess its performance under seed treatment, water and weed management practices. The factors studied were seed treatment normal practices: without seed soaking and application of recommended 16.6 kg K ha^{-1}; modified practice: seed soaking in 40% KCl solution, application of 49.8 kg K ha^{-1}; 50 ppm paraquate spraying at tillering stage); water management practices (rainfed, intermittent irrigation at 3 and 6 days); weed control measures (weedy control and application of 2 kg butachlor ha^{-1}). The modified seed treatment significantly increased the number of effective tillers and root volume compared with normal practice, although there was no significant difference in yield. In the weed control treatment, butachlor significantly increased the number of effective tillers, number of grain $panicles^{-1}$ and grain yield than the weedy control. Applying butachlor increased yield by 23% compared to the weedy control.

Laxminaryan and Mishra (2001) also observed that both hand weeding and Anilofos @ 0.04 kg ha^{-1} reduced weed competition compared to the weedy control both hand weeding resulted in higher crop dry matter compared to Anilofos in Transplant rice cv. P-33 in India. Bhowmick *et al.* (2000) observed that post emergence application of Ethoxysulfuron + Anilofos (0.02 + 0.375 kg ha^{-1}) at 10 DAT was statistically similar with hand weeding at 20 and 40 DAT in controlling weeds of transplanted rice effectively and the grain yields were also comparable. Butachlor 1 kg ha^{-1} at 5 DAT + 2, 4-D Na salt 0.4 kg ha^{-1} at 25 DAT, Pretilachlor 0.04 kg ha^{-1} at 5 DAT and Oxadiagyl 0.1 kg ha^{-1} at 5 DAT were also promising. They also recorded the highest weed density in the weedy plots at 60 DAT.

Hossain (2000) studied the effects of different weed control treatments in rice as one hand weeding, two hand weeding, three hand weeding, Ronstar, Ronstar + hand weeding. He observed that yields and yield contributing characters increased with the increase in frequency of hand weeding.

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

The yield was 0.98 t ha^{-1} in unweeded control plots, 1.56 t ha^{-1} with herbicide and 2.24 t ha^{-1} in manual weed control plots. Rafiquddualla (1999) reported that the highest sterile spikelets panicle^{-1} was found from no weeding regime and the lowest one was found from weed free regime. Moody and De Datta (1998) reported that in case of grain yield loss; they observed that the highest grain yield loss 37% in BR2 in unweeded condition, and 17% in the farmers weeded condition. The lowest grain yield loss of 14% in unweeded condition was observed in Balam, which was only 5% in farmers weeded condition.

Pernito *et al*. (1996) found that plant height, panicle density, proportion of grains panicle^{-1} and weight of 1000 seeds were increased by weed control treatments. Islam (1995) found out the effect of cultivar and weeding regime on weed growth and performance of rice. He observed that highest grain and straw yields ha^{-1} were obtained from completely weed free plots and lowest from the no weeding plots.

The highest plant height, number of effective tillers hill^{-1}, length of panicle and straw yield ha^{-1} were also observed in weed free plots.

Chowdhury *et al*. (1994) stated that the highest number of tillers hill^{-1} (10.27) was produced in the weed free conditions. The number of tillers hill^{-1} (5.07) was observed in unweeded treatment. The fertile tillers hill^{-1}, panicle length, total grain panicle^{-1}, filled grain panicle^{-1}, 1000-grain weight, grain yield, straw yield followed the similar trend and unfilled grains panicle^{-1} showed reverse trend of results as found in the total tillers hill^{-1}. The highest grain yield of 3.84 t ha^{-1} was obtained due to weed free conditions.

De Datta (1990) reported that total number of tillers hill^{-1} was higher in weed free condition and lower in unweed condition. Mamun (1990) reported that loss of grain yields due to weeds in the fields already weeded by the farmers by 16% in mixed *aus*-*aman* rice, 11% in deepwater broadcast *aman* rice, 9% in modern *boro* rice, and 10% in local *boro* rice.

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

CHAPTER 3

MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted to find out the growth and yield performance of BRRI dhan28 under irrigation and weed management. The details of the materials and methods i.e. location of experimental site, soil and climate condition of the experimental plot, materials used, design of the experiment, data collection procedure and procedure of data analysis that used or followed in this experiment has been presented below under the following headings:

3.1 Description of the experimental site

3.1.1 Experimental period

The experiment was conducted during the period from November 2012 to April, 2013 in *Boro* season.

3.1.2 Site description

The present piece of research work was conducted in the experimental area Agronomy Farm Field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka. The location of the site is $23^0 74^/$N latitude and $90^0 35^/$E longitude with an elevation of 8.2 meter from sea level.

3.1.3 Climatic condition

The geographical location of the experimental site was under the subtropical climate and its climatic conditions is characterized by three distinct seasons, namely winter season from the month of November to February and the pre-monsoon period or hot season from the month of March to April and monsoon period from the month of May to October (Edris *et al*., 1979). Details of the meteorological data of air temperature, relative humidity, rainfall and sunshine hour during the period of the experiment was collected from the Weather Station of Bangladesh, Sher-e-Bangla Nagar, Dhaka and details has been presented in Appendix I.

3.1.4 Soil characteristics of the experimental plot

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. Soil pH was 5.6 and had organic carbon 0.45%. The experimental area was flat having available irrigation and drainage system and above flood level. The selected plot was medium high land. The details have been presented in Appendix II.

3.2 Experimental details

3.2.1 Planting material

BRRI dhan28 was used as the test crop in this experiment. This variety was developed at the Bangladesh Rice Research Institute through selection process. It is recommended for *Boro* season and average plant height of the variety is 117 cm. The aromatic grains are small, fine and white. It requires about 140 days completing its life cycle with an average yield of 6.0 t ha^{-1} (BRRI, 2013).

3.2.2 Treatments of the experiment

The experiment comprised of two factors

Factors A: Levels of irrigation (5 levels)

i) I_1: All time available water

ii) I_2: Irrigation at 2 days after field drying

iii) I_3: Irrigation at 4 days after field drying

iv) I_4: Irrigation at 6 days after field drying

v) I_5: Irrigation at 8 days after field drying

Here, drying means removal of water from soil surface by evaporation process. Water may be present in macro and micropores of soil.

Factor B: Levels of weeding (3 levels)

i) W_0: No weeding

ii) W_1: Weeding at tillering stage

iii) W_2: Weeding at flag leaf initiation stage

There were in total 15 (5×3) treatment combinations such as I_1W_0, I_1W_1, I_1W_2, I_2W_0, I_2W_1, I_2W_2, I_3W_0, I_3W_1, I_3W_2, I_4W_0, I_4W_1, I_4W_2, I_5W_0, I_5W_1 and I_5W_2.

3.2.3 Experimental design and layout

The experiment was laid out in split plot design with three replications, where the experimental area was divided into three blocks representing the replications to reduce soil heterogenetic effects. Each block was divided into 15 unit plots as treatments with raised bunds around. Thus the total numbers of plots were 45. The unit plot size was 3.0 m × 2.5 m. The distance maintained between two blocks and two plots were 1.0 m and 0.5 m respectively.

3.3 Growing of crops

3.3.1 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. Seeds were immersed in water in a bucket for 24 hours. These 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.

3.3.2 Raising of seedlings

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

3.3.3 Land preparation

The plot selected for conducting the experiment was opened in the 1^{st} week of November 2012 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.

3.3.4 Fertilizers and manure application

The fertilizers N, P, K, S, Zn and B in the form of urea, TSP, MoP, Gypsum, zinc sulphate and borax, respectively were applied. The one third amount of urea and entire amount of TSP, MOP, gypsum, zinc sulphate and borax were applied during the final preparation of land. Rest urea was applied in two equal installments at tillering and panicle initiation stages. The dose and method of application of fertilizers are presented in Table 1.

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

Fertilizers	Dose (ha^{-1})	Application (%)		
		Basal	1st installment	2nd installment
Urea	150 kg	33.33	33.33	33.33
TSP	60 kg	100	--	--
MoP	90 kg	100	--	--
Gypsum	10 kg	100	--	--
Zinc sulphate	3 kg	100		
Borax	10 kg	100	--	--

Source: BRRI, 2013 (Adunik Dhaner Chash)

3.3.5 Transplanting of seedling

Thirty five days old seedlings of BRRI dhan28 were carefully uprooted from the seedling nursery and transplanted on 31 December, 2012 in well puddled plot. Three seedlings $hill^{-1}$ were used following a spacing of 20 cm × 20 cm. After one week of transplanting, all plots were checked for any missing hill, which was filled up with extra seedlings whenever required.

3.3.6 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.

3.3.6.1 Irrigation

Irrigations were provided to the plots as per the treatment of the experiment during the growing period of rice crop.

3.3.6.2 Weeding

Weeding was done as per the treatment of the experiment.

3.3.6.3 Insect and pest control

There was no infection of diseases in the field but leaf roller (*Chaphalocrosis medinalis*) was observed in the field and used Malathion @ 1.12 L ha^{-1}.

3.4 Harvesting, threshing and cleaning

The crop was harvested at full maturity at 27 April, 2013 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, cleaned and weighed for individual plot. The weight was adjusted to a moisture content of 14%. Yields of rice grain and straw m^{-2} were recorded and converted to t ha^{-1}.

3.5 Data collection on weed population

From the 1m^2 area of every plot, the total weeds were uprooted and counted at 30, 60 and 90 DAT and recorded.

3.6 Data collection on yield components and yield

3.6.1 Plant height

The height of plant was recorded in centimeter (cm) at the time of 60, 75, 90 days after transplanting (DAT) and at harvesting stage. 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/flag leaf.

3.6.2 Number of tillers hill^{-1}

Number of tillers hill^{1} was recorded at 60, 75, 90 DAT and at harvest. Data were recorded as the average of 5 plants selected at random from the inner rows of each plot.

3.6.3 Effective tillers hill^{-1}

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

3.6.4 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 harvesting. Data on non effective tiller hill^{-1} were counted from 5 selected hills and average value was recorded.

3.6.5 Length of panicle

The length of panicle was measured with a meter scale from 10 selected plants and the average value was recorded as per plant.

3.6.6 Filled grains panicle^{-1}

The total numbers of filled grain was collected randomly from selected 10 plants of a plot on the basis of grain in the spikelet and then average numbers of filled grains panicle^{-1} was recorded.

3.6.7 Unfilled grains panicle^{-1}

The total numbers of unfilled grain was collected randomly from selected 10 plants of a plot on the basis of not grain in the spikelet and then average numbers of unfilled grains panicle^{-1} was recorded.

3.6.8 Total grains panicle^{-1}

The total numbers of grain was collected randomly from selected 10 plants of a plot by adding filled and unfilled grain and then average numbers of grains panicle^{-1} was recorded.

3.6.9 Weight of 1000-grain

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

3.6.10 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 and five sample plants were added to the respective unit plot yield to record the final grain yield $plot^{-1}$ and finally converted to ton $hectare^{-1}$ (t ha^{-1}).

3.6.11 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 and five sample plants were added to the respective unit plot yield to record the final straw yield $plot^{-1}$ and finally converted to ton $hectare^{-1}$ (t ha^{-1}).

3.6.12 Biological yield

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

Biological yield = Grain yield + Straw yield.

3.6.13 Harvest index

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

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

3.7 Statistical analysis

The data obtained for different parameters were statistically analyzed to find out the significant difference of different treatments on growth and yield of *Boro* rice BRRI dhan28. The mean values of all the characters were calculated and analysis of variance was performed by the ‘F’ (variance ratio) test. The significance of the differences among the treatment means were estimated by the Duncan's Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER 4

RESULTS AND DISCUSSION

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to find out the influence of growth and yield performance of BRRI dhan28 under irrigation and weed management. Data on weed population, different growth parameter and yield of rice was recorded. The analyses of variance (ANOVA) of the data on different recorded parameters are presented in Appendix III-VII. The results have been presented and discusses with the help of table and graphs and possible interpretations were given under the following headings:

4.1 Weed Population

Weed population varied significantly at 30, 60 and 90 DAT (days after transplanting) due to different irrigation treatment in BRRI dhan28 under the present trial (Appendix III). At 30 DAT, the highest number of weed population (23.96 m^{-2}) was recorded from I_5 (Irrigation at 8 days after field drying), which was followed (22.40 m^{-2} and 20.58 m^{-2}) by I_4 (Irrigation at 6 days after field drying) and I_1 (All time available water), whereas the lowest (18.42 m^{-2}) was recorded from I_2 (Irrigation at 2 days after field drying) which was followed (19.40 m^{-2}) by I_3 (Irrigation at 4 days after field drying) treatment (Table 2). At 60 DAT, the highest number of weed population (20.47 m^{-2}) was recorded from I_5, which was followed (18.44 m^{-2} and 16.11 m^{-2}) by I_4 and I_1, whereas the lowest (13.98 m^{-2}) was recorded from I_2 which was statistically similar (14.76 m^{-2}) with I_3 treatment. At 90 DAT, the highest number of weed population (16.44 m^{-2}) was recorded from I_5, which was followed (13.02 m^{-2} and 11.96 m^{-2}) by I_4 and I_1, whereas the lowest (9.80 m^{-2}) was recorded from I_2 which was statistically similar (14.76 m^{-2}) with I_3 treatment. Data revealed that both standing water and long time drying condition for the favorable for weed growing in *Boro* rice field Laxminaryan and Mishra (2001) recorded the highest weed density was recorded in the weedy plots at 60 DAT.

Table 2. Effect of irrigation and weed management on weed population of BRRI dhan28

Treatment	Weed population (m^{-2}) at		
	30 DAT	60 DAT	90 DAT
Irrigation			
I_1	20.58 c	16.11 c	11.96 c
I_2	18.42 e	13.98 d	9.80 d
I_3	19.40 d	14.76 d	10.16 d
I_4	22.40 b	18.44 b	13.02 b
I_5	23.96 a	20.47 a	16.44 a
$LSD_{(0.05)}$	0.819	1.121	0.729
Significance level	0.01	0.01	0.01
CV(%)	5.05	5.51	4.62
Weed management			
W_0	21.11 a	21.73 a	18.61 a
W_1	20.99 a	14.32 b	7.67 c
W_2	20.76 a	14.20 b	10.55 b
$LSD_{(0.05)}$	--	0.702	0.431
Significance level	NS	0.01	0.01
CV(%)	5.04	5.50	4.61

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_1: All time available water

I_2: Irrigation at 2 days after field drying

I_3: Irrigation at 4 days after field drying

I_4: Irrigation at 6 days after field drying

I_5: Irrigation at 8 days after field drying

W_0: No weeding

W_1: Weeding at tillering stage

W_2: Weeding at flag leaf initiation stage

Number of weed population differed at 30, 60 and 90 DAT significantly due to different weed management in BRRI dhan28 (Appendix III). At 30 DAT, the highest weed population (21.11 m^{-2}) was observed by W_0 (No weeding) which was followed (20.99 m^{-2}) by W_1 (Weeding at tillering stage) and the lowest (20.76 m^{-2}) was recorded from W_2 (Weeding at flag leaf initiation stage) treatment (Table 2). At 60 DAT, the highest weed population (21.73 m^{-2}) was seen by W_0 and the lowest (14.20 m^{-2}) was recorded from W_2 which was statistically similar (14.32 m^{-2}) with W_1 treatment. At 90 DAT, the highest weed population (18.61 m^{-2}) was found by W_0 and the lowest (7.67 m^{-2}) was recorded from W_1 which was followed (10.55 m^{-2}) with W_1 treatment. From the observation it was found that weeding is essential for controlling the number of weed in *Boro* rice field. Stahyamoorthy *et al*. (2004) found two hand weeding and three hand weeding always keep the weed free on rice field even al water logging or drying condition of rice field.

There was significant effect on number of weed population at 30, 60 and 90 DAT due to the interaction effect of irrigation and weed management in BRRI dhan28 (Appendix III). At 30 DAT the highest number of weed population (25.27 m^{-2}) was observed in I_5W_1 (Irrigation at 8 days after field drying with weeding at tillering stage) while the lowest (17.73 m^{-2}) was recorded from I_2W_1 (Irrigation at 2 days after field drying with weeding at tillering stage) treatment combination (Table 3). At 60 DAT, the highest number of weed population (24.60 m^{-2}) was observed in I_5W_0, whereas the lowest (11.13 m^{-2}) was recorded from I_2W_1 treatment combination. At 90 DAT, the highest number of weed population (20.87 m^{-2}) was observed in I_5W_0, while the lowest (4.53 m^{-2}) was recorded from I_2W_1 treatment combination.

Table 3. Interaction effect of irrigation and weed management on weed population of BRRI dhan28

Treatment	Weed population (m^{-2}) at		
	30 DAT	60 DAT	90 DAT
I_1W_0	23.33 b	22.93 b	20.07 ab
I_1W_1	19.13 de	12.27 fg	5.53 j
I_1W_2	19.27 de	13.13 f	10.27 fg
I_2W_0	18.93 e	19.40 c	16.20 cd
I_2W_1	17.73 e	11.13 g	4.53 k
I_2W_2	18.60 e	11.40 g	8.67 hi
I_3W_0	19.33 de	19.73 c	16.73 c
I_3W_1	19.67 de	12.40 fg	6.00 j
I_3W_2	19.20 de	12.13 fg	7.73 i
I_4W_0	21.13 cd	22.00 b	19.20 b
I_4W_1	23.13 b	17.20 de	9.40 gh
I_4W_2	22.93 bc	16.13 e	10.47 f
I_5W_0	22.80 bc	24.60 a	20.87 a
I_5W_1	25.27 a	18.60 cd	12.87 e
I_5W_2	23.80 ab	18.20 cd	15.60 d
$LSD_{(0.05)}$	1.797	1.569	0.964
Significance level	0.01	0.01	0.01
CV(%)	5.04	5.50	4.61

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_1: All time available water
I_2: Irrigation at 2 days after field drying
I_3: Irrigation at 4 days after field drying
I_4: Irrigation at 6 days after field drying
I_5: Irrigation at 8 days after field drying

W_0: No weeding
W_1: Weeding at tillering stage
W_2: Weeding at flag leaf initiation stage

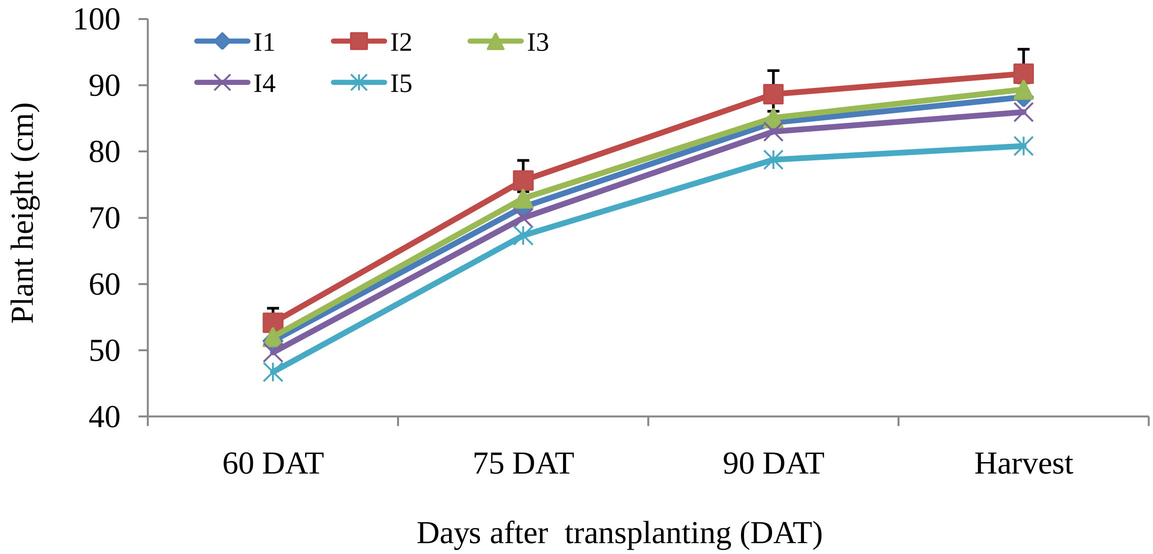
4.2 Yield contributing characters and yield of rice

4.2.1 Plant height

Plant height of BRRI dhan28 varied significantly for different irrigation treatment at 60, 75, 90 DAT and harvest (Appendix IV). At 60, 75, 90 DAT and harvest, the tallest plant (54.17, 75.62, 88.65 and 91.75 cm, respectively) were observed from I_2 which were statistically similar with I_3 (52.03, 72.92, 85.06 and 89.35, respectively) and I_1 (51.38, 71.62, 84.36 and 88.19 cm, respectively) and followed by I_4 (49.68, 69.95, 83.00 and 85.94 cm, respectively), whereas the shortest plant (46.72, 67.32, 78.77 and 80.83 cm, respectively) were recorded from I_5 (Figure 1). Chaulian *et al*. (1999) reported that water stress stages reduced plant height.

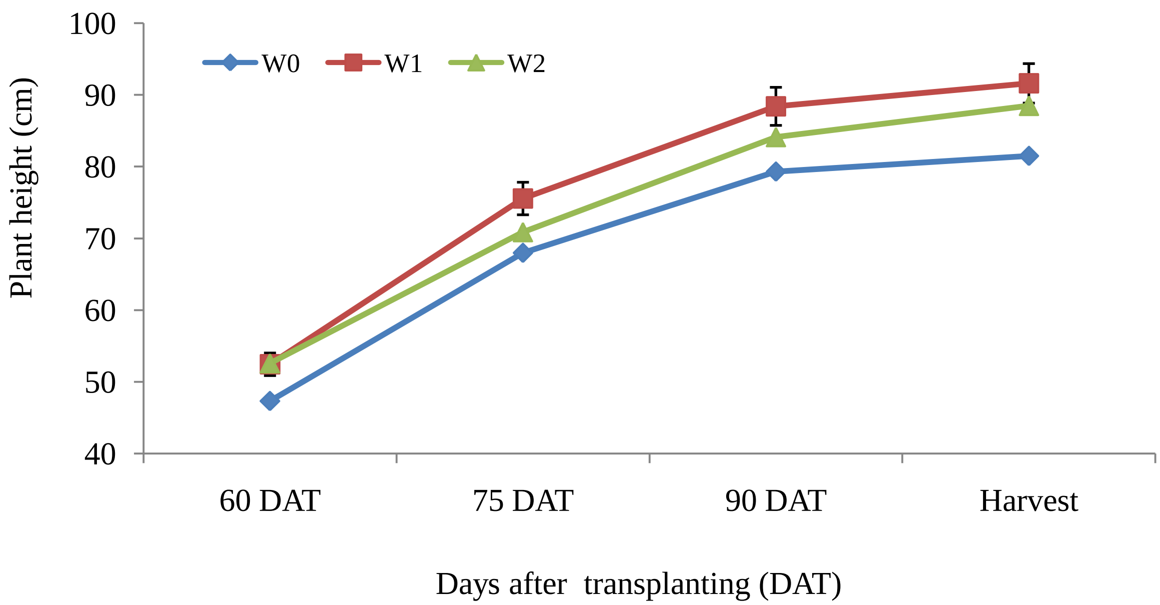
Statistically significant variation was recorded for plant height of BRRI dhan28 due to different weed management at 60, 75, 90 DAT and harvest (Appendix IV). Data revealed that at 60, 75, 90 DAT and harvest, the tallest plant (52.46, 75.57, 88.42 and 91.63 cm, respectively) were recorded from W_1 which was statistically identical (52.60, 70.89, 84.15 and 88.49 cm, respectively) with W_2, while the shortest plant (47.33, 67.99, 79.32 and 81.51 cm, respectively) was found from W_0 i.e. no weeding (Figure 2). Singh *et al*. (2009) reported that weeds competed for moisture, nutrients, light and space and as a consequence, weeds infestation in Dry Seeded Rice resulted in hampered plant growth and shortest plant. Pandey (2009) reported that among weed control treatments, three soil-aerating weedings at 14, 28 and 42 DAT was best for controlling weeds which contributed to the highest plant height.

Interaction effect of different levels of irrigations and weed management showed significant variation on plant height of BRRI dhan28 at 60, 75, 90 DAT and harvest (Appendix IV). At 60, 75, 90 DAT and harvest, the tallest plant (58.44, 79.49, 94.74 and 97.25 cm, respectively) were observed from I_2W_2 and the shortest plant (41.25, 60.89, 71.55 and 72.03 cm, respectively) from I_5W_0 treatment combination (Table 4).



I_1: All time available water
I_2: Irrigation at 2 days after field drying
I_3: Irrigation at 4 days after field drying
I_4: Irrigation at 6 days after field drying
I_5: Irrigation at 8 days after field drying

Figure 1. Effect of irrigation on plant height of BRRI dhan28. Vertical bars represnt LSD value.



W_0: No weeding
W_1: Weeding at tillering stage
W_2: Weeding at flag leaf initiation stage

Figure 2. Effect of weed management on plant height of BRRI dhan28. Vertical bars represnt LSD value.

Table 4. Interaction effect of irrigation and weed management on plant height of BRRI dhan28

Treatment	Plant height (cm) at			
	60 DAT	75 DAT	90 DAT	Harvest
I_1W_0	53.01 a-c	73.58 a-c	88.02 a-d	89.11 bc
I_1W_1	47.49 c-e	69.04 cd	79.74 d-f	85.02 cd
I_1W_2	53.64 a-c	72.23 a-c	85.32 a-d	90.42 a-c
I_2W_0	48.74 b-d	73.02 a-c	82.35 c-e	84.17 cd
I_2W_1	55.31 ab	74.35 a-c	88.85 a-d	93.83 ab
I_2W_2	58.44 a	79.49 a	94.74 a	97.25 a
I_3W_0	49.96 b-d	69.31 cd	81.20 c-f	84.48 cd
I_3W_1	53.88 a-c	78.58 ab	90.72 a-c	95.21 ab
I_3W_2	52.24 a-c	70.86 bc	83.25 b-e	88.35 bc
I_4W_0	43.67 de	63.16 de	73.48 ef	77.76 de
I_4W_1	54.35 a-c	78.27 ab	93.28 ab	95.03 ab
I_4W_2	51.02 a-d	68.43 cd	82.23 c-e	85.04 cd
I_5W_0	41.25 e	60.89 e	71.55 f	72.03 e
I_5W_1	48.16 b-e	72.50 a-c	83.64 b-e	85.65 c
I_5W_2	50.76 b-d	68.57 cd	81.11 c-f	84.81 cd
$LSD_{(0.05)}$	6.600	6.844	9.281	6.861
Significance level	0.05	0.05	0.01	0.01
CV(%)	7.63	5.62	5.34	4.62

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_1: All time available water

I_2: Irrigation at 2 days after field drying

I_3: Irrigation at 4 days after field drying

I_4: Irrigation at 6 days after field drying

I_5: Irrigation at 8 days after field drying

W_0: No weeding

W_1: Weeding at tillering stage

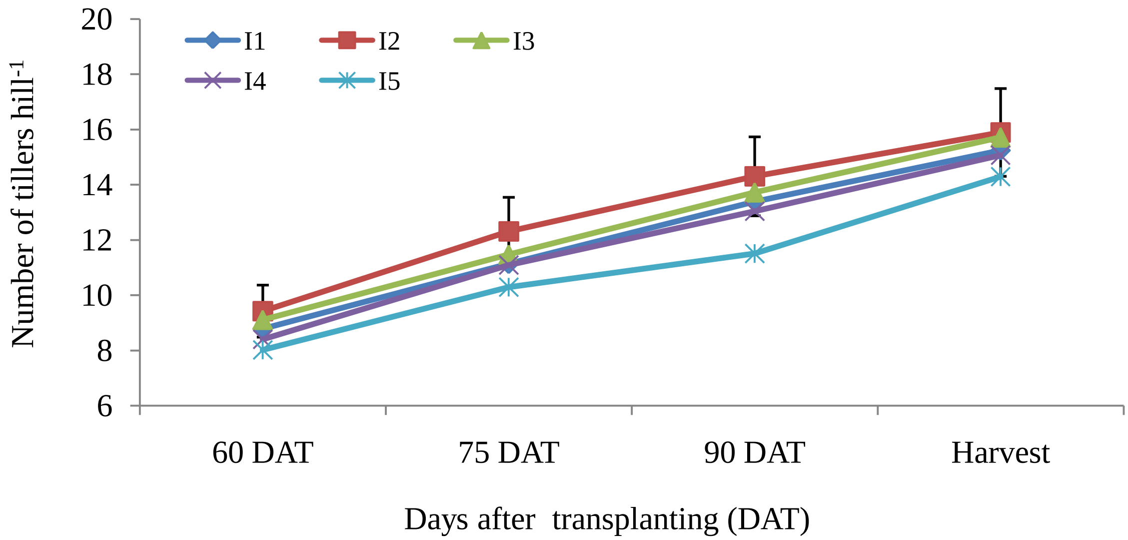
W_2: Weeding at flag leaf initiation stage

4.2.2 Number of total tillers hill^{-1}

Different irrigation treatment varied significantly in terms of number of total tillers hill^{-1} of BRRI dhan28 at 60, 75, 90 DAT and harvest (Appendix V). At 60, 75, 90 DAT and harvest, the maximum number of total tillers hill^{-1} (9.42, 12.31, 14.30 and 15.89, respectively) were observed from I_2 which were statistically similar (9.11, 11.47, 13.72 and 15.71, respectively) with I_3, while the minimum number (8.02, 10.29, 11.51 and 14.29, respectively) from I_5 (Figure 3). Chaulian *et al*. (1999) reported that water stress stages reduced total tillers.

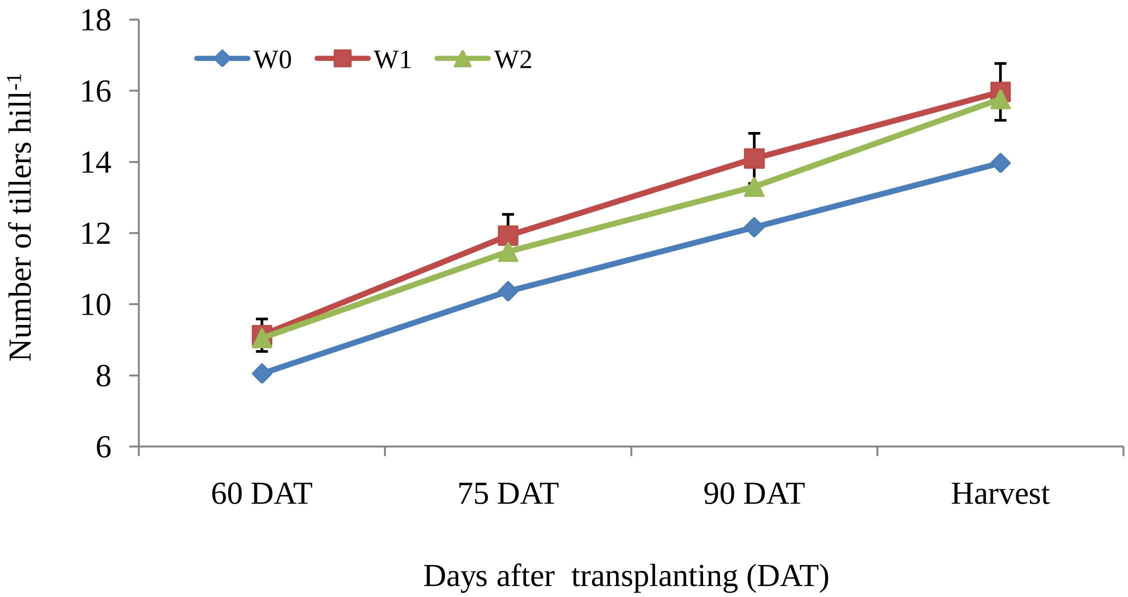
Number of total tillers hill^{-1} of BRRI dhan28 showed statistically significant variation due to different weed management at 60, 75, 90 DAT and harvest (Appendix V). At 60, 75, 90 DAT and harvest, the maximum number of total tillers hill^{-1} (9.13, 11.93, 14.10 and 15.97, respectively) were recorded from W_1 which was statistically similar (9.05, 11.48, 13.31 and 15.77, respectively) with W_2, while the minimum number (8.05, 10.36, 12.16 and 13.97, respectively) from W_0 (Figure 4). Pandey (2009) reported that among weed control treatments, three soil-aerating weeding at 14, 28 and 42 DAT was best for controlling weeds which contributed to the higher number of tillers per plant.

Interaction effect of different levels of irrigations and weed management showed significant variation on number of total tillers hill^{-1} of BRRI dhan28 at 60, 75, 90 DAT and harvest (Appendix V). At 60, 75, 90 DAT and harvest, the maximum number of total tillers hill^{-1} (9.80, 13.47, 15.43 and 16.95, respectively) were observed from I_2W_1 and the minimum number (6.27, 10.00, 11.07 and 13.40, respectively) were found from I_5W_0 treatment combination (Table 5).



I_1: All time available water I_2: Irrigation at 2 days after field drying
I_3: Irrigation at 4 days after field drying I_4: Irrigation at 6 days after field drying
I_5: Irrigation at 8 days after field drying

Figure 3. Effect of irrigation on number of tillers hill^{-1} of BRRI dhan28. Vertical bars represnt LSD value.



W_0: No weeding W_1: Weeding at tillering stage
W_2: Weeding at flag leaf initiation stage

Figure 4. Effect of weed management on number of total tillers hill^{-1} of BRRI dhan28. Vertical bars represnt LSD value.

Table 5. Interaction effect of irrigation and weed management on number of tillers $hill^{-1}$ of BRRI dhan28

Treatment	Number of tillers per hill at			
	60 DAT	75 DAT	90 DAT	Harvest
I_1W_0	9.13 a	10.60 e-g	12.80 d-g	14.07 cd
I_1W_1	8.53 a	11.33 c-e	13.60 b-d	16.93 a
I_1W_2	8.67 a	11.47 c-e	13.73 b-d	15.40 bc
I_2W_0	8.80 a	10.87 e-g	12.93 d-f	14.27 cd
I_2W_1	9.80 a	13.47 a	15.43 a	16.95 a
I_2W_2	9.67 a	12.60 ab	14.53 a-c	16.47 ab
I_3W_0	8.80 a	10.20 fg	12.60 d-g	14.47 cd
I_3W_1	9.13 a	12.27 bc	15.00 ab	16.33 ab
I_3W_2	9.40 a	11.93 b-d	13.57 b-d	16.33 ab
I_4W_0	7.27 b	10.13 g	11.40 gh	13.67 d
I_4W_1	9.20 a	11.93 b-d	14.47 a-c	15.13 bc
I_4W_2	8.73 a	11.20 d-f	13.27 c-e	16.40 ab
I_5W_0	6.27 b	10.00 g	11.07 h	13.40 d
I_5W_1	9.00 a	10.67 e-g	12.00 e-h	14.53 cd
I_5W_2	8.80 a	10.20 fg	11.47 fgh	14.27 cd
$LSD_{(0.05)}$	1.248	0.916	1.343	1.210
Significance level	0.05	0.05	0.05	0.01
CV(%)	8.38	4.78	5.98	4.66

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_1: All time available water
I_2: Irrigation at 2 days after field drying
I_3: Irrigation at 4 days after field drying
I_4: Irrigation at 6 days after field drying
I_5: Irrigation at 8 days after field drying

W_0: No weeding
W_1: Weeding at tillering stage
W_2: Weeding at flag leaf initiation stage

4.2.3 Number of effective tillers hill^{-1}

Different irrigation treatment varied significantly in terms of number of effective tillers hill^{-1} of BRRI dhan28 (Appendix VI). The maximum number of effective tillers hill^{-1} (13.71) was observed from I_2 which was statistically similar (13.29) with I_3 and closely followed (12.73) by I_1, again the minimum number (11.07) was recorded from I_5 (Table 6). Yang *et al.* (1994) reported that water deficit at the vegetative stage of the crop, decreased tiller number per plant.

Number of effective tillers hill^{-1} of BRRI dhan28 showed statistically significant variation due to different weed management (Appendix VI). The maximum number of effective tillers hill^{-1} (13.64) was recorded from W_1 which was statistically similar (13.19) with W_2, whereas the minimum number (10.91) was found from W_0 (Table 6). Pandey (2009) reported that among weed control treatments, three soil-aerating weedings at 14, 28 and 42 DAT was best for controlling weeds which contributed to higher number of effective tillers per square meter (282.67).

Interaction effect of different levels of irrigations and weed management showed significant variation on number of effective tillers hill^{-1} of BRRI dhan28 (Appendix VI). The maximum number of effective tillers hill^{-1} (14.93) was observed from I_2W_1, while the minimum number (10.13) were found from I_5W_0 treatment combination (Table 7).

4.2.4 Number of in-effective tillers hill^{-1}

Different irrigation treatment varied significantly in terms of number of in-effective tillers hill^{-1} of BRRI dhan28 (Appendix VI). The maximum number of in-effective tillers hill^{-1} (3.22) was observed from I_5 which was followed (2.98) by I_4, whereas the minimum number (2.18) was recorded from I_2 (Table 6).

Table 6. Effect of irrigation and weed management on yield contributing characters of BRRI dhan28

Treatment	Number of effective tiller $hill^{-1}$	Number of non-effective tiller $hill^{-1}$	Number of filled grain $panicle^{-1}$	Number of unfilled grain $panicle^{-1}$
Irrigation				
I_1	12.73 b	2.51 c	83.67 b	5.84 c
I_2	13.71 a	2.18 d	87.76 a	5.11 e
I_3	13.29 a	2.42 c	84.24 b	5.51 d
I_4	12.09 c	2.98 b	81.40 b	6.20 b
I_5	11.07 d	3.22 a	78.38 c	7.00 a
$LSD_{(0.05)}$	0.453	0.119	2.970	0.262
Significance level	0.01	0.01	0.01	0.01
CV(%)	5.18	5.55	6.80	4.78
Weed management				
W_0	10.91 b	3.07 a	75.97 c	6.81 a
W_1	13.64 a	2.33 c	87.77 a	5.04 c
W_2	13.19 a	2.59 b	85.52 b	5.95 b
$LSD_{(0.05)}$	0.495	0.113	1.768	0.215
Significance level	0.01	0.01	0.01	0.01
CV(%)	5.17	5.54	6.79	4.77

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_1: All time available water

I_2: Irrigation at 2 days after field drying

I_3: Irrigation at 4 days after field drying

I_4: Irrigation at 6 days after field drying

I_5: Irrigation at 8 days after field drying

W_0: No weeding

W_1: Weeding at tillering stage

W_2: Weeding at flag leaf initiation stage

Table 7. Interaction effect of irrigation and weed management on yield contributing characters of BRRI dhan28

Treatment	Number of effective tiller $hill^{-1}$	Number of in-effective tiller $hill^{-1}$	Number of filled grain $panicle^{-1}$	Number of unfilled grain $panicle^{-1}$
I_1W_0	10.53 gh	2.87 c-e	80.47 d-f	7.20 ab
I_1W_1	14.73 a	2.20 gh	81.20 de	4.33 ij
I_1W_2	12.93 c-e	2.47 fg	89.33 ab	6.00 de
I_2W_0	11.80 ef	2.47 fg	78.07 e-g	6.13 de
I_2W_1	14.93 a	2.00 h	92.73 a	4.07 j
I_2W_2	14.40 ab	2.07 h	92.47 a	5.13 gh
I_3W_0	11.60 fg	2.87 c-e	76.47 fg	6.47 cd
I_3W_1	14.27 ab	2.07 h	90.20 ab	4.73 hi
I_3W_2	14.00 a-c	2.33 g	86.07 bc	5.33 fg
I_4W_0	10.47 gh	3.20 b	74.00 gh	6.80 bc
I_4W_1	12.47 d-f	2.67 ef	90.20 ab	5.67 ef
I_4W_2	13.33 b-d	3.07 bc	80.00 ef	6.13 de
I_5W_0	10.13 h	3.93 a	70.87 h	7.47 a
I_5W_1	11.80 ef	2.73 de	84.53 cd	6.40 cd
I_5W_2	11.27 f-h	3.00 b-d	79.73 ef	7.13 ab
$LSD_{(0.05)}$	1.108	0.253	3.952	0.482
Significance level	0.05	0.01	0.01	0.01
CV(%)	5.17	5.54	6.79	4.77

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_1: All time available water

I_2: Irrigation at 2 days after field drying

I_3: Irrigation at 4 days after field drying

I_4: Irrigation at 6 days after field drying

I_5: Irrigation at 8 days after field drying

W_0: No weeding

W_1: Weeding at tillering stage

W_2: Weeding at flag leaf initiation stage

Number of in-effective tillers $hill^{-1}$ of BRRI dhan28 showed statistically significant variation due to different weed management (Appendix VI). The maximum number of in-effective tillers $hill^{-1}$ (3.07) was recorded from W_0, again the minimum number (2.33) was found from W_1 which was followed (2.59) by W_2 (Table 6).

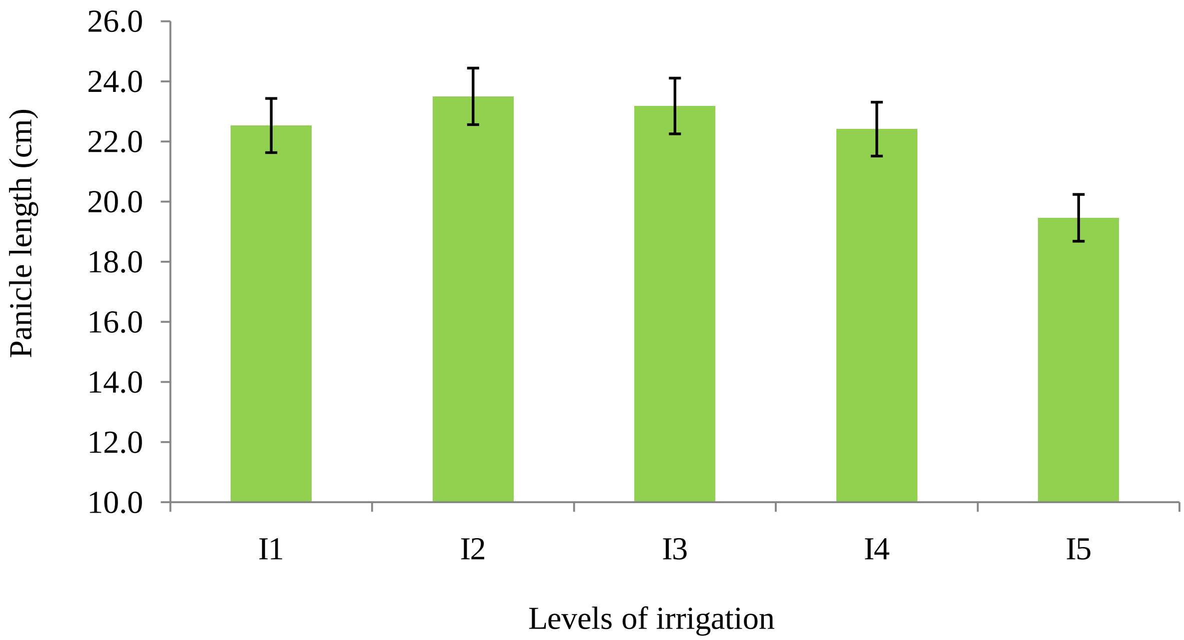
Statistically significant variation was recorded due to the interaction effect of different levels of irrigations and weed management in terms of number of in-effective tillers $hill^{-1}$ of BRRI dhan28 (Appendix VI). The maximum number of in-effective tillers $hill^{-1}$ (3.93) was observed from I_5W_0 and the minimum number (2.00) were found from I_2W_1 treatment combination (Table 7).

4.2.5 Length of panicle

Different irrigation treatment varied significantly in terms of length of panicle of BRRI dhan28 (Appendix VI). The longest panicle (23.50 cm) was observed from I_2 which was statistically similar (23.18 cm, 22.53 cm, 22.41 cm) with I_3, I_1 and I_4, while the shortest panicle (19.46 cm) was recorded from I_5 (Figure 5).

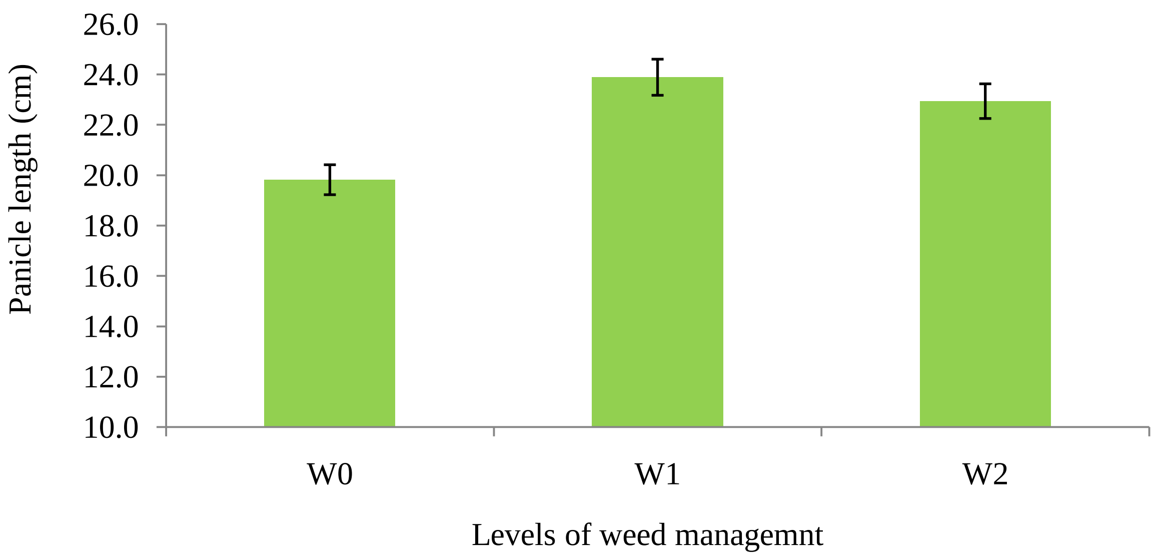
Length of panicle of BRRI dhan28 showed statistically significant variation due to different weed management (Appendix VI). The longest panicle (23.89 cm) was recorded from W_1 which was statistically similar (22.94 cm) with W_2, while the shortest panicle (19.82 cm) was found from W_0 (Figure 6).

Interaction effect of different levels of irrigations and weed management showed significant variation on length of panicle of BRRI dhan28 (Appendix VI). The longest panicle (26.43 cm) was observed from I_2W_1 and the shortest panicle (18.62 cm) were found from I_5W_0 treatment combination (Figure 7).



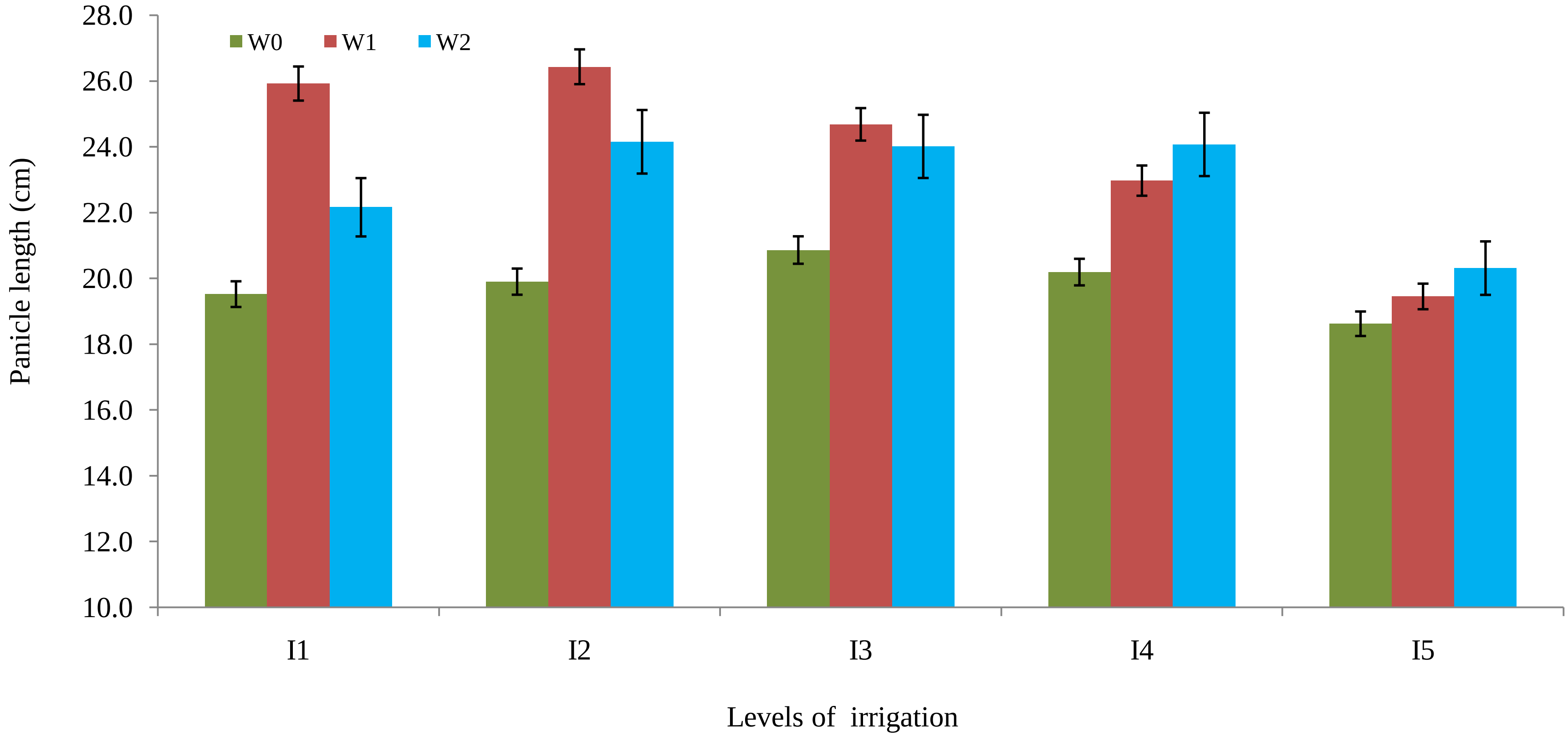
I_1: All time available water
I_2: Irrigation at 2 days after field drying
I_3: Irrigation at 4 days after field drying
I_4: Irrigation at 6 days after field drying
I_5: Irrigation at 8 days after field drying

Figure 5. Effect of irrigation on panicle length of BRRI dhan28. Vertical bars represent LSD value.



W_0: No weeding
W_1: Weeding at tillering stage
W_2: Weeding at flag leaf initiation stage

Figure 6. Effect of different levels of weed management on panicle length of BRRI dhan28. Vertical bars represent LSD value.



I_1: All time available water
I_2: Irrigation at 2 days after field drying
I_3: Irrigation at 4 days after field drying
I_4: Irrigation at 6 days after field drying
I_5: Irrigation at 8 days after field drying

W_0: No weeding
W_1: Weeding at tillering stage
W_2: Weeding at flag leaf initiation stage

Figure 7. Interaction effect of different levels of irrigation and weed management on panicle length of BRRI dhan28. Vertical bars represent LSD value.

4.2.6 Number of filled grains panicle^{-1}

Different irrigation treatment varied significantly in terms of number of filled grains panicle^{-1} of BRRI dhan28 (Appendix VI). The maximum number of filled grains panicle^{-1} (87.76) was observed from I_2 which was followed (84.24, 83.67 and 81.40) by I_3, I_1 and I_4 and they were statistically similar, whereas the minimum (78.38) was recorded from I_5 (Table 6). Yang *et al*. (1994) reported that water deficit at the reproductive stage has the reduction percentage of filled spikelets.

Number of filled grains panicle^{-1} of BRRI dhan28 showed statistically significant variation due to different weed management (Appendix VI). The maximum number of filled grains panicle^{-1} (87.77) was recorded from W_1 which was followed (85.52) by W_2, while the minimum (75.97) was found from W_0 (Table 6). Pandey (2009) reported that among weed control treatments, three soil-aerating weedings at 14, 28 and 42 DAT was best for controlling weeds which contributed to the number of grains per panicle (184.54).

Interaction effect of different levels of irrigations and weed management showed significant variation on number of filled grains panicle^{-1} of BRRI dhan28 (Appendix VI). The maximum number of filled grains panicle^{-1} (92.73) was observed from I_2W_1, while the minimum (70.87) was found from I_5W_0 treatment combination (Table 7).

4.2.7 Number of unfilled grains panicle^{-1}

Different irrigation treatment varied significantly in terms of number of unfilled grains panicle^{-1} of BRRI dhan28 (Appendix VI). The maximum number of unfilled grains panicle^{-1} (7.00) was observed from I_5 which was followed (6.20) by I_4, whereas the minimum number (5.11) was recorded from I_2 (Table 6).

Number of unfilled grains panicle^{-1} of BRRI dhan28 showed statistically significant variation due to different weed management (Appendix VI). The maximum number of unfilled grains panicle^{-1} (6.81) was recorded from W_0 which was followed (5.95) by W_2, while the minimum (5.04) was found from W_1 (Table 6).

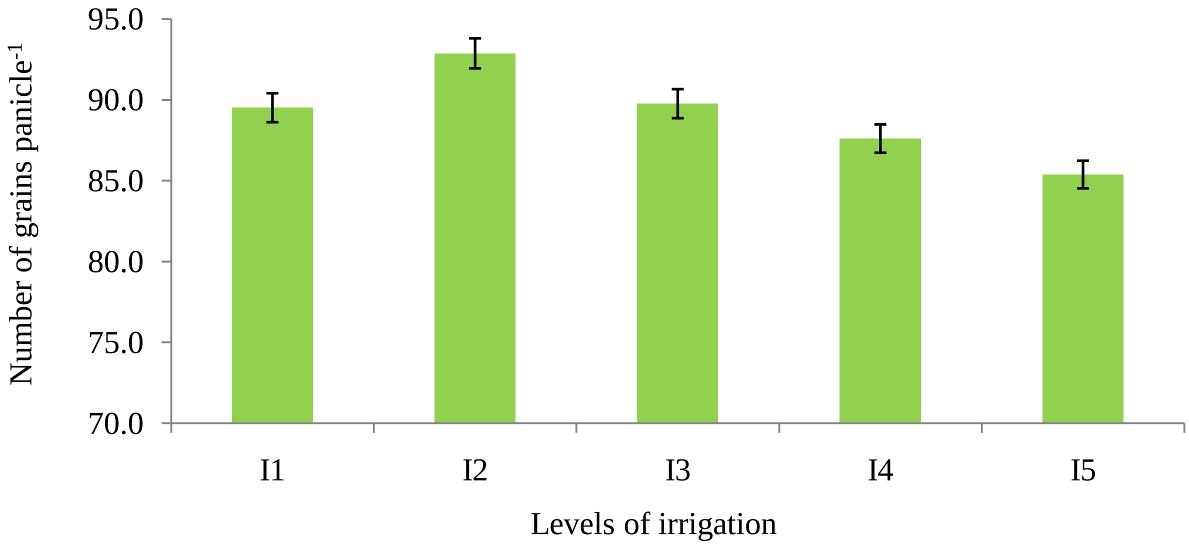
Interaction effect of different levels of irrigations and weed management showed significant variation on number of unfilled grains panicle^{-1} of BRRI dhan28 (Appendix VI). The maximum number of unfilled grains panicle^{-1} (7.47) was observed from I_2W_0 and the minimum (4.07) were found from I_2W_1 treatment combination (Table 7).

4.2.8 Number of total grains panicle^{-1}

Different irrigation treatment varied significantly in terms of number of total grains panicle^{-1} of BRRI dhan28 (Appendix VI). The maximum number of total grains panicle^{-1} (92.87) was observed from I_2 which was followed (89.76, 89.51 and 87.60) by I_3, I_1 and I_4 and they were statistically similar, whereas the minimum number (85.38) was recorded from I_5 (Figure 8).

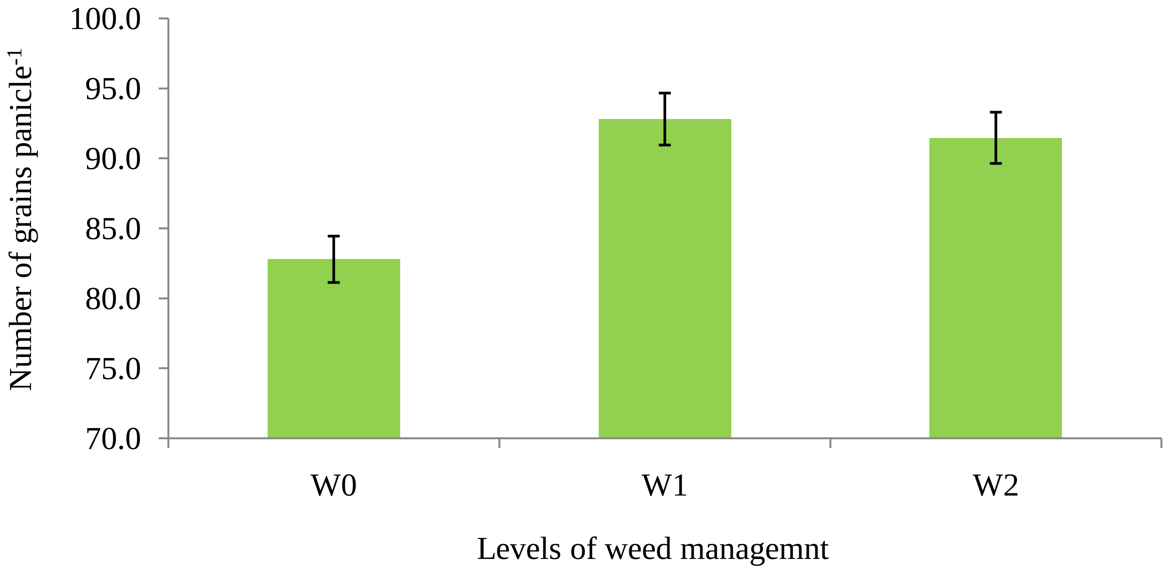
Number of total grains panicle^{-1} of BRRI dhan28 showed statistically significant variation due to different weed management (Appendix VI). The maximum number of total grains panicle^{-1} (92.81) was recorded from W_1 which was statistically similar (91.47) with W_2, while the minimum number (82.79) was found from W_0 (Figure 9).

Interaction effect of different levels of irrigations and weed management showed significant variation on number of total grains panicle^{-1} of BRRI dhan28 (Appendix VI). The maximum number of total grains panicle^{-1} (96.80) was observed from I_2W_1 and the minimum (78.33) was found from I_5W_0 treatment combination (Figure 10).



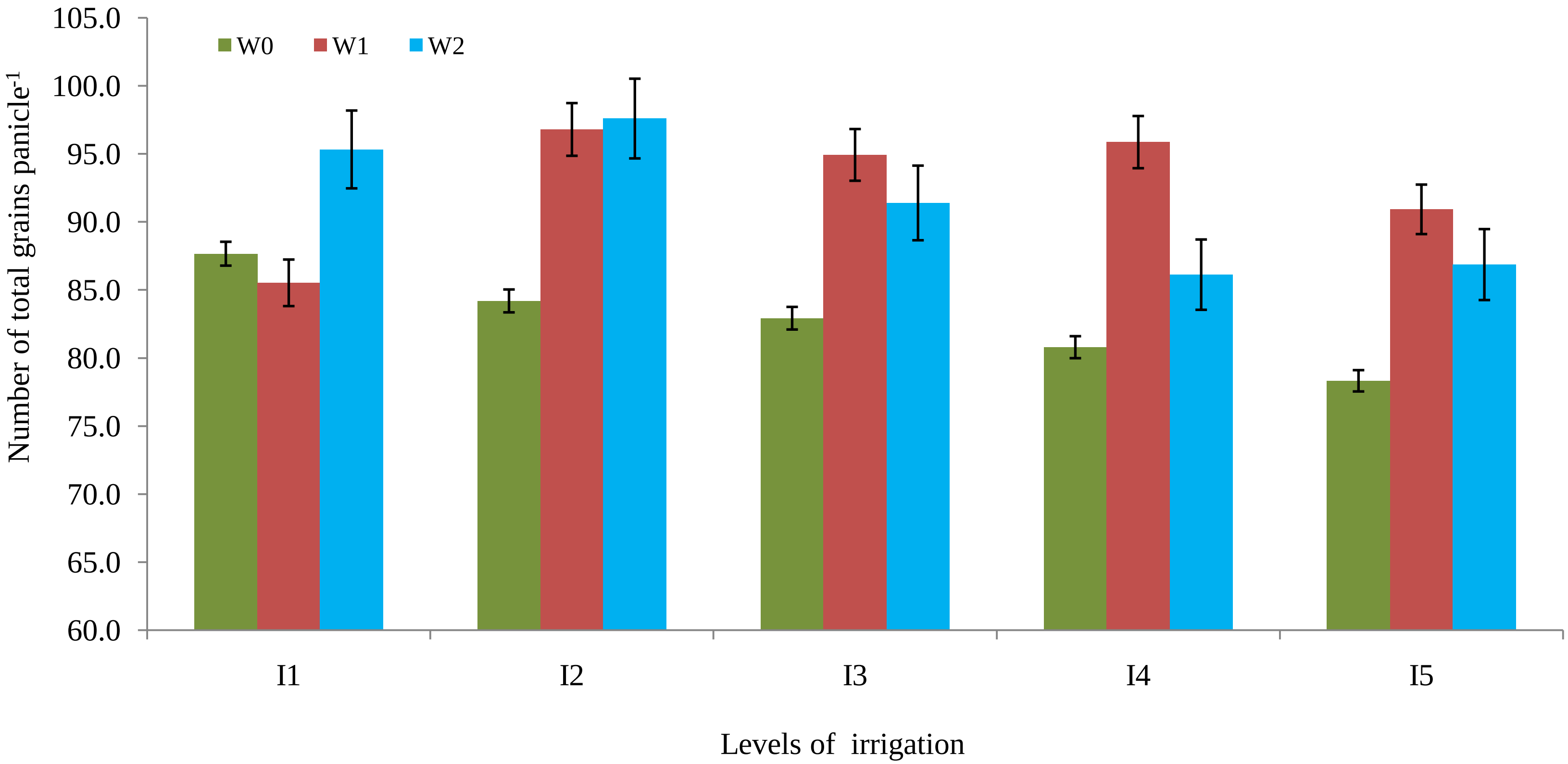
I_1: All time available water
I_2: Irrigation at 2 days after field drying
I_3: Irrigation at 4 days after field drying
I_4: Irrigation at 6 days after field drying
I_5: Irrigation at 8 days after field drying

Figure 8. Effect of irrigation on number of total grains panicle^{-1} of BRRI dhan28. Vertical bars represent LSD value.



W_0: No weeding
W_1: Weeding at tillering stage
W_2: Weeding at flag leaf initiation stage

Figure 9. Effect of different levels of weed management on number of total grains panicle^{-1} of BRRI dhan28. Vertical bars represent LSD value.



I_1: All time available water
I_2: Irrigation at 2 days after field drying
I_3: Irrigation at 4 days after field drying
I_4: Irrigation at 6 days after field drying
I_5: Irrigation at 8 days after field drying
W_0: No weeding
W_1: Weeding at tillering stage
W_2: Weeding at flag leaf initiation stage

Figure 10. Interaction effect of different levels of irrigation and weed management on number of total grains panicle^{-1} of BRRI dhan28. Vertical bars represent LSD value.

4.2.9 Weight of 1000 grains

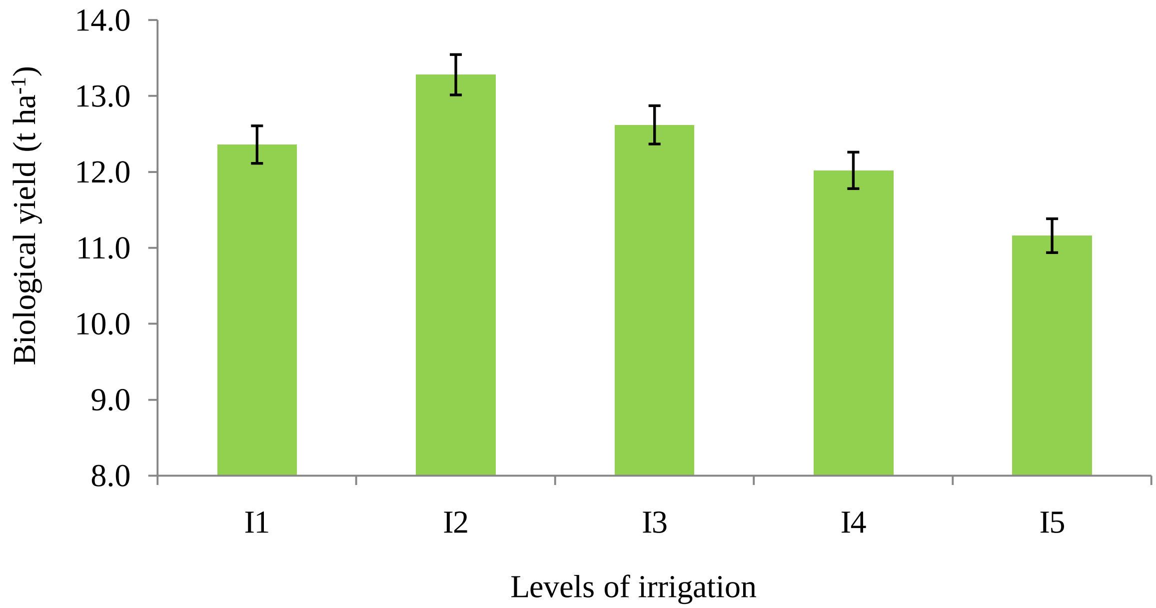
Different irrigation treatment varied significantly in terms of weight of 1000 grains of BRRI dhan28 (Appendix VII). The highest weight of 1000 grains (23.69 g) was observed from I_2 which was statistically similar (23.30 g) with I_3 and followed (22.39 g and 22.23 g) by I_4 and I_1 and they were statistically similar, whereas the lowest weight (21.86 g) was recorded from I_5 (Figure 11). Yang *et al.* (1994) reported that water deficit at the reproductive stage has the reduction 1000-grain weight.

Weight of 1000 grains of BRRI dhan28 showed statistically significant variation due to different weed management (Appendix VII). The highest weight of 1000 grains (23.50 g) was recorded from W_1 which was statistically similar (23.10 g) with W_2, while the lowest weight (21.48 g) was found from W_0 (Figure 12).

Interaction effect of different levels of irrigations and weed management showed significant variation on weight of 1000 grains of BRRI dhan28 (Appendix VII). The highest weight of 1000 grains (24.56 g) was observed from I_2W_1 and the lowest (19.86 g) was found from I_5W_0 treatment combination (Figure 13).

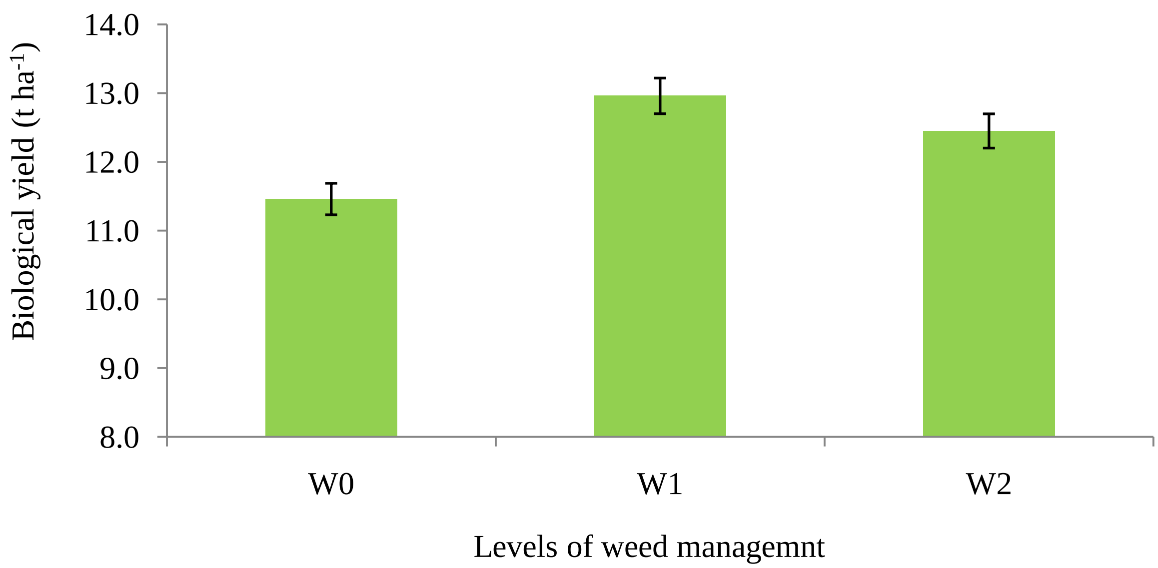
4.2.10 Grain yield

Different irrigation treatment varied significantly in terms of grain yield of BRRI dhan28 (Appendix VII). The highest grain yield (5.90 t ha^{-1}) was observed from I_2 which was followed (5.33 t ha^{-1} and 5.20 t ha^{-1}) with I_3 and I_1 and they were statistically similar, whereas the lowest (4.94 t ha^{-1}) was recorded from I_5 which was statistically similar (5.01 t ha^{-1}) with I_4 (Table 8). Pandey *et al.* (2003) stated that grain yield were higher under irrigated condition over rainfed.



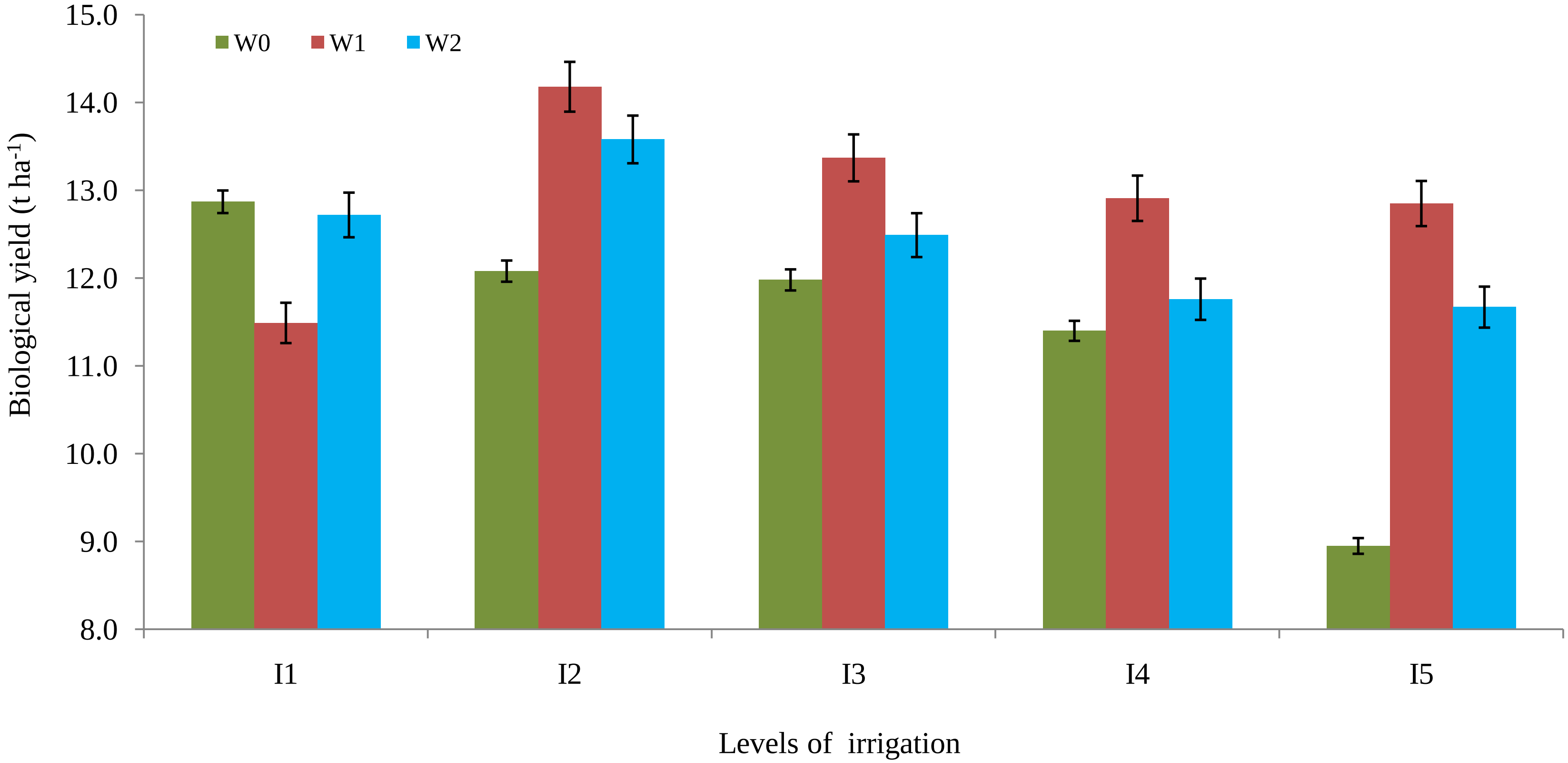
I_1: All time available water
I_2: Irrigation at 2 days after field drying
I_3: Irrigation at 4 days after field drying
I_4: Irrigation at 6 days after field drying
I_5: Irrigation at 8 days after field drying

Figure 11. Effect of irrigation on biological yield of BRRI dhan28. Vertical bars represent LSD value.



W_0: No weeding
W_1: Weeding at tillering stage
W_2: Weeding at flag leaf initiation stage

Figure 12. Effect of different levels of weed management on biological yield of BRRI dhan28. Vertical bars represent LSD value.



I_1: All time available water
I_2: Irrigation at 2 days after field drying
I_3: Irrigation at 4 days after field drying
I_4: Irrigation at 6 days after field drying
I_5: Irrigation at 8 days after field drying

W_0: No weeding
W_1: Weeding at tillering stage
W_2: Weeding at flag leaf initiation stage

Figure 13. Interaction effect of different levels of irrigation and weed management on biological yield of BRRI dhan28. Vertical bars represent LSD value.

Table 8. Effect of irrigation and weed management on yield contributing characters and yield of BRRI dhan28

Treatment	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
Irrigation				
I_1	5.20 bc	7.16 a	12.36 bc	42.01 b
I_2	5.90 a	7.38 a	13.28 a	44.30 a
I_3	5.33 b	7.29 a	12.62 b	42.12 b
I_4	5.01 c	7.01 a	12.02 c	41.71 b
I_5	4.94 c	6.21b	11.16 d	43.90 a
$LSD_{(0.05)}$	0.264	0.361	0.563	1.089
Significance level	0.01	0.01	0.01	0.01
CV(%)	5.09	5.14	4.08	3.47
Weed management				
W_0	4.80 c	6.66 b	11.46 c	41.76 b
W_1	5.69 a	7.27 a	12.96 a	43.77 a
W_2	5.34 b	7.10 a	12.45 b	42.90 a
$LSD_{(0.05)}$	0.04	0.275	0.381	1.128
Significance level	0.01	0.01	0.01	0.01
CV(%)	5.08	5.13	4.07	3.46

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_1: All time available water
I_2: Irrigation at 2 days after field drying
I_3: Irrigation at 4 days after field drying
I_4: Irrigation at 6 days after field drying
I_5: Irrigation at 8 days after field drying

W_0: No weeding
W_1: Weeding at tillering stage
W_2: Weeding at flag leaf initiation stage

Grain yield of BRRI dhan28 showed statistically significant variation due to different weed management (Appendix VII). The highest grain yield (5.69 t ha^{-1}) was recorded from W_1 which was followed (5.34 t ha^{-1}) by W_2, while the lowest (4.80 t ha^{-1}) was found from W_0 (Table 8). A number of studies showed that weed control through both traditional and chemical methods influence crop growth and yield attributes of rice (Mandal *et al.,* 1995; Gill *et al.,* 1992; Panwar *et al.,* 1992). Singh *et al*. (2009) reported that weeds competed for moisture, nutrients, light and space and as a consequence, weeds infestation in Dry Seeded Rice resulted in yield losses in the range to 30 to 90%, reduced grain quality and enhanced the cost of production. Pandey (2009) reported that among weed control treatments, three soil-aerating weedings at 14, 28 and 42 DAT was best for controlling weeds which contributed to the higher grain yield (6.53 t ha^{-1}).

Interaction effect of different levels of irrigations and weed management showed significant variation on grain yield of BRRI dhan28 (Appendix VII). The highest grain yield (6.44 t ha^{-1}) was observed from I_2W_1 and the lowest (3.59 t ha^{-1}) was found from I_5W_0 treatment combination (Table 9).

4.2.11 Straw yield

Different irrigation treatment varied significantly in terms of straw yield of BRRI dhan28 (Appendix VII). The highest straw yield (7.38 t ha^{-1}) was observed from I_2 which was statistically similar (7.29 t ha^{-1}, 7.16 t ha^{-1} and 7.01 t ha^{-1}) with I_3, I_1 and I_4, while the lowest (6.21 t ha^{-1}) was recorded from I_5 (Table 8). Pandey *et al*. (2003) stated that straw yield were higher under irrigated condition over rainfed.

Straw yield of BRRI dhan28 showed statistically significant variation due to different weed management (Appendix VII). The highest straw yield (7.27 t ha^{-1}) was recorded from W_1 which statistically similar (7.10 t ha^{-1}) with W_2, while the lowest straw yield (6.66 t ha^{-1}) was found from W_0 (Table 8).

Table 9. Interaction effect of irrigation and weed management on yield contributing characters and yield of BRRI dhan28

Treatment	Grain yield ($t\ ha^{-1}$)	Straw yield ($t\ ha^{-1}$)	Biological yield ($t\ ha^{-1}$)	Harvest index (%)
I_1W_0	5.71 cd	7.16 a-c	12.87 b-d	44.36 a-c
I_1W_1	4.58 h	6.91 b-d	11.49 f	39.85 e
I_1W_2	5.32 d-f	7.40 ab	12.72 b-d	41.83 c-e
I_2W_0	4.94 f-h	7.14 a-c	12.08 d-f	40.88 de
I_2W_1	6.44 a	7.74 a	14.18 a	45.43 ab
I_2W_2	6.33 ab	7.25 a-c	13.58 ab	46.61 a
I_3W_0	4.92 f-h	7.06 a-c	11.98 d-f	41.09 de
I_3W_1	5.95 bc	7.43 ab	13.37 a-c	44.47 a-c
I_3W_2	5.11 e-g	7.38 ab	12.49 c-e	40.81 de
I_4W_0	4.82 f-h	6.58 cd	11.40 f	42.32 c-e
I_4W_1	5.57 c-e	7.33 ab	12.91 b-d	43.20 b-d
I_4W_2	4.64 gh	7.12 a-c	11.76 ef	39.63 e
I_5W_0	3.59 i	5.35 e	8.95 g	40.14 e
I_5W_1	5.91 bc	6.94 b-d	12.85 b-d	45.92 ab
I_5W_2	5.32 d-f	6.35 d	11.67 ef	45.64 ab
$LSD_{(0.05)}$	0.457	0.614	0.852	2.523
Significance level	0.01	0.05	0.01	0.01
CV(%)	5.08	5.13	4.07	3.46

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_1: All time available water

I_2: Irrigation at 2 days after field drying

I_3: Irrigation at 4 days after field drying

I_4: Irrigation at 6 days after field drying

I_5: Irrigation at 8 days after field drying

W_0: No weeding

W_1: Weeding at tillering stage

W_2: Weeding at flag leaf initiation stage

Interaction effect of different levels of irrigations and weed management showed significant variation on straw yield of BRRI dhan28 (Appendix VII). The highest straw yield (7.74 t ha^{-1}) was observed from I_2W_1 and the lowest (5.35 t ha^{-1}) was found from I_5W_0 treatment combination (Table 9).

4.2.12 Biological yield

Different irrigation treatment varied significantly in terms of biological yield of BRRI dhan28 (Appendix VII). The highest biological yield (13.28 t ha^{-1}) was observed from I_2 which was followed (12.62 t ha^{-1} and 12.36 t ha^{-1}) with I_3 and I_1 and they were statistically similar, whereas the lowest (11.16 t ha^{-1}) was recorded from I_5 which was statistically similar (12.02 t ha^{-1}) with I_4 (Table 8).

Biological yield of BRRI dhan28 showed statistically significant variation due to different weed management (Appendix VII). The highest biological yield (12.96 t ha^{-1}) was recorded from W_1 which was followed (12.45 t ha^{-1}) by W_2, while the lowest (11.46 t ha^{-1}) was found from W_0 (Table 8).

Interaction effect of different levels of irrigations and weed management showed significant variation on biological yield of BRRI dhan28 (Appendix VII). The highest biological yield (14.18 t ha^{-1}) was observed from I_2W_1 and the lowest (8.95 t ha^{-1}) was found from I_5W_0 treatment combination (Table 9).

4.2.13 Harvest index

Different irrigation treatment varied significantly in terms of harvest index of BRRI dhan28 (Appendix VII). The highest harvest index (44.30%) was observed from I_2 which was statistically similar (43.90%) with I_5, while the lowest (41.71%) was recorded from I_4 which was statistically similar (42.01% and 42.12%) with I_1 and I_3 (Table 8).

Harvest index of BRRI dhan28 showed statistically significant variation due to different weed management (Appendix VII). The highest harvest index (43.77%)

was recorded from W_1 which was followed (42.90%) by W_2, while the lowest (41.76%) was recorded from W_0 (Table 8).

Interaction effect of different levels of irrigations and weed management showed significant variation on harvest index of BRRI dhan28 (Appendix VII). The highest harvest index (46.61%) was observed from I_2W_1 and the lowest (39.85%) was found from I_1W_1 treatment combination (Table 9).

CHAPTER 5

SUMMARY AND CONCLUSION

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted in the experimental area Agronomy Farm of Sher-e-Bangla Agricultural University, Dhaka during the period from November 2012 to April, 2013 in *Boro* season to find out the growth and yield performance of BRRI dhan28 under irrigation and weed management. The experiment comprised of two factors: Factors A: Levels of irrigation (5 levels)- I_1: All time available water; I_2: Irrigation at 2 days after field drying;I_3: Irrigation at 4 days after field drying; I_4: Irrigation at 6 days after field drying and I_5: Irrigation at 8 days after field drying; Factor B: Levels of weeding (3 levels); W_0: No weeding, W_1: Weeding at tillering stage and Weeding at flag leaf initiation stage. The experiment was laid out in split plot design with three replications. Data on weed population, different growth parameter and yield of rice was recorded and significant variation was observed for different treatments.

In case of irrigation consideration of weed population, at 30 DAT, the highest number of weed population (23.96 m^{-2}) was recorded from I_5, whereas the lowest (18.42 m^{-2}) from I_2. At 60 DAT, the highest number of weed population (20.47 m^{-2}) was recorded from I_5, whereas the lowest number of weed population (13.98 m^{-2}) from I_2. At 90 DAT, the highest number of weed population (16.44 m^{-2}) was recorded from I_5, whereas the lowest (9.80 m^{-2}) from I_2.

At 60, 75, 90 DAT and harvest, the tallest plant (54.17, 75.62, 88.65 and 91.75 cm, respectively) were observed from I_2, whereas the shortest plant (46.72, 67.32, 78.77 and 80.83 cm, respectively) were recorded from I_5. At 60, 75, 90 DAT and harvest, the maximum number of total tillers $hill^{-1}$ (9.42, 12.31, 14.30 and 15.89, respectively) were observed from I_2, while the minimum number (8.02, 10.29, 11.51 and 14.29, respectively) from I_5. The maximum number of effective tillers $hill^{-1}$ (13.71) was observed from I_2, again the minimum number (11.07) was recorded from I_5. The maximum number of ineffective tillers $hill^{-1}$ (3.22) was observed from I_5, whereas the minimum number (2.18) from I_2. The longest panicle (23.50 cm) was observed from I_2, while the shortest (19.46 cm) was recorded from I_5. The maximum number of filled grains panicle^{-1} (87.76) was observed from I_2, whereas the minimum number (78.38) from I_5. The maximum number of unfilled grains panicle^{-1} (7.00) was observed from I_5, whereas the minimum number (5.11) was recorded from I_2. The maximum number of total grains panicle^{-1} (92.87) was observed from I_2, whereas the minimum number (85.38) from I_5. The highest weight of 1000 grains (23.69 g) was observed from I_2, whereas the lowest weight (21.86 g) from I_5. The highest grain yield (5.90 t ha^{-1}) was observed from I_2, whereas the lowest (4.94 t ha^{-1}) was recorded from I_5. The highest straw yield (7.38 t ha^{-1}) was observed from I_2, while the lowest straw yield (6.21 t ha^{-1}) from I_5. The highest biological yield (13.28 t ha^{-1}) was observed from I_2, whereas the lowest (11.16 t ha^{-1}) was recorded from I_5. The highest harvest index (44.30%) was observed from I_2, while the lowest (41.71%) was recorded from I_4.

For weed management, at 30 DAT, the highest weed population (21.11 m^{-2}) was observed by W_0 and the lowest weed population (20.76 m^{-2}) was recorded from W_2. At 60 DAT, the highest weed population (21.73 m^{-2}) was seen by W_0 and the lowest (14.20 m^{-2}) was recorded from W_2. At 90 DAT, the highest weed population (18.61 m^{-2}) was found by W_0 and the lowest (7.67 m^{-2}) was recorded from W_1.

At 60, 75, 90 DAT and harvest, the tallest plant (52.46, 75.57, 88.42 and 91.63 cm, respectively) were recorded from W_1, while the shortest plant (47.33, 67.99, 79.32 and 81.51 cm, respectively) was found from W_0. At 60, 75, 90 DAT and harvest, the maximum number of total tillers hill^{-1} (9.13, 11.93, 14.10 and 15.97, respectively) were recorded from W_1, while the minimum number (8.05, 10.36, 12.16 and 13.97, respectively) from W_0. The maximum number of effective tillers hill^{-1} (13.64) was recorded from W_1, whereas the minimum number (10.91) was found from W_0. The maximum number of in-effective tillers hill^{-1} (3.07) was recorded from W_0, again the minimum number (2.33) was found from W_1. The longest panicle (23.89 cm) was recorded from W_1, while the shortest (19.82 cm) was found from W_0. The maximum number of filled grains panicle^{-1} (87.77) was recorded from W_1 while the minimum (75.97) was found from W_0. The maximum number of unfilled grains panicle^{-1} (6.81) was recorded from W_0, while the minimum number (5.04) was found from W_1. The maximum number of total grains panicle^{-1} (92.81) was recorded from W_1, while the minimum number (82.79) was found from W_0. The highest weight of 1000 grains (23.50 g) was recorded from W_1, while the lowest (21.48 g) was found from W_0. The highest grain yield (5.69 t ha^{-1}) was recorded from W_1, while the lowest (4.80 t ha^{-1}) was found from W_0. The highest straw yield (7.27 t ha^{-1}) was recorded from W_1, while the lowest straw yield (6.66 t ha^{-1}) from W_0. The highest biological yield (12.96 t ha^{-1}) was recorded from W_1, while the lowest (11.46 t ha^{-1}) from W_0. The highest harvest index (43.77%) was recorded from W_1, while the lowest (41.76%) was recorded from W_0.

Due to the interaction effect of irrigation and weed management, at 30 DAT the highest number of weed population (25.27 m^{-2}) was observed in I_5W_1 while the lowest (17.73 m^{-2}) was recorded from I_2W_1. At 60 DAT, the highest number of weed population (24.60 m^{-2}) was observed in I_5W_0, whereas the lowest (11.13 m^{-2}) was recorded from I_2W_1 treatment combination. At 90 DAT, the highest number of weed population (20.87 m^{-2}) was observed in I_5W_0, while the lowest (4.53 m^{-2}) was recorded from I_2W_1 treatment combination.

At 60, 75, 90 DAT and harvest, the tallest plant (58.44, 79.49, 94.74 and 97.25 cm, respectively) were observed from I_2W_2 and the shortest plant (41.25, 60.89, 71.55 and 72.03 cm, respectively) from I_5W_0 treatment combination. At 60, 75, 90 DAT and harvest, the maximum number of total tillers hill^{-1} (9.80, 13.47, 15.43 and 16.95, respectively) were observed from I_2W_1 and the minimum number (6.27, 10.00, 11.07 and 13.40, respectively) were found from I_5W_0. The maximum number of effective tillers hill^{-1} (14.93) was observed from I_2W_1, while the minimum (10.13) were found from I_5W_0. The maximum number of non-effective tillers hill^{-1} (3.93) was observed from I_5W_0 and the minimum (2.00) were found from I_2W_1 treatment combination. The longest panicle (26.43 cm) was observed from I_2W_1 and the shortest (18.62 cm) were found from I_5W_0. The maximum number of filled grains panicle^{-1} (92.73) was observed from I_2W_1, while the minimum (70.87) was found from I_5W_0. The maximum number of unfilled grains panicle^{-1} (7.47) was observed from I_2W_0 and the minimum number (4.07) were found from I_2W_1. The maximum number of total grains panicle^{-1} (96.80) was observed from I_2W_1 and the minimum number (78.33) was found from I_5W_0 treatment combination. The highest weight of 1000 grains (24.56 g) was observed from I_2W_1 and the lowest (19.86 g) was found from I_5W_0. The highest grain yield (6.44 t ha^{-1}) was observed from I_2W_1 and the lowest (3.59 t ha^{-1}) was found from I_5W_0 treatment combination. The highest straw yield (7.74 t ha^{-1}) was observed from I_2W_1 and the lowest (5.35 t ha^{-1}) was found from I_5W_0 treatment combination. The highest biological yield (14.18 t ha^{-1}) was observed from I_2W_1 and the lowest (8.95 t ha^{-1}) was found from I_5W_0. The highest harvest index (46.61%) was observed from I_2W_1 and the lowest (39.85%) was found from I_1W_1 treatment combination.

Conclusion

It was observed that, irrigation at 2 days after field drying and weeding at tillering stage have significant positive effect on growth and yield of BRRI dhan28.

Considering the above results of this experiment, further studies in the following areas may be suggested:

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

2. More experiments may be carried out with other level of irrigation.

3. More experiments may be carried out with other management practices.

REFERENCES

REFERENCES

Aktaruzzaman, M. (2007). Effect of weeding regime and nitrogen level on the transplant *aman* rice cv. BRRI dhan 32. MS Thesis, Dept. of Agron., Bangladesh Agril. Univ., Mymensingh.

Amarjit, S. B., Singh, M., Kachroo, D., Sharma, B. C. and Shirvan, D. R. (2005). Efficacy of herbicides in transplanted, medium duration rice under sub-tropical conditions of Jammu. *Indian J. Agron*. **51**(2): 128-130.

Babu, B. T. R., Reddy, V. C., Yogananda, S. B. (2000). Performance of rainfed low land rice varieties. Current Research, University of Agricultural Science, Bangalore. **29**(3/4): 51-53.

Bali, A. S. and Uppal, H. S. (2006). Irrigation schedule in producing quality basmati rice *(Oryza sativa* L.). Punjab Agricultural University, Ludhiana, India.

Bari, M. N. (2010). Effect of herbicides on weed suppression and rice yield in transplanted wetland rice. *Pakistan J. Weed Sci. Res*. **16**(4): 349-361.

BBS. (Bangladesh Bureau of Statistics). (2013). Statistical Year Book of Bangladesh. Bangladesh Bur. Stat., Stat. Div., Min. Plan., Govt. People's Repub. Bangladesh, Dhaka. Pp. 32-37.

Behera, B. K., Behera, D., Swain, S. and Sahoo, P. K. (1996). Performance evaluation manual weeders for paddy crop in Orissam India. AMA 20-22.

Bhagat, S., Malik, R. K., Ashok, Y. and Nandal, D. P. (2008). Suitable methods of sowing and weed management in direct seeded rice. Department of Agronomy, CCS Haryana Agricultural University, Hisar-125 004, India. *Haryana J. Agron*. **24**(1/2): 34-36.

Bhandari, A. L., Tarlok, S., Gill, M. S. (2000). Feasibility of different cropping systems under irrigated and rainfed conditions of Punjab. *Journal Research of Punjab Agricultural University.* **37(3/4)** 167-172.

Bhowmick, M. K., Ghosh, R. K. and Pal, D. (2000). Bio-efficiency of new promising herbicides for weed management in summer rice. *Indian J. Weed Sci*. **32**(17&2):35-38.

Bhowmick, M. N., Nayar, R. L. and Ray, D. (2002). Herbicide status on weed management, crop phytotoxicity, growth and yield of dry season rice. *Ann. Agril. Res*. **23**(1): 116-122.

Boling, A., Tuong, T. P., Jatmiko, S. Y., Burac, M. A. (2004). Yield constraints of rainfed low land rice in Central Java, Indonesia. International Rice Research Institute, Manila, Philippines. *Field Crops Research.* **90**(2/3): 351-360.

BRRI (Bangladesh Rice Research Institute). (2013). Adhunik Dhaner Chash. Joydebpur, Dhaka. p. 80.

BRRI (Bangladesh Rice Research Institute). (1992). Annual Report for 1991. Bangladesh Rice Res. Inst. Joydebpur, Gazipur. pp.8-9.

BRRI (Bangladesh Rice Research Institute). (2008). Annual Report for 2007. Bangladesh Rice Res. Inst., Joydevpur, Bangladesh. pp. 28-35.

Chandra, S. and Pandey, J. (2001). Effect of rice culture, nitrogen and weed control on nitrogen competition between scented rice and weeds. *Indian J. Agron*. **46**(1): 68- 74.

Chauhan, B. S., Singh, V. P., Kumar, A. and Johnson, D. E. (2011). Relations of rice seeding rates to crop and weed growth in aerobic rice. *Field Crop Res*. **21**: 105-115.

Chaulian, J. S., Moya, T. B., Singh, R. K., Singh, C. V. (1999). Influence of soil moisture stress during reproductive stage on physiological parameters and grain yield in upland rice. *Indian J. Agril. Sci.,* **36:** 130-135.

Chen, H. S., Tao, L. X., Wang, X., Huang, X. L., Tan, H. J., Cheng, S.H., Min, S. K. (2005). Effect of different irrigation modes during grain filling of rice on translocation and allocation of carbohydrate in rice. China National Rice Research Institute, Hangzhou, China. *Scientia-Agricultura-Sinica*. **38**(4)**:** 678-683.

Chowdhury, M. J. U., Sarkar, A U., Sarkar, M. A. R. and Kashem, M. A. (1994). Effect of weed infestation regime on the growth and yield of transplant aman rice. Bangladesh *J. Agril. Sci*., **21**(1): 141-147.

De Datta, S. K. (1990). Weed control on rice in South East Asia. Ext. Bull. No. 146. FFTC. Taiwan. pp.1-24.

Edris, K. M., Islam, A. T. M. T., Chowdhury, M. S. and Haque, A. K. M. M. (1979). Detailed Soil Survey of Bangladesh, Dept. Soil Survey, Govt. People's Republic of Bangladesh. p. 118.

FAO (Food and Agricultural Organization). (2006). Retrieved from: http// www.fao.org

FAO (Food and Agriculture Organization). (2009). FAO Production Yearbook, Food and Agriculture Organization, Rome, Italy. 56-77.

FAO. (1988). Production Year Book. Food and Agricultural of the United Nations Rome, Italy. **42**: 190-193.

Ganesh, H. V. (2003). Effect of various irrigation schedules on yield and water use in transplanted paddy. *Mysore J. Agril. Sci,* **34**(3): 222-226.

Gill, P. S., Bhangoo, B. S. and Boparai, B. S. (1992). Weed control efficacy of tridiphane and fluroxypyr in transplanted rice (*Oryza sativa*). *Indian J.Agron*. **37**(3): 573-575.

Gomez, K. A. and Gomez, A. A. (1984). *Statistical Procedures for Agricultural Research*. John Wiley Pub. New York.

Gul-Hassan, K., Khan, Q. N. and Khan, S. U. (2002). Studies on herbicideal efficiency and spectrum of different herbicides in transplanted rice. *Pakistan J. Weed Sci. Res*., **8**(1&2): 13-17.

Hien, N. L., Yoshihashi, T. and Sarhadi, W. A. (2006). Evaluation of aroma in rice (*Oryza sativa* L.) using KOH method, molecular markers and measurement of 2-acetyl-1-pyrroline concentration. *Jpn. J. Trop. Agric*., **50**: 190-198.

Hirasawa, T. (1998). Physiological characterization of the rice plant for tolerance of water deficit. Proc. of a workshop, 1-3 Dec, 1998. Los. Banos, Leguna, Philippines.

Hossain, M. D. (2000). Autoecology of *Ehinochloa crusgalli* and its control in direct seeded *aus* rice. MS Thesis. Dept. Agron., Bangladesh Agril. Univ., Mymensingh.

Hossain, M. M. and Haque, M. Z. (2002). Seedling age and weed density effects on basal tillers survival and yield of transplanted deep water rice. In: Proc. Intl. Deep Water Rice Workshop. Manila. Philippines. pp. 16-20.

IRRI (International Rice Research Institute). (1998): World Rice Statistics 1996-97. Intl. Rice Res. Inst., Manila, Philippines. pp.2-19.

IRRI (International Rice Research Institute). (2009). Rough rice production by country and geographical region-USDA. Trend in the rice economyIn: world rice statistics. Retrieved from: www.irri.org/science/ricestat.

Islam, M. T. and Salam, M. A. (1994a). Growth and yield performance of some rice genotypes under different soil moisture regimes. *Bangladesh J. Agril. Sci.,***7**(2): 57-62.

Islam, M. T., Salam, M. A., Kauser, M. (1994b). Effect of soil water stress at different growth stage of rice on yield components and yield progress. *Agric*. **5**: 151-156.

Islam, M. S. (1995). Effect of cultivar and weeding regime on weed growth and performance of boro rice. MS Thesis, Dept. Agron., Bangladesh Agril. Univ., Mymensingh. pp. 40-43.

Islam, M. Z. (2003). Effect of weeding regime on the growth and yield of BRRI dhan 31 under varying spacings. MS Thesis, Dept. Agron. Bangladesh Agril. Univ., Mymensingh. pp. 70-72.

Ismail, U., Kolo, M. G. M. and Gbanguba, U. A. (2011). Efficacy and Profitability of some weed control practices in upland rice (*Oryza sativa*) at Badeggi, Nigeria. *American J. Exp. Agric*. **1**(4): 175-186.

Jadhav, A.S., Dhoble, M.V. and Chavan, D.A. (2003). Effect of irrigation and nitrogen on yield and quality of Basmati rice. *Journal Maharashtra Agricultural University India*. **28**(2): 187-188.

Kabir SM 2011: Effects of Supplemental Irrigation on the Yield and Yield Contributing Components of BINA Dhan7. M.S. Thesis. Dept. of Soil Science, Bangladesh Agril. Univ., Mymensingh. pp. 32-34.

Karim, M. R., Alam, M. M., Ladha, J. K., Islam, M. S. and Islam M. R. (2014). Effect of different irrigation and tillage methods on yield and resource use efficiency of boro rice (*Oryza sativa*). *Bangladesh J. Agril. Res*., **39**(1): 151-163.

Khan, M. and Ashraf, M. (2006). Effects of herbicides on weed control and paddy yield in rice. *Sarhad J. Agric*. **22**(11): 131-135.

Laxminarayan, P. and Mishra, B. N. 2001. Effect of nutrient and weed management practices on weeds and yield of transplanted rice. Ann. Agril. Res. 22(2): 258-261.

Mahadi, M. A., Dadari, S. A., Mahmud, M. and Babaji, B. A. (2006). Effect of hand weeding and pre-emergence herbicides on yield and yield components of rice. *Indian J. Food Agric. Environ*. **4**(2): 164-167.

Mahajan, G., Chauhan, B. S. and Johnson, D. E. (2009). Weed management in aerobic rice in North Western Indo-Gangetic Plains. *Crop Improv*. **23**: 366-382.

Mamun, A. A. (1990). Agro-ecological studies of weed control in a flood prone village of Bangladesh. Japan Intl. Co-operation Agency, Dhaka, Bangladesh. JSARD Pub. No. 17. pp. 22-29 and 165.

Mandol, M. A. H., Rahman, M. A. and Gaffar, M. A. (1995). Field efficacy of Rilof H and Rifit herbicides for weed control in transplanted *aman* rice (BRI1). *Bangladesh J. Agric*. **19**(20): 7-12.

Mitra, B. K., Karim, A. J. M., Hague, M. M., Ahmed, G. J. U. and Bari, M. N. (2005). Effect of weed management practices on transplanted *Aman* rice. *Bangladesh J. Agron*., **4**(3): 238-241.

Moody, K. and De Detta, S. K. (1998). Integrated control of weeds in rice. Paper presented at the 7th Session of FAO Panel of Expert on Integrated Pest Control and Resistance Breeding, 21-28 April, 1977, Rome, Italy.

Mukherjee, P. K. and Malty, S. K. (2007) weed control in transplanted and wet seeded rainy season rice (*Oryza sativa*). *Indian J. Agric. Sci*. **81**(2): 134-139.

Nair, A. K., Pramanic, S. C., Ravisankar, N and Dinesh, R. (2002). Effect of varieties and weed control practices on productivity of rice and weed growth in lowlands of the South Andamans. *Indian J. Agric. Sci*. **72**(8): 477-479.

Nandal, D. P. and Singh, C. M. (1994). Effect of weed control on direct seeded puddle rice. *Haryana Agril. Univ. J. Res*. **24**(4): 154-157.

Nojavan, M. (2001). Principles of weed control. Urmia: University of Urmia Press, p. 430.

Pandey, V. K., Mishra, R. K., Sharma, R. B. (2003). Study on performance of rice under rainfed and irrigated condition. Zonal Agricultural Research Station, Indira Gandhi KrishiVishwavidyalaya, India. *Advances in Plant Sci*., **14**(2): 511-515.

Pandey, S. (2009). Effect of weed control methods on rice cultivars under the system of rice intensification (SRI). MS Thesis, Dept. Agron, Tribhuvan University**,** Institute of Agriculture And Animal Science**,** Rampur, Chitwan, Nepal. pp. 35.

Panwar, R. S., Malik, R. K. and Malik, R. S. (1992). Effect of weedicides on weed control in wheat (*Tritichum aestivum*) crop. *Indian J. Agron*. **37**(2): 320-323.

Pasha, H. Y., Koloor, R. T. and Hashemi, S. J. (2012). Effects of weed control methods on yield and yield components of Iranian rice. *AJAE,* **3**(2): 59-64.

Pathak, K., Kendra, K. V. and Chowdhury, A. K. (2001). Water and weed management studies in direct-seeded upland rice. Assam Agricultural University (AAU), Arunachal 778 025, Cachar, India. *Intl. Rice Res. Notes*., **26**(2): 55-57.

Pernito, R. G., Edillo, N. A., Baquiran, V. A. and Garrity, D. P. (1996). Differential weed suppressing ability in rainfed low land rice. *Philippines J. Crop. Sci*. **1**: 11.

Prakash, N. B. (2010). Different sources of silicon for rice farming in Karnataka. Paper presented in Indo-US workshop on silicon in agriculture, held at University of Agricultural Sciences, Bangalore, India, 25-27th February 2010, p.14.

Prasad, R. (2011). Aerobic rice systems. *Adv. Agron*. **111**: 207-233.

Rafiquddaulla, M. (1999). Effect of weeding regime and time of harvesting on the yield and quality of fine rice. cv. Kalizira. MS Thesis. Dept. Agron., Bangladesh Agril. Univ., Mymensingh. pp. 63-64.

Rahman, A. B. M. Z., Islam, M. A., Hoque, M. A., Karim, S. M. R. (2007). Economic study on use of different level of herbicide and hand weeding method in controlling weeds in transplant *Aman* rice (*Oryza sativa)* J. Socioecono. *Res. Develop*. **3**(1): 66-73.

Rao, A. N., Johnson, D. E., Sivaprasad, B., Ladha, J. K. and Mortimer, A. M. (2007). Weed management in direct-seeded rice. *Adv. Agron*. 93: 153–255.

RRDI (Rice Research and Development Institute). (1999). Netscape-Effect of water deficit. Department of Agriculture, Batalagoda, Ibbagamuwa, Srilanka.

Sanjoy, S., Moorty, B. T. S. and Jha, K. P. (1999). Influence of different production factors on the performance of rainfed upland rice. *Indian J. Agril. Sci*. **69**(6): 449-450.

Sattar, M. A. (2004). Water Management in Rice Production. Handout preparation for rice production training programme, Bangladesh Rice Research Institute (BRRI), Gazipur, Bangladesh.

Shamsuzzaman, A. K. M. (2007). Comparative Study On The Yield Performance Of Transplant Aman Rice Under Rainfed And Supplemental Irrigated Conditions. M.S. Thesis. Dept. of Soil Science, Bangladesh Agril. Univ., Mymensingh. pp.52-55.

Singh, A. K., Chandra, N., & Bharati, R.C. (2012). Effects genotypes and planting time on phenology and performance of rice (*Oryzasativa* L.). *Vegetos,* **25**: 151-156.

Singh, G. 2008. Integrated weed management in direct-seeded rice. In: *Direct* Seeding of Rice and Weed Management in the Irrigated Rice-Wheat Cropping System of the Indo-Gangetic Plains. pp. 161–176.

Singh, G., Singh, R. G., Singh, O. P., Kumar, T., Metha, R. K. and Singh, P. P. 2005. Effect of weed management practices on transplant rice. *Indian J. Agron*., **50**(1): 25-37.

Singh, S., Chhokar, R. S., Gopal, R., Kumar, V., and Singh, M. 2009. Integrated weed management–A key for success of direct seeded rice. *Indian J. Agron*., **44**(2):310-312.

Spanu, A,, Murtas, A., Ledda, L., Ballone, F. (2004). Comparison of rice varieties subjected to non-continuous irrigation. *Informatore Agrario.* **60**(18)**:** 61-64.

Stanley, W. D. L. (2002). Irrigation under conditions of water scarcity. Vol.1D17th-ICID-International Congress on Irrigation and Drainage, Granada. *Agricultura Revista Agropecuaria.***70**(827): 354-357.

Subramanian, E., Martin, G. J. and Balasubramanian, R. (2006). Effect of integrated weed management practices on growth and yield of wet seeded rice. *Indian J. Agron*. **51**(2): 93-96.

Sujit, A, Sarkar, B. K. (2003). Evaluation of drought tolerance in some rainfed upland rice *(Oryza sativa* L.) cultivars. *Indian Agriculturist*. **47(3/4)** 259-263.

TaoLong, X., Wang, X., Huang, X. L., MinSha, K., Cheng, S. H. (2004). Effects of soil moisture content on physiological activity of rice root system during grain filling stage. China National Rice Research Institute, Hangzhou, China. *Scientia Agricultura Sinica***. 37**(11): 1616-1620.

Tomar, S. S., Tembe, G. P., Sharma, S. K. (2000). Improved management practices for increase productivity of Vertisols under rainfed condition. Department of Soil Science &Agril.Chemistry, Jawaharlal Nehru KrishiVishwaVidyalaya, Jabalpur. India. *JNKVV-Research J.,* **32(1/2):** 21-26.

Torres, P. J, Valle, F. H. (2006). Financial feasibility of supplementary irrigation for rice: a demonstration programme in Southern Campeche. *Revista-Chapingo-Serie-Ingenieria-Agricola.***1(1):** 91-96.

Walia, U. S., Gill, G., Walia, S. S. and Sidhu, A. S. (2011). Production of direct seeded rice (*Oriza sativa*) under differential plant densities and herbicides in central plains of punjab. *J. crop and weed*. **7**(2):1-5

Yaghoobi B, and Yousefi D. M. (2008). Weeds and herbicide in rice cultivation. Agricultural management, coordination and Extension press. Guilan, Iran. pp. 35.

Yang, C., Hsiang, W., Hsiang, W. M. (1994). Growth and yield of rice as affected by water deficits. *Chinese Journal of Agrometerology.***1:** 143-150.

Yang, X. G., Bouman, B. A. M., WangHua, Q., Wang, Z. M., Zhao, J. F., Chen, B. (2005). Performance of temperate aerobic rice under different water regimes in North China. China Agricultural University, 2 Yuanmingyuan

West Rd., Beijing, China. Agricultural-Water-Management. **74**(2): 107-122.

Zaman, F., Sarkar, M. A. R., Salim, M. and Islam, M. S. (2013). Effect of seedling depth and weed management options on the performance of *Aus* rice cv. NERICA 1 under dry direct seeded rice (DDSR) system of cultivation. *Bangladesh J. crop Sci*. **24**: 103-110.

Zeng, X., LiYang, S., XieXiao, L., Xiao, G. Y., Liao, J. L. (2003). Effect of different irrigation patterns on physiological characteristics of root and photosynthetic traits of flag leaf after flowering stage in hybrid rice. *Chinese J. of Rice Sci*., **17**(4): 355-359.

ZouGui, H., MeiHan, W., YuXin, Q., LiuHong, Y., LiuGuo, L., LiMing, S., Luo, L. J. (2006). Effects of different water supply treatment on vegetative growth, photosynthetic characteristics and grain yield in upland rice. Shanghai Agrobiological Gene Center, Shanghai, China. *Acta Agronomica-Sinica*. **32**(8): 1179-1183.

APPENDICES

APPENDICES

Appendix I. Monthly average of air temperature, relative humidity and total rainfall of the experimental site during the period from Novenber, 2012 to April, 2013

Month	*Air temperature (^oC)		*Relative humidity (%)	*Rainfall (mm) (total)
	Maximum	Minimum		
November, 2012	25.8	16.0	78	00
December, 2012	22.4	13.5	74	00
January, 2013	25.2	12.8	69	00
February, 2013	27.3	16.9	66	39
March, 2013	31.7	19.2	57	23
April, 2013	33.4	23.2	67	78

* Monthly average,

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

Appendix II. Characteristics of soil of experimental field

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Agronomy 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

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 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

Appendix III. Analysis of variance of the data on weed population of BRRI dhan28 as influenced by irrigation and weed management

Source of variation	Degrees of freedom	Mean square		
		Weed population (m^{-2}) at		
		30 DAT	60 DAT	90 DAT
Replication	2	0.220	0.113	0.100
Irrigation (A)	4	45.150**	64.701**	64.490**
Error	8	0.568	1.063	0.450
Weed Management (B)	2	0.465^{NS}	279.308**	482.988**
Interaction (A×B)	8	6.554**	3.961**	5.688**
Error	20	1.113	0.849	0.320

** Significant at 0.01 level of probability; * Significant at 0.05 level of probability

Appendix IV. Analysis of variance of the data on plant height of BRRI dhan28 as influenced by irrigation and weed management

Source of variation	Degrees of freedom	Mean square			
		Plant height (cm) at			
		60 DAT	75 DAT	90 DAT	Harvest
Replication	2	0.945	1.076	0.451	3.116
Irrigation (A)	4	69.830**	87.404**	115.229*	153.888**
Error	8	6.169	6.370	29.691	17.611
Weed Management (B)	2	135.457**	219.579**	311.113**	402.549**
Interaction (A×B)	8	36.525*	46.702*	87.517**	62.033**
Error	20	15.017	16.149	20.075	16.226

** 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 BRRI dhan28 as influenced by irrigation and weed management

Source of variation	Degrees of freedom	Mean square			
		Number of tillers hill^{-1} at			
		60 DAT	75 DAT	90 DAT	Harvest
Replication	2	0.019	0.038	0.076	0.152
Irrigation (A)	4	2.779**	4.806**	9.879**	3.550**
Error	8	0.280	0.737	0.090	0.220
Weed Management (B)	2	5.432**	9.838**	14.282**	18.200**
Interaction (A×B)	8	1.510*	0.644*	2.122*	1.641**
Error	20	0.537	0.289	0.622	0.505

** Significant at 0.01 level of probability; * Significant at 0.05 level of probability

Appendix VI. Analysis of variance of the data on yield contributing characters of BRRI dhan28 as influenced by irrigation and weed management

Source of variation	Degrees of freedom	Mean square					
		Number of effective tiller hill^{-1}	Number of in-effective tiller hill^{-1}	Length of panicle (cm)	Number of filled grain panicle^{-1}	Number of unfilled grain panicle^{-1}	Number of total grain panicle^{-1}
Replication	2	0.172	0.001	0.188	8.705	0.035	9.838
Irrigation (A)	4	9.758**	1.639**	23.150**	109.111**	4.660**	69.438**
Error	8	0.174	0.012	1.257	7.464	0.058	8.080
Weed Management (B)	2	32.188**	2.081**	68.110**	588.641**	11.795**	444.225**
Interaction (A×B)	8	1.173*	0.092**	5.639*	47.416**	0.455**	54.544**
Error	20	0.423	0.022	1.961	5.385	0.080	5.945

** Significant at 0.01 level of probability; * Significant at 0.05 level of probability

Appendix VII. Analysis of variance of the data on yield contributing characters and yield of BRRI dhan28 as influenced by irrigation and weed management

Source of variation	Degrees of freedom	Mean square				
		Weight of 1000 grains (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
Replication	2	0.134	0.059	0.070	0.124	2.290
Irrigation (A)	4	5.315**	1.311**	1.953**	5.513**	12.880**
Error	8	0.394	0.059	0.110	0.268	1.004
Weed Management (B)	2	17.140**	3.039**	1.497**	8.770**	15.291**
Interaction (A×B)	8	5.391*	1.508**	0.373*	2.957**	20.544**
Error	20	2.280	0.072	0.130	0.250	2.194

** Significant at 0.01 level of probability; * Significant at 0.05 level of probability