NITROGEN, WEED AND IRRIGATION MANAGEMENT FOR MAXIMIZING GROWTH AND YIELD OF BORO RICE (cv. BRRI dhan29)

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BY

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This is to certify that the thesis entitled **'Nitrogen, Weed and Irrigation Management for Maximizing Growth and Yield of Boro Rice (cv. BRRI dhan29)'** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka-1207, in partial fulfilment of the requirements for the degree of **DOCTOR OF PHILOSOPHY IN Agronomy**, embodies the result of a piece of bona fide research work carried out by **Md. Shafiqul Islam**, Registration number: **01537** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

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DEDICATED

TO MY DEPARTED

GRANDFATHER AND FATHER

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ABSTRACT

Two consecutive field experiments were conducted at the Suapur Union of Dhamrai Upazila, Dhaka. The experimental field is located at $23^0 88'$N latitude and $90^0 14'$E longitude and AEZ-12, during the period of 2014-2015 and 2015-2016 to find out nitrogen, weed and irrigation management for maximizing growth and yield of boro rice (cv.BRRI dhan29). The experiment comprised three factors; Factor A: Nitrogen management (4 levels), N_0: No urea (control), N_1: Urea super granules-USG (77 kg N ha^{-1}), N_2: Prilled urea at recommended dose (150 kg N ha^{-1}) and N_3: ½ of the recommended dose (75 kg N ha^{-1}); Factor B: Weed management (4 levels), W_0: No weeding (control), W_1: Two hand weeding (20 and 40 DAT), W_2: Pre emergence herbicide (Butachor) and W_3: Post emergence herbicide (Prityloclor); Factor C: Irrigation management (4 levels), I_1: Irrigating all time, I_2: Irrigating 3 days after drying, I_3: Irrigating 5 days after drying, I_4: Alternate wetting and drying (AWD) method. The experiments were laid out in split-split-plot designs with three replications. Data on different growth characters, yield components and yield of BRRI dhan29 were recorded. Statistically significant variation was observed for different nitrogen, weed and irrigation management and also for their combined effect. For nitrogen management, on an average of two consecutive years, the highest grain yield (6.01 t ha^{-1}) was recorded from N_1, while the lowest (4.35 t ha^{-1}) from N_0. In weed management, the highest grain yield (5.92 t ha^{-1}) was recorded from W_2, while the lowest (4.49 t ha^{-1}) from W_0. In case of irrigation management, the highest grain yield (5.88 t ha^{-1}) was found from I_4, while the lowest (4.70 t ha^{-1}) from I_1. For the combined effect of different nitrogen and weed management, the

highest grain yield (6.80 t ha^{-1}) was recorded from N_1W_2, whereas the lowest (3.85 t ha^{-1}) from N_0W_0. Due to the combined effect of different nitrogen and irrigation management, the highest grain yield (6.36 t ha^{-1}) was recorded from N_1I_4, whereas the lowest (3.80 t ha^{-1}) from N_0I_1. In case of combined effect of different weed and irrigation management based on pooled data, the highest grain yield (6.52 t ha^{-1}) was recorded from W_2I_4, whereas the lowest (3.85 t ha^{-1}) from W_0I_1. Due to the combined effect of different nitrogen, weed and irrigation management, on polled basis the highest grain yield (6.99 t ha^{-1}) was recorded from $N_1W_2I_4$, while the lowest yield (3.18 t ha^{-1}) from $N_0W_0I_1$. The treatments having significantly high grain yields over others were $N_1W_1I_4$ (6.61 t ha^{-1}), $N_1W_2I_4$ (6.99 t ha^{-1}), $N_1W_3I_4$ (6.90 t ha^{-1}), $N_2W_2I_4$ (6.70 t ha^{-1}),$N_2W_3I_4$(6.6 t ha^{-1}), $N_3W_2I_4$ (6.54 t ha^{-1}) and $N_3W_3I_4$ (6.61 t ha^{-1}), which were identical among themselves.

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LIST OF ABBREVIATIONS AND ACRONYMS

%	=	Percent
@	=	at the rate of
AEZ	=	Agro- Ecological Zone
AIS	=	Agricultural Information Service
ANOVA	=	Analysis of Variance
AWD	=	Alternate Wetting and Drying
BAS	=	Bangladesh Academy of Sciences
BAU	=	Bangladesh Agricultural University
BBS	=	Bangladesh Bureau of Statistics
BRRI	=	Bangladesh Rice Research Institute
CGR	=	Crop Growth Rate
cm	=	Centimeter
CV	=	Coefficient of varience
cv.	=	Cultivar
DAS	=	Day after sowing
DAT	=	Day after transplanting
DMRT	=	Duncan's Multiple Range Test
EC	=	Emulsifiable Concentrate
et al.	=	and others (*at elli*)
FAO	=	Food and Agricultural Organigation
g	=	gram (s)
HI	=	Harvest Index
HW	=	Hand Weeding
i.e.	=	That is
kg/ha	=	Kilogram/hectare
LAI	=	Leaf Area Index
LCC	=	Leaf Color Chart
m^2	=	Square Meter
N	=	Nitrogen
NAG	=	Net Assimilation Rate
PU	=	Prilled Urea
PVC	=	Polyvinyl chloride
RGR	=	Relative Growth Rate
SE	=	Standard Error
SRDI	=	Soil Resource and Development Institute
t	=	Ton
TDM	=	Total dry matter.
USG	=	Urea Super Granules
Viz.	=	Namely
WP	=	Wettable power
WUE	=	Water Use Efficiency

CHAPTER I

INTRODUCTION

Rice (*Oryza sativa* L.), belongs to the family Poeaceae, is the most important food in tropical and subtropical regions (Singh *et al*., 2012). The term "rice" refers to the species *Oryza sativa* L. and *Oryza glaberrima* Steud. *O. glaberrima*, also known as "African rice", is native to sub-Saharan Africa, where it is still grown, but due to its lower yield potential progressively replaced by *O. sativa* (Linares, 2002). It is grown in more than a hundred countries with a total area of about 160 million hectares, producing more than 700 million tons every year (IRRI, 2013). There are about 13 million farm families, who grow different types of rice, which includes traditional, modern or hybrid rice varieties. It is the grain that has shaped the culture, diet, and economies of billions of people in the world (Farooq *et al.*, 2009).

Almost the entire rice produced is *O. sativa*, which is one of the three mega-crops (rice, maize, and wheat) on which more than half the world's population relies as main staple food, grown in wide range of climatic zones, to nourish the mankind and is particularly important in Asia, where approximately 90% of world's rice is produced and consumed (Maclean *et al.,* 2002; Khush, 2005; Chaturvedi, 2006; Zeigler and Wassmann *et al.*, 2009). Bangladesh ranks 4th in both area and production and 6th in the production of per hectare yield of rice (Sarkar *et al*., 2016). In Bangladesh, people also consumed rice as staple food and it constituted about 90% of the total food grain production (Huda, 2001). The geographical, climatic and edaphic conditions of Bangladesh are favorable for year round rice cultivation. There are several major rice-growing ecosystems in Bangladesh. Of the three types of rice *aus* (early monsoon rice), *aman* (monsoon rice) and *boro* (dry/winter season rice), the *boro* rice alone contributed the highest share of total production since 1998-99 to date (BER, 2005). *Aman* season rice accounts for nearly 51% of total land, followed by *boro* and *aus* season rice which is 40% and 9%, respectively.

The area and production of total rice in Bangladesh is about 11.53 million hectares and production is about 33.91 million metric tons, respectively where *boro* covers the largest part of about 4.81 million hectares with the production of 18.78 million metric tons. The area and production of hybrid rice in *boro* season were about 6.58 lac hectares and the productions is about 330.17 lac metric tons, respectively (AIS, 2013). The country is said to have among the highest per capita consumption of rice is about 170 kg annually (BBS, 2013) and its food security and economy largely depend on good harvests year after year. In the last three to four decades, great efforts in rice research and farming innovations were made to boost rice production, and it has increased to about 48 million tons in 2009 from about 17 million tons in 1970. Scientists, extension agents, and farmers worked hard to achieve this success. However, challenges still lie ahead as Bangladesh becomes more densely populated and the cultivable land is reducing year after year due to urbanization, industrialization and different works.

The population of Bangladesh is growing by two million every year and may increase by another 30 million over the next 20 years. Thus, Bangladesh will require additional about 27.26 million tons of rice for the year 2020 (BRRI, 2011). Population growth demands a continuous increase in rice production in Bangladesh and it needs to be increased by 53.3% (Mahamud *et al.*, 2013). In Bangladesh, the average yield of rice is about 2.92 t ha^{-1} (BBS, 2013) which is very low compared to other rice growing countries of the World, like China (6.30 t ha^{-1}), Japan (6.60 t ha^{-1}) and Korea (6.30 t ha^{-1}) (FAO, 2008). In some years and in some seasons it is noticed that the level of food security and hunger rises due to crop loss, low rice yield. Therefore, increase of *boro* rice production would be a significant possible way to overcome food deficiency in the country. Thus, the production of dry season irrigated rice has a predominant importance for national food security (Fujita, 2004). Therefore, attempts should be taken to increase the yield per unit area through use of comparatively high yielding varieties along with judicial irrigation, fertilizer and weed management.

Among the production factors affecting crop yield, nutrient is the single most important factor that plays a dominant role in yield increase if other production factors are not limiting. Water is one of the most important requirements of rice production. A large part of the variation in annual rice yield generally may be merely due to variations in timing and the quantity of irrigation water applied (Bertolacci *et al.,* 2006; Prasad *et al.,* 2006; Ghinassi, 2007; Ghinassi *et al.,* 2007). The cultivation of rice in flooded fields requires about 2500-3000 m^3 water to produce one ton of rice grain (Bouman *et al.,* 2002). Paddy rice is usually grown in lowland areas under continuous flooded conditions. Rice grown under traditional practices in the Asian tropics and subtropics requires between 700-1500 mm of water per cropping season depending on soil texture (Bhuiyan, 1992). It is estimated that over 75 percent of the world's rice is produced using continuous flooding water management practices (Van der Hoek *et al.,* 2001; Tuong and Bouman, 2003). According to Sharma, (1989) the continuous flooding method is very inefficient as about 50-80 percent of the total water input is wasted through surface runoff, seepage, and percolation. Other disadvantages of continuous flooding are: high emissions of methane (Wassmann *et al.,* 2009; FAO, 2010); greater vulnerability to water shortages than other cropping systems (Wassmann, 2010); leaching of soluble nutrients, blocking of soil microbial activities, and reduced mineralization and nutrient release from the soil complexes (Uphoff and Randriamiharisoa, 2002).

Water, it is said, may become as precious as oil during this century. Even though the total amount of water made available by the hydrologic cycle is enough to provide world's current population with adequate freshwater, most of this water is concentrated in specific regions leaving other areas water-deficit (Pimentel *et al.,* 1999). Because of the uneven distribution of water resources and population densities worldwide, water demands already exceeded supplies in nearly 80 countries with more than 40% population of the world (Bennett, 2000). The amount of liquid freshwater compared with the world's total water is just like a spoon of water. This is because of the fact that almost 97% of the world's water occur in the oceans. By 2025, the per capita available water resources in Asia are expected to decline by 15-54 percent compared with 1990 availability (Moya *et al.,* 2001) and more than one-third of the world population would face absolute water scarcity by the year 2025 (Seckler *et al.,* 1999; Rosegrant *et al.,* 2002). Agriculture's share of water will decline at an even faster rate because of the increasing competition for available water from urban and industrial sectors. Despite the constraints of water scarcity, rice production and productivity must rise in order to address the growing demand for rice driven largely by population growth and rapid economic development in Asia. Producing more rice with less water is therefore a formidable challenge for achieving food, economic, social, and water security for the region (Facon, 2000). In other words, the efficiency of water use in irrigated rice production systems must be significantly increased.

Water saving is the main issue in maintaining the sustainability of rice production when water resources are becoming scarce (Arif *et al.,* 2012). In Asia, with relatively more suitable growing conditions for rice production has declined due to increasing water stress (Aggarwal *et al.,* 2000; Tao *et al.,* 2004). One such water-saving technology that has been developed for rice cultivation in Asia is the alternate wetting and drying (AWD) irrigation approach (Bhuiyan, 1992; Bouman and Tuong, 2001; Belder *et al.,* 2004). AWD is an irrigation technique where water is applied to the field a number of days after disappearance of ponded water. This is in contrast to the traditional irrigation practice of continuous flooding (i.e., never letting the ponded water disappear). This means that the rice fields are not kept continuously submerged but are allowed to dry intermittently during the rice growing stage. The number of days where the field is allowed to be ‘‘non-flooded’’ before irrigation is applied can vary from 1 day to more than 10 days. The underlying premise behind this irrigation technique is that the roots of the rice plant are still adequately supplied with water for some period (due to the initial flooding) even if there is currently no observable ponded water in the field. In certain areas and under the right conditions, AWD is a promising method in irrigated rice cultivation and the benefits of AWD can be summarized as: increased water use efficiency (WUE), increased productivity (Li, 2001), reduced vulnerability to drought, decreased methane emission and increased food security. However, many factors play a role in determining the success or failure of AWD. Some of these factors can be influenced, such as irrigation infrastructure and irrigation management capacity, while others cannot be, such as rainfall and soil conditions (Rajendran *et al.,* 1995). The increased productivity of water is likely to be the critical factor that will make farmers and officials adopt AWD in water-scarce areas. AWD is one method that can increase the productivity of water at the field level by reducing seepage and percolation during the crop growing period. AWD is one method of managing the water so that water will not be wasted but it will aid the root growth, facilitate higher nutrient uptake and increase land and water productivity (Sarkar, 2001).

It is reported that chemical fertilizers today hold the key role to success of production systems of Bangladesh agriculture being responsible for about 50% of the total crop production. Unbalance fertilizer use and practice of inappropriate production technologies are common among farmers. Inadequate and improper applications of nitrogen (N) are now considered one of the major reasons for low yield of rice in Bangladesh. Nutrient imbalance can be minimized by judicious application of different fertilizers. There is need to develop appropriate management technique to evaluate the performance and to assess the nutrient requirement for rice cultivation in the country. Among the fertilizers, N is essential for vegetative growth but excess nitrogen may cause excessive vegetative growth, prolong the growth duration and delay crop maturity with reduction in grain yield.

Judicious use of N is a key factor in rice based production system which can increase crop yield and reduce production cost. Nitrogen is a constituent of compounds such as amino acids, proteins, RNA, DNA and several phytohormones is thereby an essential macro element for plants (Wang and

Schjoerring, 2012). Nitrogen management is essential for rice under aerobic culture as the N use efficiency is be in the range of 40 to 60 percent, application of N at right time is perhaps the simplest agronomic solution for improving the use efficiency of N (Ganga *et al.*, 2012). Nitrogen fertilization is the major agronomic practice that affects the yield and quality of rice crop, which requires as much as possible at early and mid tillering, stages to maximize panicle number and during reproductive stage to produce optimum spikelets per panicle and percentage filled spikelets (Sathiya and Ramesh, 2009). But excessive N application would lead to increased production cost and negative effects of blocking agricultural sustainable development such as environmental pollution and rice quality decline. N split application at three growth stages (transplanting, tillering and panicle emergence) should be followed to obtain higher paddy yield and greater economic benefits (Ehsanullah *et al.*, 2001). Rate and timing of N application are critical in terms of their effects on yield, N increase plant height, panicle number, leaf size, spikelet number and number of filled spikelets and ultimately the highest yield (Shakouri *et al*, 2012).

The utilization efficiency of applied N by the rice plant is very low. The submerged conditions of wetland soils produces N losses through NH_3-volatilization, denitrification, leaching, surface runoff, and chemical fixation which can be improve N use efficiency for rice production. Deep placement of N fertilizer into the anaerobic soil zone is a recognized effective method to reduce its volatilization loss from rice field. Urea in the form of USG Urea Super Granule (USG) has been proved to be superior to granular urea in all aspects. Instead of normal does of 247 kg granular urea, only 160 kg ha^{-1} of USG was required (35% less) even to increase 20% rice yield (Hoque *et al.,* 2013). Depending on agro-climate and nitrogen use, deep-placed USG can save urea fertilizer up to 65% with a 33% increase in grain yields, and up to 50% with 15 to 20% yield increase over the same amount of split-applied N as prilled urea (Zohra *et al.*, 2013). It is reported that USG placement at 8-10 cm depth in wet land rice field at the center of 4 consecutive hills of 2 adjacent rows can save

30% N compared to broadcasted prilled urea. Hand placement of USG of 1.8 g to 2.7 g sizes into flood soil resulted in less loss of N, higher N recovery, increase absorption rate, improve soil health and ultimately increase the rice yield than conventional N application method (Hoque *et al.*, 2013).

Weeds are often called plants out of place and they are unwanted, prolific, competitive, often harmful to the environment and they occur in the every rice field of the world. Weeds reduced the potential production of rice by interfering with agricultural operations. There is no doubt that maximum benefit from costly inputs like fertilizers and pesticides in rice can be fully derived when the crop is kept free from weed infestation. The average yield of rice in Bangladesh is very low due to several constrains. Among them, poor weed management is one of the major factors for yield reduction in rice, the extent of which depends on type of weed flora and their intensity of infestation. Yield losses due to weed infestation are greater than the combined losses of insect pests and diseases. In Bangladesh, weed infestation reduces the grain yield by 70-80% in *aus* rice (early summer), 30-40% for transplanted *aman* rice (autumn) and 22-36% for modern *boro* rice cultivars (winter rice) (Mamun, 1995; BRRI, 2008). Production cost of rice increases due to increase in weed control cost. The prevailing climatic and edaphic conditions are very much favorable for luxuriant growth of numerous species of weeds that strongly compete with rice plant. High competitive ability of weeds exerts a serious negative effect on crop production causing significant losses in crop yield. Any delay in weeding will lead to increased weed biomass as a result drastic reduction in yield.

Weed control is one of the most important and suggestive practices for potential rice production. Manual weeding is common in Asian countries, but its use is decreasing because of labor scarcity at the critical time of weeding and increasing labor costs (Chauhan and Opena, 2013). Mechanical weeding and herbicides are the alternative to hand weeding (Ahmed *et al.,* 2005). Chemical methods of weed control are therefore the most practical and cost-efficient

(Singh *et al.*, 2006, Bastiaans *et al.*, 2008). Several pre emergence (e.g. pendimethalin, oxadiazon, oxdiargyl, and pyrazosulfuron) and post emergence herbicides (e.g. bispyribac-sodium, azimsulfuron, penoxsulam, fenoxaprop, ethoxysulfuron, and 2,4-D) are now available in various Asian countries and have been reported to provide effective weed control (Chauhan, 2012). In Bangladesh, chemical weed control is becoming popular because of labor scarcity and also because it costs less than hand weeding (Hasanuzzaman *et al.*, 2008; Ahmed *et al.*, 2011). Results from different studies reveal that no single herbicide can control all weeds effectively. So, there is a necessity that these herbicides are supplemented with hand weeding for broad spectrum weed control with respect to all kind of weeds in rice. Moreover, the continuous use of a single herbicide over a long period of time may develop herbicide resistance in weeds and shifts in weed flora (Buhler *et al.*, 2000; Chauhan *et al.*, 2012).

Under this circumstance the present research work has been undertaken with the following objectives to:

- Evaluate the proper methods of nitrogen application in cultivation of BRRI dhan29;
- Find out the suitable methods of irrigation for cultivation of BRRI dhan29;
- Study the efficacy of traditional as well as chemical methods of weed management of BRRI dhan29; and
- Explore the interaction effect of irrigation, nitrogen and weed control methods on the growth and yield of BRRI dhan29.

CHAPTER II

REVIEW OF LITERATURE

Rice has remarkable adaptability to different environmental conditions as is evident from its worldwide distribution. Many researchers at home and abroad investigated various aspects of successful rice production. Water is one of the most important factors in rice production. Many investigators and researchers have reported that water requirement in rice field varies with crop species and the growth stages of crop. Initially, crop needs less amount of water and reaches its peak at the reproductive stages to fulfill the crop demand. When supply of water is less than the demand, the crop faces the water stress. If the crop is subjected to water stress, it affects the physical characters of rice plant, growth, yield and nutrient status of the soil. So, it is necessary to determine the tolerable limit of drying duration of rice field to obtain satisfactory yield. Nitrogen is one of the major essential plant nutrient elements, which greatly influence the vegetative growth and yield of rice. Weed is one of the limiting factors for successful rice production. The crop loss due to weed infestation is greater than the combined losses caused by insects, pests and diseases in rice. Some related research findings on the agronomic performances of rice varieties as affected by different management of irrigation, N fertilizer applied as prilled urea (PU) and USG and weed have been reviewed in this chapter.

2.1 Nitrogen management on rice

2.1.1 Role of nitrogen

Nitrogen (N) is an integral component of many essential plant compounds such as amino acids, which are the building blocks of all proteins including enzymes, nucleic acid and chlorophyll (Brady and Well, 2002, Mutters *et al.*, 2006). Being the essential constituent of protein is involved in all the major process of development (FAO, 2008) and good supply of N to the plant stimulates root growth and development as well as uptake of the other nutrients (Stevenson and

Cole, 1999; FAO, 2008). N is a regulator that governs to a considerable degree the utilization of K, P and other nutrient constituents in all plants (Brady, 1985).

Nitrogen is the most vital nutrient for rice growth. Rice absorbs large quantities of nitrogen to enhance growth, development, yields and grain quality. It promotes rapid growth (*i.e,* increased plant height and number of tillers). Yoshida (1981) reported a linear increase in tillering rate with an increasing N content up to 5%. It promotes increased leaf size, spikelet number panicle^{-1}, percentage of filled spikelet in each panicle and grain protein content (Dobermann and Fairhurst, 2000). Thus N affects all parameters contributing to yield (Dobermann and Fairhurst, 2000). Because N is present in so many essential compounds, it is not surprising that even slight deficiencies can result in reduced growth and productivity (Mutters *et al.*, 2006).

Nitrate and ammonium are the major sources of inorganic N taken up by the root of higher plants (Marschner, 1993). Depending on the plant species, development stage, and organ, the N content required for optimal growth varies between 2 and 5% of the plant dry weight (Marschner, 1993). The maximum up-take of N occurs during the period of most active growth. Rice needs N almost through the vegetative cycle, but in particular at tillering and panicle initiation stages (Wopereis *et al.*, 2009). N absorbed by rice during the vegetative growth stages contributes in growth during reproduction and grain-filling through translocation (Norman *et al.*, 1992; Bufogle *et al.*, 1997). N accumulates first in the leaves during vegetative phase, and then migrates to the panicles and grain. At maturity 75% of the N assimilated is present in the grains (Wopereis *et al.*, 2009). When sufficient N is applied to the crop, the demand for other macronutrients such as P and K is increased (Doberman and Fairhurst, 2000).

2.1.2 Effect of nitrogen levels/prilled urea on different crop characters of rice

2.1.2.1 Plant height

Rahman *et al.* (2016a) conducted an experiment to evaluate the effect of levels of USG and depth of placement on the growth of T. *aman* rice. USG levels showed non-significant effect on plant height. Rahman *et al.* (2016b) carried out a field experiment to assess the comparative advantages of using USG over normal urea and also predict the better performing transplanted *aus* rice in the tidal ecosystem. They reported that plant height was found highest when USG was applied with BRRI dhan48 and all the characters showed lowest value when absolute control with BRRI dhan55.

Haque and Pervin (2015) conducted an experiment to study the effect of varieties and number of guti urea hill^{-1} on the yield of T. *aman* rice. They found that, the tallest plant (136.4 cm) was recorded in 2 guti hill^{-1} of Shakorkura. Chamely *et al.* (2015) conducted an experiment to study the effect of variety and rate of N on the performance of *boro* rice. The tallest plant (84.01 cm) was obtained from 200 kg N ha^{-1}. The tallest plant (86.48 cm) was recorded from BRRI dhan28 with 200 kg N ha^{-1}. The results of the experiment also indicate that plant height was not significantly affected by levels of N.

Kumar *et al.* (2015) conducted a field experiment to evaluate the effect of four N levels *i.e.* 0, 50, 100 and 150% recommended dose of N on growth, yield and yield attributes of four rice cultivars. Plant height showed increasing trend from 50% upto 150% recommended dose of N ha^{-1}. Sikuku *et al.* (2015) revealed that N treatment showed significant effect on plant growth and the measured parameters increased significantly with increase in N level.

Azarpour *et al.* (2014) studied the effects of N fertilizer on yield and physiological traits of rice cultivars. Results of growth analysis indicated that, increasing rates of N caused the increment of growth indexes. Jalali-Moridani and Amiri (2014) revealed that N had significant effect on plant height of rice.

Jisan *et al.* (2014) carried out an experiment to examine the yield performance of some T. *aman* rice varieties as influenced by different levels of N. They found that the tallest plant (111.70 cm) was obtained from 75 kg N ha^{-1} and the lowest values were obtained from control. Malik *et al.* (2014) conducted a field trail to evaluate the effect of different levels of N on growth of different varieties of basmati rice. They found that, 120 kg N ha^{-1} was significantly different in plant height of rice.

Singh *et al.* (2014) conducted a field experiment to study the effect of different N levels on the growth of direct-seeded hybrid rice. Different N levels showed significant difference in plant height. Tayefe *et al.* (2014) showed that plant height (127.9 cm) reached the highest value at high N level (90 kg ha^{-1}).

Debnath *et al.* (2013) found that plant height was found highest when NPK briquette was applied and all the characters showed lowest value when control. Islam *et al.* (2013) conducted a field experiment to find out the varietal performance of *aman* rice as affected by different methods of urea application. The results showed that urea fertilizer application method significantly influenced the plant height.

Pramanik and Bera (2013) conducted a field experiment to investigate the optimization of N levels under different age of seedlings transplanted on growth of hybrid rice. 200 kg N ha^{-1} gave significant higher plant height. Zayed *et al.* (2013) carried out two field experiments to investigate the impact of eco-friendly organic fertilizers and bio-fertilizers on the reduction of chemical fertilizer use for minimizing environmental hazards associated with standard soil management practices in rice production under saline soil conditions. In the first year of the study, they observed that, application of 165 kg N ha^{-1} gave the highest growth parameter values.

Akanda *et al.* (2012) conducted a pot experiment to study the effect of nitrogen (0, 25, 50 and 75 kg N ha^{-1}) and potassium and their interaction on morpho-physiological characteristics of fine grain aromatic rice cv. RM 100-16. The results revealed that plant height increased till 75 kg N ha^{-1}. Haque *et al.* (2012) investigate the response of different doses of nitrogen application at different growth stages on fine *aman* rice (cv. Kalizira). The results revealed that different doses of nitrogen had significant positive effect on the most of the vegetative parameters. Plant height was highest with the increasing rate of nitrogen at all sampling dates excluding final harvest.

Islam *et al.* (2012) conducted an experiment with five nitrogen levels such as 0, 20, 40, 60, 80 kg N ha^{-1}. Results revealed that highest plant height (97.66 cm) was obtained from 80 kg N ha^{-1} compared to other nitrogen levels. Nesgea *et al.* (2012) carried out a field experiment to establish the application rates of N (0, 46, 92 and 138 kg N ha^{-1}) and P fertilizers for rice variety NERICA-3 (*Oryza sativa* x *Oryza glaberrima*). The effects of year by N interaction were significant for plant height.

Sultana *et al.* (2012) carried out an experiment with five level and sources of nitrogen (PU@ 160 kg ha^{-1}, PU @ 80 kg ha^{-1}, USG @ 60 kg ha^{-1}, USG @ 90 kg ha^{-1} ang USG @ 120 kg ha^{-1}) and three rice varieties *viz.*, BR11, BRRI dhan51 and BRRI dhan52. Results showed that highest plant height (99.72 cm) was obtained from USG @ 120 kg ha^{-1} and lowest one (97.51 cm) was obtained from PU @ 80 kg ha^{-1}.

Youseftabar *et al.* (2012a) investigated the effect of split application of nitrogen fertilizer on growth and yield of hybrid rice (GRH1). The results showed that plant height increased significantly with nitrogen fertilizer. Effect of different split application N-fertilizer was significantly on this parameter, increase split application decrease in growth parameter. Study interaction effect of treatment‘s revealed that all the parameter’s increased significantly with an application of 300 kg/ha N-fertilizer at different stage.

Awan *et al.* (2011) carried out an experiment to study the effect of different N levels on growth and yield of rice. They reported that, 156 kg N ha^{-1} gave the maximum values of plant height (79.07 cm). Mannan *et al.* (2010) recorded that the plant height increased with the increase of N levels up to 75 kg N ha^{-1}. Kandil *et al.* (2010) conducted an experiment in order to study the effect of five N levels (0, 48, 96, 144 and 192 kg ha^{-1}) on productivity and quality of rice cv. "Giza 177". The addition of 144 or 192 kg N ha^{-1} recorded the tallest plants without significant differences.

Mizan (2010) reported that the highest plant height (83.32 cm) was obtained from 160 kg N ha^{-1} followed by 120 kg N ha^{-1}. Razib (2010) observed that the highest plant height (100.23 cm) was recorded when 120 kg N ha^{-1} was applied.

Rekabder (2009) found that plant height increased significantly with the increase level of USG/4 hills. Salahuddin and Parvin (2009) reported that plant height increased with the increasing rate of N up to 200 kg ha^{-1} and it was found significantly higher from the other levels of N. Sathiya and Ramesh (2009) carried out a field experiment to study the effect of different split doses of nitrogen management on growth and yield of aerobic rice. The results showed that nitrogen management at LCC value of 4 (150 kg N ha^{-1}) produced significantly higher plant height (81.7 cm) at maturity than LCC value of 3. Among the different split doses of N, application of 150 kg N ha^{-1} in four splits-1/3 at tillering showed plant height (77.0 cm) over four equal splits.

Hosseiny and Maftoun (2008) conducted an experiment to study the effects of varying sources and levels of N rate on the growth of rice. They reported that, application of N up to 200 mg kg^{-1} increased rice growth significantly. Islam *et al.* (2008) showed that the application of N fertilizer significantly influenced the plant height.

Das (2007) reported that the tallest plant (91.86 cm) was found with 120 kg ha^{-1} of N. Hossain *et al.* (2007a) reported that the tallest plant height was observed with the application of 69 kg N ha^{-1}, which was significantly followed by 51.75, 34.5 and 17.25 kg N ha^{-1}, respectively and the lowest was observed in control treatment (0 kg N ha^{-1}). Pasha *et al.* (2011) concluded that in general, plant height recorded at different growth stages increased with increase in N level from 0 to 150 kg N ha^{-1}.

Manzoor *et al.* (2006) reported that plant height showed increasing trend from 0 kg N ha^{-1} up to 175 kg N ha^{-1}. The plant height (139.8 cm) was highest at 225 kg N ha^{-1} level. Rahman (2006) found that effect of depth of placement of USG showed non-significant effect on plant height.

2.1.2.2 Leaf area index

Islam *et al.* (2013) conducted a field experiment to find out the varietal performance of *aman* rice as affected by different methods of urea application. The results showed that urea fertilizer application method significantly influenced leaf area index. The experiment conducted with three USG levels and showed that leaf area index was significantly influenced by application of USG. He reported that the highest leaf area was found at 60 DAT when 1.8 g USG was applied and lowest was found at 15 DAT when 2.7 g USG was applied.

Abou-Khalifa (2012) conducted two field experiments to study the evaluation of some rice varieties under different N levels. Main results induced that leaf area index showed the highest value at 220 kg N ha^{-1}. Abou-Khalifa (2012) conducted two field experiments to study the evaluation of some rice varieties under different N levels. Main results induced that leaf area index was the highest value at 220 kg N ha^{-1}.

Akanda *et al.* (2012) conducted a pot experiment to study the effect of nitrogen (0, 25, 50 and 75 kg N ha^{-1}) and potassium and their interaction on morpho-physiological characteristics of fine grain aromatic rice cv. RM 100-16. The results revealed that leaf area increased till 75 kg N ha^{-1}. Nesgea *et al.* (2012) carried out a field experiment to establish the application rates of N (0, 46, 92 and 138 kg N ha^{-1}) and P fertilizers for rice variety NERICA-3 (*Oryza sativa* x *Oryza glaberrima*). The effects of year by N interaction were significant for LAI.

Salem *et al.* (2011) conducted two field experiments to study the effect of N fertilizer (0, 55, 110 and 165 kg N ha^{-1}) on Giza 178, H1 and Sakha 101. The results indicated that LAI was increased by increasing N levels up to 165 kg N ha^{-1}.

Tari *et al.* (2009) showed that N fertilization levels had significant effect on leaf area. According to this research use of 138 kg N ha^{-1} for the best performance of agronomical attributes were recommended. Hosseiny and Maftoun (2008) conducted an experiment to study the effects of varying sources and levels of N rate on the growth of rice. N addition generally increased leaf area.

Sarkar *et al.* (2004) found that the leaf area duration increased with the increasing levels of N upto 80 kg N ha^{-1} in combination with green manuring crops. Nneke and Ndon (2003) conducted a field experiment to determine the optimum N fertilizer rate (0, 50, 100, 150 and 200 kg ha^{-1}) for the area as well as select the rice varieties that responded optimally. The results showed that 150 kg ha^{-1} produced the broadest leaf area in both years. Prasad *et al.* (2003) reported that the effect of N on the growth of early rice and observed that the level of N had significant effect on the leaf area index.

2.1.2.3 Dry matter content

Chamely *et al.* (2015) conducted an experiment to study the effect of variety and rate of N on the performance of *boro* rice. The highest dry matter (69.58 g m^{-2}) was obtained from 200 kg N ha^{-1}. The maximum dry matter (72.30 g m^{-2}) was recorded from BRRI dhan45 with 200 kg N ha^{-1}. Khatun *et al.* (2015) aimed to optimize N fertilization and it’s response to the growth and yield of lowland rice. Positive response of N fertilization was observed in dry matter production from the early growing stage.

Kumar *et al.* (2015) conducted a field experiment to evaluate the effect of four N levels *i.e.* 0, 50, 100 and 150% recommended dose of N on growth, yield and yield attributes of four rice cultivars. Dry weight showed increasing trend from 50% upto 150% recommended dose of N ha^{-1}. Mollah *et al.* (2015) conducted a field experiment to study the response of *boro* rice (BRRI dhan29) to the different doses of fertilizers in Bangladesh. The result indicated significant variations in dry matter content due to fertilizer management. Among the treatment on maximum dry matter content recorded of plant in balanced fertilizer lower dose irrespective of growing period. Moro *et al.* (2015) conducted a study to determine the optimum N rate required for lowland rice production. Results showed that total dry matter production increased significantly with increasing levels of N. Total biomass yield increased significantly and linearly with increasing levels of N.

Malik *et al.* (2014) conducted a field trail to evaluate the effect of different levels of N on growth and yield attributes of different varieties of basmati rice. They found that, 120 kg N ha^{-1} was significantly different in dry weight of rice. Rao *et al.* (2014) conducted a field experiment to find out suitable variety with optimum N level. Dry matter production was progressively augmented by incremental levels of N. Tayefe *et al.* (2014) showed that total biomass (8386 kg ha^{-1}) reached the highest value at high N level (90 kg ha^{-1}).

Zhu *et al.* (2013) indicated that N-application rates significantly improved the dry matter accumulation, with N application of 270 kg ha^{-1} showing the maximum dry matter accumulation at the four N application levels. Haque *et al.* (2012) investigate the response of different doses of nitrogen application at different growth stages on fine *aman* rice (cv. Kalizira). The results revealed that different doses of nitrogen had significant positive effect on the most of the vegetative parameters. Dry matter $hill^{-1}$ was highest with the increasing rate of nitrogen at all sampling dates excluding final harvest.

Sathiya and Ramesh (2009) carried out a field experiment to study the effect of different split doses of nitrogen management on growth and yield of aerobic rice. The results showed that nitrogen management at LCC value of 4 (150 kg N ha^{-1}) produced significantly dry matter at flowering (5.71 t ha^{-1}) than LCC value of 3. Among the different split doses of N, application of 150 kg N ha^{-1} in four splits-1/3 at PI recorded dry matter at flowering (5.20 t ha^{-1}) over four equal splits.

Prudente *et al.* (2008) conducted a field experiment to determine the effect of different levels of N on dry matter yield of *japonica* (*Hatsuboshi*) and *indica* (IR-13) rice varieties. Results showed an increasing trend in the dry matter production with increased amount of applied N fertilizer.

Pasha and Reddy (2011) concluded that dry matter production recorded at different growth stages increased with increase in N level from 0 to 150 kg N ha^{-1}.

2.1.2.4 Crop Growth Rate

Sathiya *et al.* (2008) reported that the application of 175 kg N ha^{-1} resulted in higher growth attributes as compared to 100 and 125 kg N ha^{-1}. Crop growth rate (CGR) was also increased with the increasing N level. Prasad *et al.* (2003) reported that the effect of N on the growth and yield of early rice and observed that the CGR was increased with the increased with increasing levels of N. Lawal and Lawal (2002) from Nigeria reported that application of fertilizer up to 80 kg N ha^{-1} significantly increased CGR of rice.

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

Imrul *et al.* (2016) carried out a field experiment to investigate the influence of N on the growth and yield of BRRI dhan57. They reported that 120 kg N ha^{-1} treatment gave the highest effective tillers $hill^{-1}$. Rahman *et al.* (2016b) carried out a field experiment to assess the comparative advantages of using USG over normal urea and also predict the better performing transplanted Aus rice in the tidal ecosystem. The highest number of effective tillers $hill^{-1}$ (11.15) was obtained from USG and BRRI dhan48 and where lowest number of effective tillers hill^{-1} (9.21) in absolute control with BRRI dhan55.

Chamely *et al.* (2015) conducted an experiment to study the effect of variety and rate of N on the performance of *boro* rice. The results of the experiment also indicate that effective tillers hill^{-1} was significantly affected by levels of N. Haque and Pervin (2015) conducted an experiment to study the effect of varieties and number of guti urea hill^{-1} on the yield of T. *aman* rice. They found that, 2 guti hill^{-1} interaction with BRRI dhan51 showed the maximum effective tillers hill^{-1} (8.767).

Khatun *et al.* (2015) aimed to optimize N fertilization and it's response to the growth and yield of lowland rice. Positive response of N fertilization was observed in tiller production from the early growing stage. Tillering increased progressively with the advancement of growth stage and reached at the peak within 60 days after transplanting (DAT) in all cases. Kumar *et al.* (2015) conducted a field experiment to evaluate the effect of four N levels *i.e.* 0, 50, 100 and 150% recommended dose of N on growth, yield and yield attributes of four rice cultivars. Number of tillers hill^{-1} showed increasing trend from 50% upto 150% recommended dose of N ha^{-1}. Number of productive tillers increased upto 150% recommended dose of N ha^{-1}.

Mollah *et al.* (2015) conducted a field experiment to study the response of *boro* rice (BRRI dhan29) to the different doses of fertilizers in Bangladesh. The result indicated significant variations in number of effective tillers hill^{-1} due to fertilizer management. Among the treatment on maximum number of effective tillers hill^{-1} recorded of plant in balanced fertilizer lower dose irrespective of growing period. Moro *et al.* (2015) conducted a study to determine the optimum N rate required for lowland rice production. Results showed that total number of tillers m^{-2} increased significantly with increasing levels of N.

Jalali-Moridani and Amiri (2014) revealed that N had significant effect on the number of tillers. They also showed that 90 kg N ha^{-1} possessed the highest number of tillers m^{-2} (526.7). Jisan *et al.* (2014) carried out an experiment to examine the yield performance of some T. *aman* rice varieties as influenced by different levels of N. They found that the highest number of total tillers $hill^{-1}$ (12.34) was obtained from 75 kg N ha^{-1} and the lowest values were obtained from control.

Malik *et al.* (2014) conducted a field trail to evaluate the effect of different levels of N on growth and yield attributes of different varieties of basmati rice. They found that, 120 kg N ha^{-1} was significantly different in number of tillers $hill^{-1}$ of rice. Rao *et al.* (2014) conducted a field experiment to find out suitable variety with optimum N level. Tiller production was progressively augmented by incremental levels of N.

Singh *et al.* (2014) conducted a field experiment to study the effect of different N levels on the growth of direct-seeded hybrid rice. Different N levels showed significant difference in effective tillers m^{-2}. Tayefe *et al.* (2014) showed that tillers m^{-2} (250.22) reached the highest value at high N level (90 kg ha^{-1}).

Debnath *et al.* (2013) found that the highest number of effective tillers $hill^{-1}$ (13.00) was obtained from NPK briquette and lowest (5.66) from control. Hasanuzzaman *et al.* (2013) carried out a field experiment was to study the influence of PU and USG on the yield attributes of hybrid rice Heera1. The highest number of effective tillers $hill^{-1}$ (13.63) was obtained from the application of USG showing 10% better result than PU.

Kisetu *et al.* (2013) conducted a screen-house pot experiment using NERICA-4 cultivar of rice and urea-N fertilizer application on soil of one of the Dakawa rice growing fields. Number of tillers increased significantly with N levels from 11 and 3. Pramanik and Bera (2013) conducted a field experiment to investigate the optimization of N levels under different age of seedlings transplanted on growth, yield of hybrid rice. 150 kg N ha^{-1} gave significant higher number of effective tillers hill^{-1} as compared to other N treatments.

Tasnin *et al.* (2013) conducted an experiment to study the yield performance of transplant *aman* rice cv. BRRI dhan51 under integrated N management. Levels of nitrogenous fertilizers exerted significant influence on yield contributing characters of transplant *aman* rice cv. BRRI dhan51. Application of USG @ 125 kg ha^{-1} produced the highest number of effective tillers hill^{-1} (12.50). Zhu *et al.* (2013) indicated that N application rates significantly affected number of tillers, productive tiller ratio.

Abou-Khalifa (2012) conducted two field experiments to study the evaluation of some rice varieties under different N levels. Main results induced that number of tillers m^{-2} was the highest value at 220 kg N ha^{-1}. Abou-Khalifa (2012) induced that number of tillers m^{-2} was the highest value at 220 kg N ha^{-1}.

Akanda *et al.* (2012) conducted a pot experiment to study the effect of nitrogen (0, 25, 50 and 75 kg N ha^{-1}) and potassium and their interaction on morpho-physiological characteristics of fine grain aromatic rice cv. RM 100-16. The results revealed that number of effective tillers hill^{-1} increased with increasing N levels till 50 kg N ha^{-1}. Ehsanullah *et al.* (2012) investigated that application of N at 75 kg ha^{-1} revealed the poorest results with respect to panicle bearing tillers hill^{-1}.

Haque *et al.* (2012) investigate the response of different doses of nitrogen application at different growth stages on fine *aman* rice (cv. Kalizira). The results revealed that different doses of nitrogen had significant positive effect on the most of the vegetative parameters. Tiller number hill^{-1} was highest with the increasing rate of nitrogen at all sampling dates excluding final harvest.

Hasanuzzaman *et al.* (2012) carried out an experiment to study the response of hybrid rice to different levels of N. Results indicated that, N showed significant variation in respect of yield contributing characters. The highest effective tillers $hill^{-1}$ (13.63) was obtained from the application of USG.

Miah *et al.* (2012) carried out a field experiment to study the effects of two slow releases nitrogenous fertilizer named PU and USG on yield attributes of BRRI dhan28. Results revealed that application of different forms and doses of urea had significant effect on total tillers of BRRI dhan28. Youseftabar *et al.* (2012b) showed that number of effective tillers increased significantly with N fertilizer. Interesting in comparison to 50 and 100 kg ha^{-1} level application of higher N-fertilizer 150 kg ha^{-1} showed a positive respond to application of high N.

Awan *et al.* (2011) carried out an experiment to study the effect of different N levels on growth and yield of rice. They reported that, 156 kg N ha^{-1} gave the maximum values of tillers (594 m^{-2}). Das (2011) observed that the highest number of total tillers $hill^{-1}$ (13.14) was produced in treatment 1.8 g USG 4 $hill^{-1}$ and the lowest (8.57) was produced in no application of nitrogenous fertilizer.

Salem *et al.* (2011) conducted two field experiments to study the effect of N fertilizer (0, 55, 110 and 165 kg N ha^{-1}) on Giza 178, H1 and Sakha 101. The results indicated that number of tillers $hill^{-1}$ was increased by increasing N levels up to 165 kg N ha^{-1}. Mannan *et al.* (2010) recorded that the tiller number increased with the increase of N levels up to 75 kg N ha^{-1}.

Alam (2009) observed that effective tillers $hill^{-1}$ increased significant with the increase of level of USG, when USG was applied as one, two, three and four granules per 4 hills during the Boro season. Ramesh *et al.* (2009) reported that application of 150 kg N ha^{-1} registered significantly higher number of tillers than 100 kg N ha^{-1}.

Sathiya and Ramesh (2009) carried out a field experiment to study the effect of different split doses of nitrogen management on growth and yield of aerobic rice. The results showed that nitrogen management at LCC value of 4 (150 kg N ha^{-1}) produced significantly higher tillers (369.3 m^{-2}) at maximum tillering stage.

Among the different split doses of N, application of 150 kg N ha^{-1} in four splits-1/6 at 15 DAS, 1/6 at flowering recorded higher tillers (361 m^{-2}) over four equal splits. Thus, N application with LCC value of 4 or application of 150 kg N ha^{-1} in four splits-1/6 at 15 DAS, 1/3 at tillering, 1/3 at PI, 1/6 at flowering is considered a suitable N management technique in aerobic rice cultivation.

Ahammed (2008) found that the highest effective tillers were observed in 120 kg N ha^{-1} followed by 80 kg N ha^{-1}. Islam *et al.* (2008) reported that the application of N fertilizer significantly influenced the number of effective tillers. Prudente *et al.* (2008) showed an increasing trend in the tiller number with increased amount of applied N fertilizer.

Hossain *et al.* (2007a) reported that the highest number of tillers $hill^{-1}$ were observed with the application of 69 kg N ha^{-1}, which was significantly followed by 51.75, 34.5 and 17.25 kg N ha^{-1}, respectively and the lowest was observed in control treatment (0 kg N ha^{-1}). Pasha *et al.* (2011) concluded that tiller production recorded at different growth stages increased with increase in N level from 0 to 150 kg N ha^{-1}. Rahman *et al.* (2007) conducted an experiment to study the effect of different level of N on yield attributes of T. *aman* rice. They found that the highest number of effective tillers $hill^{-1}$ (9.20) was obtained with 80 kg N ha^{-1}.

Alam (2006) studied the effect of different N levels and found that increasing rate of N from 0 to 120 kg ha^{-1} also increased the effective tillers $hill^{-1}$ and N application of 150 kg ha^{-1} decreased effective tillers $hill^{-1}$ was produced in 140 kg N ha^{-1}, which was statistically identical with 80, 100 and 120 kg N ha^{-1}. Manzoor *et al.* (2006) found that number of productive tillers $hill^{-1}$ showed increasing trend from 0 kg N ha^{-1} up to 175 kg N ha^{-1}. The number of productive tillers $hill^{-1}$ (23.42) was highest at 225 kg N ha^{-1} level.

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

Debnath *et al.* (2013) found that the maximum number of non-effective tillers hill^{-1} was found when NPK briquette was applied and all the characters showed lowest value when control.

2.1.2.7 Number of filled grains panicle^{-1}

Imrul *et al.* (2016) carried out a field experiment to investigate the influence of N on the growth and yield of BRRI dhan57. They reported that 120 kg N ha^{-1} treatment gave the highest filled grains panicle^{-1}. Rahman *et al.* (2016a) conducted an experiment to evaluate the effect of levels of USG and depth of placement on the growth of T. *aman* rice. USG levels showed non-significant effect on total grains panicle^{-1}.

Haque and Pervin (2015) conducted an experiment to study the effect of varieties and number of guti urea hill^{-1} on the yield of T. *aman* rice. They found that, 2 guti hill^{-1} interaction with BRRI dhan51 showed the maximum total grains panicle^{-1} (147.4). Chamely *et al.* (2015) conducted an experiment to study the effect of variety and rate of N on the performance of *boro* rice. The results of the experiment also indicate that grains panicle^{-1} was significantly affected by levels of N.

Kumar *et al.* (2015) conducted a field experiment to evaluate the effect of four N levels *i.e.* 0, 50, 100 and 150% recommended dose of N on growth, yield and yield attributes of four rice cultivars. Number of filled grain hill^{-1} increased upto 150% recommended dose of N ha^{-1}. Mollah *et al.* (2015) conducted a field experiment to study the response of *boro* rice (BRRI dhan29) to the different doses of fertilizers in Bangladesh. The result indicated significant variations in number of filled grains panicle^{-1} due to fertilizer management.

Singh *et al.* (2015) conducted a field experiment to study N management in direct seeded aerobic rice. They showed that number of grains panicle^{-1} was higher in 150 kg N ha^{-1}.

Jalali-Moridani and Amiri (2014) revealed that N had significant effect on number of filled grains panicle^{-1}. Jisan *et al.* (2014) carried out an experiment to examine the yield performance of some T. *aman* rice varieties as influenced by different levels of N. They reported that the highest number of grains panicle^{-1} (133.6) was obtained from 75 kg N ha^{-1} and the lowest values were found from control.

Malik *et al.* (2014) conducted a field trail to evaluate the effect of different levels of N on growth and yield attributes of different varieties of basmati rice. They found that, 120 kg N ha^{-1} was significantly different in number of filled grains panicle^{-1} of rice. Sharma *et al.* (2014) conducted an experiment to find out the effect of N levels on yield components of Basmati rice cultivars. Results revealed that the differences in filled grains panicle^{-1} between 120 kg N ha^{-1} and 160 kg N ha^{-1} were statistically similar.

Singh *et al.* (2014) conducted a field experiment to study the effect of different N levels on the growth of direct-seeded hybrid rice. Different N levels showed significant difference in grains panicle^{-1}. Tayefe *et al.* (2014) showed that total grains panicle^{-1} (103.8) reached the highest value at high N level (90 kg ha^{-1}).

Yesuf and Balcha (2014) conducted an experiment to determine grain yield and yield components and N efficiency responses of rice to five N rates (0, 3.5, 7, 10.5, 14 g m^{-2}) using commonly grown rice variety, Nerica-4. Filled grains panicle^{-1} increased from 302-469 g m^{-2}, total biomass 786-1268 g m^{-2}, tillers 477-661m^{-2} and 80-100 when N rate increased from 0-14 g m^{-2}. Maximum values for filled grains panicle^{-1} (110) was obtained at 7 and 10.5 g m^{-2} N rate, respectively.

Hasanuzzaman *et al.* (2013) carried out a field experiment was to study the influence of PU and USG on the yield attributes of hybrid rice Heera1. The highest number of filled grains panicle^{-1} (154.67) was obtained from the application of USG showing 10% more better result than PU. Islam *et al.* (2013)

conducted a field experiment to find out the varietal performance of *aman* rice as affected by different methods of urea application. The results showed that urea fertilizer application method significantly influenced the number of filled grains panicle^{-1}.

Pramanik and Bera (2013) conducted a field experiment to investigate the optimization of N levels under different age of seedlings transplanted on yield attributes of hybrid rice. 150 kg N ha^{-1} gave significant higher filled grain panicle^{-1} as compared to other N treatments. Tasnin *et al.* (2013) conducted an experiment to study the yield performance of transplant *aman* rice cv. BRRI dhan51 under integrated N management. Levels of nitrogenous fertilizers exerted significant influence on yield contributing characters of transplant *aman* rice cv. BRRI dhan51. Application of USG @ 125 kg ha^{-1} produced the highest number of grains panicle^{-1} (145.66).

Yoseftabar (2013b) showed that total grain increased significantly with 300 kg N ha^{-1} fertilizer. Interaction effect of treatments revealed that the total grain increased significantly with an application of 300 kg N ha^{-1} at four stages. Zhu *et al.* (2013) indicated that N application rates significantly affected grain number panicle^{-1} and filled grain number.

Abou-Khalifa (2012) conducted two field experiments to study the evaluation of some rice varieties under different N levels. Results induced that number of grains panicle^{-1} the highest value at 220 kg N ha^{-1}. Akanda *et al.* (2012) conducted a pot experiment to study the effect of nitrogen (0, 25, 50 and 75 kg N ha^{-1}) and potassium and their interaction on morpho-physiological characteristics of fine grain aromatic rice cv. RM 100-16. The results revealed that number of filled grains panicle^{-1} (170.6) increased with increasing N levels till 50 kg N ha^{-1}.

Ehsanullah *et al.* (2012) investigated that the grains panicle^{-1} remained unaffected at varying levels of N. Hasanuzzaman *et al.* (2012) carried out an experiment to study the response of hybrid rice to different levels of N. Results indicated that, N showed significant variation in respect of yield contributing characters and yield. The highest filled grains panicle^{-1} (154.67) was obtained from the application of USG. Nesgea *et al.* (2012) carried out a field experiment to establish the application rates of N (0, 46, 92 and 138 kg N ha^{-1}) and P fertilizers for rice variety NERICA-3 (*Oryza sativa* x *Oryza glaberrima*). The effects of year by N interaction were significant for grains panicle^{-1}.

Youseftabar *et al.* (2012a) investigated the effect of split application of nitrogen fertilizer on growth and yield of hybrid rice (GRH1). The results showed that filled grain increased significantly with nitrogen fertilizer. Number of filled grain yield increased with increasing split application. Interaction effect of treatment‘s revealed that all the parameter’s increased significantly with an application of 300 kg/ha N-fertilizer at different stage. Youseftabar *et al.* (2012b) showed that number of filled grains increased significantly with N fertilizer. Interesting in comparison to 50 and 100 kg ha^{-1} level application of higher N-fertilizer 150 kg ha^{-1} showed a positive respond to application of high N.

Awan *et al.* (2011) carried out an experiment to study the effect of different N levels on growth and yield of rice. They reported that, 156 kg N ha^{-1} gave the maximum values of number of grains panicle^{-1} (132.97). Xia *et al.* (2011) conducted a field experiment on super rice variety Xinliangyou 6 with four treatments of different rates of N fertilizer *viz.*, no N fertilizer, 189 kg ha^{-1}, 270 kg ha^{-1}, 351 kg ha^{-1}. The highest number of filled grains was recorded with application of 270 kg N ha^{-1}.

Kandil *et al.* (2010) conducted an experiment in order to study the effect of five N levels (0, 48, 96, 144 and 192 kg ha^{-1}) on productivity and quality of rice cv. "Giza 177". Increasing N fertilizer levels up to 80 kg N ha^{-1} resulted in marked increases in number of number of filled grains panicle^{-1}.

Ramesh *et al.* (2009) revealed that application of 150 kg N ha^{-1} registered significantly higher number of filled grains panicle^{-1} than 100 kg N ha^{-1}. Salahuddin *et al.* (2009) showed that a gradual increase in grains panicle^{-1} (110) was observed with the increase in N levels up to 150 kg ha^{-1} and declined thereafter.

Islam *et al.* (2008) showed that the application of N fertilizer significantly influenced the grains panicle^{-1}. Rahman *et al.* (2007) conducted an experiment to study the effect of different level of N on growth and yield of T. *aman* rice. They found that N level significantly influenced the yield components. The highest number of maximum grains panicle^{-1} (100.80) was obtained with 80 kg N ha^{-1}.

BRRI (2006) found that increasing level of N increased the number of grains panicle^{-1} of rice and the highest number of grains panicle^{-1} (82.2) was obtained with 120 kg ha^{-1} compared to 90 and 0 kg ha^{-1}, respectively. Manzoor *et al.* (2006) reported that number of grains panicle^{-1} showed increasing trend from 0 kg N ha^{-1} up to 175 kg N ha^{-1}. The number of grains panicle^{-1} started declining at 200 kg N ha^{-1} level and above.

Ahmed *et al.* (2005) carried out an experiment to seek the effect of N on different characteristics of transplanted local *aman* rice variety, Jatai. Results of this study revealed that the highest effective tiller hill^{-1} was obtained with 40 kg N ha^{-1}.

2.1.2.8 Number of unfilled grains panicle^{-1}

Mollah *et al.* (2015) conducted a field experiment to study the response of *boro* rice (BRRI dhan29) to the different doses of fertilizers in Bangladesh. The result indicated significant variations in number of unfilled grains panicle^{-1} due to fertilizer management.

Islam *et al.* (2013) conducted a field experiment to find out the varietal performance of *aman* rice as affected by different methods of urea application.

The results showed that urea fertilizer application method significantly influenced the unfilled grains panicle^{-1}.

2.1.2.9 Panicle length

Imrul *et al.* (2016) carried out a field experiment to investigate the influence of N on the growth and yield of BRRI dhan57. They reported that 120 kg N ha^{-1} treatment gave the highest length of panicle. Rahman *et al.* (2016b) carried out a field experiment to assess the comparative advantages of using USG over normal urea and also predict the better performing transplanted Aus rice in the tidal ecosystem. They reported that panicle length was found highest when USG was applied with BRRI dhan48 and all the characters showed lowest value when absolute control with BRRI dhan55.

Chamely *et al.* (2015) conducted an experiment to study the effect of variety and rate of N on the performance of *boro* rice. The results of the experiment also indicate that panicle length was not significantly affected by levels of N.

Malik *et al.* (2014) conducted a field trail to evaluate the effect of different levels of N on growth and yield attributes of different varieties of basmati rice. They found that, 120 kg N ha^{-1} was significantly different in length of panicle of rice. Singh *et al.* (2014) conducted a field experiment to study the effect of different N levels on the growth, yield and quality of direct-seeded hybrid rice. Different N levels showed significant difference in panicle length.

Debnath *et al.* (2013) found that panicle length was found highest when NPK briquette was applied and all the characters showed lowest value when control. Jafari *et al.* (2013b) showed that with application of N fertilizer panicle length had increased 7.41%. Pramanik and Bera (2013) conducted a field experiment to investigate the optimization of N levels under different age of seedlings transplanted on yield contributing characters of hybrid rice. 200 kg N ha^{-1} gave significant higher panicle length.

Tasnin *et al.* (2013) conducted an experiment to study the yield performance of transplant *aman* rice cv. BRRI dhan51 under integrated N management. Levels of nitrogenous fertilizers exerted significant influence on yield contributing characters of transplant *aman* rice cv. BRRI dhan51. Application of USG @ 125 kg ha^{-1} produced the longest panicle (23.60 cm). Uddin *et al.* (2013) conducted an experiment to study the influence of N and plant spacing on yield of *boro* rice. Results revealed that panicle length was not responsive to higher rate of N application.

Yoseftabar (2013b) showed that panicle length increased significantly with 300 kg N ha^{-1} fertilizer. Interaction effect of treatments revealed that the panicle length at harvesting stage increased significantly with an application of 300 kg N ha^{-1} at four stages. Abou-Khalifa (2012) reported that panicle length was the highest value at 220 kg N ha^{-1}.

Ehsanullah *et al.* (2012) investigated that the panicle length remained unaffected at varying levels of N. Nesgea *et al.* (2012) carried out a field experiment to establish the application rates of N (0, 46, 92 and 138 kg N ha^{-1}) and P fertilizers for rice variety NERICA-3 (*Oryza sativa* x *Oryza glaberrima*). The effects of year by N interaction were significant for panicle length.

Awan *et al.* (2011) carried out an experiment to study the effect of different N levels on growth and yield of rice. They reported that, 156 kg N ha^{-1} gave the maximum values of panicle length (25.40 cm). Salem *et al.* (2011) conducted two field experiments to study the effect of N fertilizer (0, 55, 110 and 165 kg N ha^{-1}) on Giza 178, H1 and Sakha 101. The results indicated that panicle length was increased by increasing N levels up to 165 kg N ha^{-1}. Mannan *et al.* (2010) recorded that the panicle length increased with the increase of N levels up to 75 kg N ha^{-1}.

Salahuddin *et al.* (2009) showed that a gradual increase in panicle length (24.50 cm) was observed with the increase in N levels up to 150 kg ha^{-1} and declined thereafter. Tari *et al.* (2009) showed that N fertilization levels had significant effect on panicle length. According to this research use of 138 kg N ha^{-1} for the best performance of agronomical attributes were recommended.

Islam *et al.* (2008) found that the application of N fertilizer significantly influenced the panicle length. Hossain *et al.* (2007b) reported that the N levels also exerted non-significant effect on panicle length. Tari *et al.* (2007) observed that the N rates had significant effect on panicle length. Manzoor *et al.* (2006) said that panicle length showed increasing trend from 0 kg N ha^{-1} up to 175 kg N ha^{-1}. Panicle length (29.75 cm) was highest at 225 kg N ha^{-1} level.

2.1.2.10 1000-grain weight

Imrul *et al.* (2016) carried out a field experiment to investigate the influence of N on the growth and yield of BRRI dhan57. They reported that 120 kg N ha^{-1} treatment gave the highest 1000-grain weight (20.85 g).

Rahman *et al.* (2016a) conducted an experiment to evaluate the effect of levels of USG and depth of placement on the yield attributes of T. *aman* rice. USG levels showed non-significant effect on 1000-grain weight. Depth of placement of urea super granules had non-significant effect on 1000-grain weight.

Chamely *et al.* (2015) conducted an experiment to study the effect of variety and rate of N on the performance of *boro* rice. The results of the experiment also indicate that 1000-grain weight was not significantly affected by levels of N. Haque and Pervin (2015) conducted an experiment to study the effect of varieties and number of guti urea $hill^{-1}$ on the yield of T. *aman* rice. They found that, 2 guti $hill^{-1}$ interaction with BRRI dhan51 showed the maximum 1000-grain weight (32.07 g).

Kumar *et al.* (2015) conducted a field experiment to evaluate the effect of four N levels *i.e.* 0, 50, 100 and 150% recommended dose of N on growth, yield and yield attributes of four rice cultivars. Maximum 1000-grain weight (26.08 g) was obtained from 150 kg ha^{-1} N. Singh *et al.* (2015) conducted a field experiment to study N management in direct seeded aerobic rice. They recorded that, 1000-grain weight was higher in 150 kg N ha^{-1}.

Jisan *et al.* (2014) carried out an experiment to examine the yield performance of some T. *aman* rice varieties as influenced by different levels of N. They reported that the maximum 1000-grain weight (24.55 g) was obtained from 75 kg N ha^{-1} and the lowest values were recorded from control. Husan *et al.* (2014) conducted an experiment to examine the effect of PU, and USG alone or in combination with poultry manure or cowdung on the yield attributes of rice (cv. BRRI dhan50). Application of PU, USG alone or in combination with poultry manure or cowdung had non-significant effect on 1000-grain weight of BRRI dhan50.

Singh *et al.* (2014) conducted a field experiment to study the effect of different N levels on the growth, yield and quality of direct-seeded hybrid rice. Different N levels showed significant difference in 1000-grain weight.

Hasanuzzaman *et al.* (2013) carried out a field experiment was to study the influence of PU and USG on the yield attributes of hybrid rice Heera1. The highest 1000-grain weight (29.35 g) was obtained from the application of USG showing 10% more better result than PU. Islam *et al.* (2013) conducted a field experiment to find out the varietal performance of *aman* rice as affected by different methods of urea application. The results showed that urea fertilizer application method significantly influenced 1000-grain weight.

Tasnin *et al.* (2013) conducted an experiment to study the yield performance of transplant *aman* rice cv. BRRI dhan51 under integrated N management. Levels of nitrogenous fertilizers exerted significant influence on yield contributing characters of transplant *aman* rice cv. BRRI dhan51. Application of USG @ 125 kg ha^{-1} produced the highest 1000-grain weight (20.34 g). Zhu *et al.* (2013) indicated that N application rates significantly affected grain weight.

Abou-Khalifa (2012) showed that 1000-grain weight was the highest value at 220 kg N ha^{-1}. Akanda *et al.* (2012) conducted a pot experiment to study the effect of nitrogen (0, 25, 50 and 75 kg N ha^{-1}) and potassium and their interaction on morpho-physiological characteristics of fine grain aromatic rice cv. RM 100-16. The results revealed that 1000-grain weight increased with increasing N levels till 50 kg N ha^{-1}.

Youseftabar *et al.* (2012a) investigated the effect of split application of nitrogen fertilizer on growth and yield of hybrid rice (GRH1). The results showed that 1000-grain weight increased significantly with nitrogen fertilizer. 1000-grain weight increase with increase split application. Study interaction effect of treatment‘s revealed that 1000-grain weight increased significantly with an application of 300 kg/ha N-fertilizer at different stage.

Youseftabar *et al.* (2012b) showed that 1000-grain weight increased significantly with N fertilizer. Interesting in comparison to 50 and 100 kg ha^{-1} level application of higher N-fertilizer 150 kg ha^{-1} showed a positive respond to application of high N.

Pramanik and Bera (2013) conducted a field experiment to investigate the optimization of N levels under different age of seedlings transplanted on yield attributes of hybrid rice. 150 kg N ha^{-1} gave significant higher 1000-grain weight as compared to other N treatments. Uddin *et al.* (2013) conducted an experiment to study the influence of N and plant spacing on yield of *boro* rice. Results revealed that 1000-grain weight was not responsive to higher rate of N application. But with the application of 200 kg N ha^{-1} with plant spacing of 25 cm × 15 cm gave the highest 1000-grain weight (26.21 g).

Salem *et al.* (2011) conducted two field experiments to study the effect of N fertilizer (0, 55, 110 and 165 kg N ha^{-1}) on Giza 178, H1 and Sakha 101. The results indicated that 1000-grain weight was increased by increasing N levels up to 165 kg N ha^{-1}. Xia *et al.* (2011) conducted a field experiment on super rice variety Xinliangyou 6 with four treatments of different rates of N fertilizer *viz.,* no N fertilizer, 189 kg ha^{-1}, 270 kg ha^{-1}, 351 kg ha^{-1}. The highest 1000-grain weight was recorded with application of 270 kg N ha^{-1}. According to results, the suitable rate of N fertilizer for the variety Xinliangyou 6 was 270 kg.

Ramesh *et al.* (2009) revealed that application of 150 kg N ha^{-1} registered significantly higher 1000-grain weight than 100 kg N ha^{-1}. Salahuddin *et al.* (2009) showed that 1000-grain weight was not significantly influenced by application of different levels of N.

Hasan (2007) showed that different levels of USG did not have any significant effect on 1000-grain weight of three *aman* rice cultivars. Hossain *et al.* (2007b) showed that the N levels also exerted non-significant effect on 1000-grain weight. Tari *et al.* (2007) observed that the N rates had significant effect on 1000-grain weight.

Manzoor *et al.* (2006) reported that 1000-grain weight and paddy yield showed increasing trend from 0 kg N ha^{-1} up to 175 kg N ha^{-1}. Panicle length (29.75 cm) was highest at 225 kg N ha^{-1} level. Salem (2006) conducted two field experiments during 2004 and 2005 seasons to study the effect of N levels (0, 35 and 70 kg N/fed) on growth, yield and its components of Sakha 101 rice cultivar. Increasing N levels showed non-significant effect on 1000-grain weight in 2005 season, which responded to N up to 35 kg N/fed only. Singh *et al.* (2006) recorded that N application significantly increased 1000-grains weight.

2.1.2.11 Grain yield

Haque and Haque (2016) conducted a field experiment to assess the growth and yield of a new rice variety. The highest grain yield (5.36 t ha^{-1}) was found when the variety was fertilized with 60 kg N ha^{-1}. They concluded that application of the intermediate level of N was economical and environment-friendly for the cultivation of new rice variety.

Imrul *et al.* (2016) carried out a field experiment to investigate the influence of N on the growth and yield of BRRI dhan57. They reported that 120 kg N ha^{-1} treatment gave the highest grain yield (4.95 t ha^{-1}). Rahman *et al.* (2016a) conducted an experiment to evaluate the effect of levels of USG and depth of placement on the yield of T. *aman* rice. The highest grain yield (5.22 t ha^{-1}) was obtained when the crop fertilized with 80 kg N ha^{-1} as USG. The highest grain yield (5.36 t ha^{-1}) was obtained when the crop grown with 6 cm depth of placement of USG. Depth of 8 cm placement of USG gave the lowest grain yield (4.58 t ha^{-1}). In case of interaction, the highest grain yield (7.00 t ha^{-1}) was found in BRRI dhan32 coupled with 80 kg N ha^{-1} as USG at 6 cm depth of placement and the lowest grain yield (3.33 t ha^{-1}) was found in BINA dhan4 fertilized with 120 kg N ha^{-1} as USG at 8 cm depth of placement.

Rahman *et al.* (2016b) carried out a field experiment to assess the comparative advantages of using USG over normal urea and also predict the better performing transplanted Aus rice in the tidal ecosystem. The highest grain yield (3.33 t ha^{-1}) was obtained from USG and BRRI dhan48 and where lowest grain yield (2.28 t ha^{-1}) in absolute control with BRRI dhan55.

Chamely *et al.* (2015) conducted an experiment to study the effect of variety and rate of N on the performance of *boro* rice. The results of the experiment also indicate that grain yield was significantly affected by levels of N. The highest grain yield (5.58 t ha^{-1}) was obtained from 200 kg N ha^{-1}. Haque and Pervin (2015) conducted an experiment to study the effect of varieties and number of guti urea $hill^{-1}$ on the yield of T. *aman* rice. They found that, the variety BRRI dhan51 and 2 guti $hill^{-1}$ individually or combined would be more effective for greater yield of T. *aman* rice.

Khatun *et al.* (2015) aimed to optimize N fertilization and it’s response to the growth and yield of lowland rice. N application significantly increased the grain yield of both varieties. The highest yield of 5.15 and 6.34 t ha^{-1} was obtained with 150 kg N ha^{-1} in BRRI dhan28 and BRRI dhan29, respectively. However, the N dose was optimized at 156 and 158 kg ha^{-1} for BRRI dhan28 and BRRI dhan29, respectively. Kumar *et al.* (2015) conducted a field experiment to evaluate the effect of four N levels *i.e.* 0, 50, 100 and 150% recommended dose of N on growth, yield and yield attributes of four rice cultivars. Maximum grain yield (9.97 t ha^{-1}) was obtained from 150 kg ha^{-1} N application.

Mollah *et al.* (2015) conducted a field experiment to study the response of *boro* rice (BRRI dhan29) to the different doses of fertilizers in Bangladesh. The result indicated significant variations in grain yield due to fertilizer management. When ensure the optimum fertilizer then *boro* rice ensure maximum grain yield. Moro *et al.* (2015) conducted a study to determine the optimum N rate required for lowland rice production. They reported that grain yield significantly increased from 1.7 t ha^{-1} (control) to a maximum of 9.4 t ha^{-1} (90 kg N ha^{-1}) before declining to 5.8 t ha^{-1} (150 kg N ha^{-1}) in the order: 0 < 30 < 60 < 150 < 120 < 90 kg N ha^{-1}, respectively. They recommended 90 kg N ha^{-1} for lowland rice production.

Singh *et al.* (2015) conducted a field experiment to study N management in direct seeded aerobic rice. They found that grain yield was higher in 150 kg N ha^{-1}. Sultana *et al.* (2015) conducted an experiment during T. *aman* season to determine the optimum dose of N on yield of BRRI dhan49. The highest grain yield (6.17 t ha^{-1}) was recorded in 90 kg N ha^{-1} treatment. The grain yield increased due to the different treatments by 20 to 64.53% over control. The results showed that the use of 90 kg N ha^{-1} had better performance on the grain yields.

Anil *et al.* (2014) conducted a field experiment on aerobic rice to evaluate the effect of different N levels and times of application growth parameters of aerobic rice. The results revealed that application of 180 kg N ha^{-1} with 4 splits given higher grain yield. Azarpour *et al.* (2014) studied the effects of N fertilizer on yield and physiological traits of rice cultivars. They reported that with the increasing N application, grain yield increased significantly (17.13 and 57 %).

Ferdous *et al.* (2014) conducted a field experiment to evaluate the effects of PU, USG on yield performance of rice (BRRI dhan29). Application of N as PU and

USG resulted in a significant increase in grain yield of BRRI dhan29. Application of 52 kg N ha^{-1} from USG + 52 kg N ha^{-1} from PU produced the highest grain yield (5.82 t ha^{-1}). The lowest grain yield (2.78 t ha^{-1}) was recorded in control plots. Husan *et al.* (2014) conducted an experiment to examine the effect of PU, and USG alone or in combination with poultry manure or cowdung on yield of rice (cv. BRRI dhan50). USG with poultry manure produced the highest grain yield and the lowest values were recorded from control. The overall results suggest that application of USG in combination with poultry manure could be considered more effective for increasing the yield of BRRI dhan50.

Jalali-Moridani and Amiri (2014) revealed that N had significant effect on grain yield. They also showed that 90 kg N ha^{-1} possessed the highest yield (5.71 t ha^{-1}). Jisan *et al.* (2014) carried out an experiment to examine the yield performance of some T. *aman* rice varieties as influenced by different levels of N. They found that the highest grain yield (5.64 t ha^{-1}) was obtained from 75 kg N ha^{-1} and the lowest values were obtained from control.

Khatun *et al.* (2014) conducted an experiment to evaluate the effect of N fertilizer on grain yield and its quality. Grain yield increased significantly in a quadratic fashion with the increase of N rate both in BRRI dhan28 and BRRI dhan29. Application of N fertilizer increased grain yield by about 3-4 t ha^{-1} compared to control. The highest yield of 5.15 and 6.34 t ha^{-1} was obtained with 150 kg N ha^{-1} in BRRI dhan28 and BRRI dhan29, respectively. Malik *et al.* (2014) conducted a field trail to evaluate the effect of different levels of N on growth and yield attributes of different varieties of basmati rice. They found that, 120 kg N ha^{-1} was significantly different in grain yield of rice.

Mishu (2014) conducted a field experiment to evaluate the effect of USG on yield performance of T. *aman* rice. 1.8 g and 2.7 g weight of USG per pellets and 80 kg N ha^{-1} dose of PU were used in this experiment. Grain yield was found to be the highest (4.99 t ha^{-1}) from the 2.7 g weight of USG per pellets. It was observed that in most of the cases, all the varieties performed better for their yield contributing characters with 2.7 g weight of USG per pellets. BRRI dhan57 combined with 2.7 g weight of USG produced the highest grain yield (5.36 t ha^{-1}) which was statistically identical with the combination of BRRI dhan52 and 2.7 g weight of USG (5.26 t ha^{-1}). Therefore, farmers may be advised to grow BRRI dhan57 and BRRI dhan52 with 2.7 g weight of USG to obtain higher rice yield.

Rao *et al.* (2014) conducted a field experiment to find out suitable variety with optimum N level. Grain yield was progressively augmented by incremental levels of N. Nutrient response in terms of partial factor productivity was progressively decreased with incremental levels of N from 60 kg to the highest dose tried. Sharma *et al.* (2014) conducted an experiment to find out the effect of N levels on yield components of Basmati rice cultivars. Differences in grain yield between 160 kg N ha^{-1} (44.68 q ha^{-1}) and 120 kg N ha^{-1} (43.53 q ha^{-1}) were statistically at par.

Singh *et al.* (2014) conducted a field experiment to study the effect of different N levels on the growth and yield of direct-seeded hybrid rice. Different N levels showed significant difference in grain yield. Application of N at 200 and 125 kg ha^{-1} produced significantly higher grain yield of 53.4 and 52.0 q ha^{-1} during 2012 and 2013, respectively, as compared to control and remained statistically at par with all other N levels.

Tayefe *et al.* (2014) showed that grain yield (3662 kg ha^{-1}) reached the highest value at high N level (90 kg ha^{-1}). Yesuf and Balcha (2014) conducted an experiment to determine grain yield and yield components and N efficiency responses of rice to five N rates (0, 3.5, 7, 10.5, 14 g m^{-2}) using commonly grown rice variety, Nerica-4. Grain yield increased from 302-469 g m^{-2} when N rate increased from 0-14 g m^{-2}. Maximum value for grain yield (510 g m^{-2}) was obtained at 7 and 10.5 g m^{-2} N rate, respectively. Zadeh (2014) carried out a factorial experiment to evaluate the effect of chemical and biological fertilizer on yield and yield components of rice. Results showed that, the highest grain yield (3.37 t ha^{-1}) belonged to highest N level.

Afroz (2013) conducted a field experiment to investigate the effects of PU, USG, and NPK briquettes on growth and yield of BRRI dhan28. She found that USG performed better in increasing grain yield of rice compared to PU. Debnath *et al.* (2013) found that grain yield was found highest when NPK briquette was applied and all the characters showed lowest value when control. The highest grain yield (6.60 t ha^{-1}) was obtained from NPK briquette and where lowest grain yield (4.48 t ha^{-1}).

Hasanuzzaman *et al.* (2013) carried out a field experiment was to study the influence of PU and USG on the yield of hybrid rice Heera1. The highest grain yield (9.42 t ha^{-1}) was obtained from the application of USG showing 10% more grain yield than PU. Islam *et al.* (2013) conducted a field experiment to find out the varietal performance of *aman* rice as affected by different methods of urea application. The results showed that application of USG N as at 7 DAT gave highest yield (7.82 t ha^{-1}) while application of 15 kg N ha^{-1} as PU 30 DAT+ 15 kg N ha^{-1} as PU at 50 DAT gave lowest yield (4.88 t ha^{-1}).

Jafari *et al.* (2013b) showed that N_{138} and N_0 had the maximum and the minimum grain yield (6.1 and 4.3 t ha^{-1}). Masum *et al.* (2013) conducted a field experiment to find out the effect of N application on BRRI dhan33. From the result they observed that all the yield components significantly increase with increased N application but not significantly indicating that a still higher level of N may be required to obtain a significance difference. The highest grain yield (4.56 t ha^{-1}) was obtained from 90 kg ha^{-1} N application.

Naznin *et al.* (2013) conducted an experiment to investigate the effects of PU, USG and NPK briquette on the yield of BR22 rice under reduced water conditions. The highest grain yield (3.93 t ha^{-1}) was recorded from 104 kg N ha^{-1} as USG and the lowest value of 2.12 t ha^{-1} was obtained from control. Pramanik and Bera (2013) conducted a field experiment to investigate the optimization of N levels under different age of seedlings transplanted on yield of hybrid rice. 150 kg N ha^{-1} gave significant higher grain yield as compared to other N treatments. The percentage of grain yields an increase of 72.5, 44.4, 23.8 and 5.1 % in first year and 69.9, 44.1, 22.1 and 3.5 % in second year over 0, 50, 100 and 200 kg N ha^{-1}, respectively.

Sabnam (2013) conducted a field experiment at Bangladesh Agricultural University, Mymensingh to investigate the effects of PU, USG, and NPK briquettes on yield of BR22 rice under continuous flooded condition. She reported that rice grain yield was higher from USG in comparison with Prilled Urea. Tasnin *et al.* (2013) conducted an experiment to study the yield performance of transplant *aman* rice cv. BRRI dhan51 under integrated N management. Levels of nitrogenous fertilizers exerted significant influence on yield of transplant *aman* rice cv. BRRI dhan51. Application of USG @ 125 kg ha^{-1} produced the highest grain yield (5.26 t ha^{-1}) which was statistically similar with the application of 125 kg PU ha^{-1} but superior to that of any other level of N management.

Uddin *et al.* (2013) conducted an experiment to study the influence of N and plant spacing on yield of *boro* rice. Results showed that grain yield was not responsive to higher rate of N application. But with the application of 200 kg N ha^{-1} gave the highest grain yield (7.58 t ha^{-1}). Uwanyirigira (2013) undertaken a study in paddy field using “upland 26’’ variety with the objective of assessing the sufficiency levels of N (0, 40, 80 and 120 kg N ha^{-1}) to develop tools for fertilizer recommendation for optimal rice yields. N application significantly improved the rice yield by increasing plant height, leaf area, tillering and panicle numbers. Observed differences in grain yield among N rates were significant. Tillering activity was the growth parameter that affected most significantly the grain yield, therefore the tiller number was used in estimating the soil nutrients sufficiency levels along with the yield functions.

Xiang *et al.* (2013) showed that urea and USG deep placement increased grain yield of aerobic rice by 1.66 t ha^{-1} in continuous aerobic rice cultivation. They suggested that there is a possibility of improving aerobic rice yield in the continuous aerobic rice system by using right N source or changing conventional method of N application to deep placement.

Yoseftabar (2013a) investigated the effect of N fertilizer on yield in rice. The results showed that grain yield increased significantly with N fertilizer. Interesting in comparison to 50 and 100 kg ha^{-1} level application of higher N fertilizer 150 kg ha^{-1} showed a positive respond to application of high N. Yoseftabar (2013b) showed that grain yield increased significantly with 300 kg N ha^{-1} fertilizer.

Zayed *et al.* (2013) observed that application of 165 kg N ha^{-1} gave the highest yield and yield component values. Zhu *et al.* (2013) indicated that N-application rates significantly improved the grain yield, with N application of 270 kg hm^{-2} showing the highest grain yields (9657.7 kg hm^{-2}) at the four N application levels.

Abou-Khalifa (2012) reported that grain yield was the highest value at 220 kg N ha^{-1}. Akanda *et al.* (2012) conducted a pot experiment to study the effect of nitrogen (0, 25, 50 and 75 kg N ha^{-l}) and potassium and their interaction on morpho-physiological characteristics of fine grain aromatic rice cv. RM 100-16. The results revealed that the highest grain yield (25.82 g ha^{-l}) was recorded in 50 kg N ha^{-l}.

Ehsanullah *et al.* (2012) reported that 100 kg N ha^{-1} resulted in maximum rice grain yield. While application of N at 75 kg ha^{-1} revealed the poorest results with respect to grain yield of rice. Hasanuzzaman *et al.* (2012) carried out an experiment to study the response of hybrid rice to different levels of N. Results indicated that, N showed significant variation in respect of yield contributing characters and yield. The maximum grain yield (9.42 t ha^{-1}) was obtained from the application of USG. About 10% more grain yield was measured from USG than PU.

Miah *et al.* (2012) carried out a field experiment to study the effects of two slow release nitrogenous fertilizer named PU and USG on yield of BRRI dhan28. Results revealed that application of different forms and doses of urea had significant effect on grain yield of BRRI dhan28. The highest grain yield (5.77 t ha^{-1}) was found in USG_{240} was found in USG_{300} and the lowest grain (4.12 t ha^{-1}) was found in control. A positive and significant correlation was found between grain yield. The results suggest that urea super granule @ 240 kg ha^{-1} may be suitable for better yield of *boro* rice cv. BRRI dhan28 in the agroclimatic condition of the study area.

Naznin (2012) conducted an experiment to investigate the effect of PU and USG on rice yield of BR 22 rice under reduced water conditions. Application of PU and USG showed a positive effect on yield of BR 22 rice. The highest grain yield of 3.93 t ha^{-1} was recorded from 104 kg N ha^{-1} from USG which was significantly superior to PU. This might be due to optimum release of N from deep placed fertilizers (USG) for a prolonged period.

Nesgea *et al.* (2012) carried out a field experiment to establish the application rates of N (0, 46, 92 and 138 kg N ha^{-1}) and P fertilizers for rice variety NERICA-3 (*Oryza sativa* x *Oryza glaberrima*). The application of 92 kg N ha^{-1} to improve grain yield of rain fed NERICA-3 rice might be more profitable even under risky market situations in and around the study area.

Youseftabar *et al.* (2012a) investigated the effect of split application of nitrogen fertilizer on growth and yield of hybrid rice (GRH1). The results reported that grain yield increased significantly with nitrogen fertilizer. Grain yield increased with increasing split application. Study interaction effect of treatment‘s showed that grain yield increased significantly with an application of 300 kg/ha N-fertilizer at different stage.

Youseftabar *et al.* (2012b) showed that yield and yield components increased significantly with N fertilizer. Study on interaction effect of treatments revealed that all the yield and yield parameters increased significantly with an application of 300 kg ha^{-1} N-fertilizer at 4 stages. Youseftabar *et al.* (2012c) showed that yield increased significantly with N fertilizer. Interesting in comparison to 50 and 100 kg ha^{-1} level application of higher N-fertilizer 150 kg ha^{-1} showed a positive respond to application of high N.

Awan *et al.* (2011) carried out an experiment to study the effect of different N levels on growth and yield of rice. They showed that, 156 kg N ha^{-1} gave the highest values of grain yield (5.46 t ha^{-1}). Bolinga *et al.* (2011) stated that adequately simulated growth, development, and yield of Jasmine rice over a 0-150 kg N ha^{-1} range under irrigated and normal to above-normal rainfall conditions. The simulated attainable yields ranged from 3.47 to 5.96 Mg ha^{-1}. Yield gaps could be substantially reduced by 1.48 Mg ha^{-1} (34%) through improved N-management practices. The large yield gap beyond the farmers' current fertilizer level suggests considerable scope for increasing yields through site- and time-specific nutrient management.

Das (2011) found the highest grain yield (4.28 t ha^{-1}) in 240 kg PU and the lowest grain yield (3.06 t ha^{-1}) in no N application. Ethan *et al.* (2011) reported that yields generally increased with increasing levels of N and declined from 80 kg ha^{-1}. Hirzel *et al.* (2011) showed that N rates significantly increased the grain yield up to 140 kg N ha^{-1} as compared with lower doses of N of 80 and 100 kg ha^{-1} but was at par with 160 kg N ha^{-1}.

Jun *et al.* (2011) conducted an experiment in a rice field with different crop rotation systems and N application rates. They found Alfalfa-rice and rye-rice rotation systems significantly improved rice yield. Li *et al.* (2011) conducted a field experiment to study the effects of applying N fertilizer and fertilizer additive on the rice yield. Applying N fertilizer had significant positive effects on the rice yield. However, when the N application rate exceeded 200 kg x hm^{-2}, its yield-increasing effect was not significant. Applying fertilizer additive further improved the rice yield. Relatively high rice yield and NUE were achieved when applying 150 kg x hm^{-2} of N fertilizer without the application of fertilizer additive.

Salem *et al.* (2011) conducted two field experiments to study the effect of N fertilizer (0, 55, 110 and 165 kg N ha^{-1}) on Giza 178, H1 and Sakha 101. The results indicated that grain yield was increased by increasing N levels up to 165 kg N ha^{-1}. Tahura (2011) found the highest grain yield (3.38 t ha^{-1}) in 1.8 g USG 4 $hill^{-1}$ and the lowest grain yield (1.99 t ha^{-1}) in control. Xia *et al.* (2011) conducted a field experiment on super rice variety Xinliangyou 6 with four treatments of different rates of N fertilizer *viz.*, no N fertilizer, 189 kg ha^{-1}, 270 kg ha^{-1}, 351 kg ha^{-1}. The highest yield was recorded with application of 270 kg N ha^{-1}. According to results, the suitable rate of N fertilizer for the variety Xinliangyou 6 was 270 kg.

The mean N fertilizer response was the highest at 40 kg N ha^{-1} as compared to other N levels (0, 20, and 60 kg N ha^{-1}), indicating that further increase in N level had no effect on crop response to fertilizer. The mean grain yield was increased by 64.2% when plots were supplemented with 40 kg N ha^{-1} as compared with control (Mahajan *et al.*, 2010). Mannan *et al.* (2010) recorded that the maximum plant growth at the highest level of N caused lodging of plant which increased spikelet sterility and lower number of grains $panicle^{-1}$ and ultimately decreased grain yield.

Hasanuzzaman *et al.* (2009) conducted an experiment to find out the economic and effective method of urea application in rice crop. They reported that application of USG @ 75 kg ha^{-1} produced 22.03% and 5.88% more yield than granular urea application at 2 and 3 equal splits. There were significant differences in rice grain yield, quality and water productivity under different water regimes with various N rates (Pan *et al.*, 2009).

Ramesh *et al.* (2009) revealed that application of 150 kg N ha^{-1} registered significantly higher grain yield than 100 kg N ha^{-1}. Salahuddin *et al.* (2009) showed that a gradual increase in grain yield (4.91 t ha^{-1}) was observed with the increase in N levels up to 150 kg ha^{-1} and declined thereafter.

Sathiya and Ramesh (2009) carried out a field experiment to study the effect of different split doses of nitrogen management on growth and yield of aerobic rice. The results showed that nitrogen management at LCC value of 4 (150 kg N ha^{-1}) produced significantly higher grain yield (2.92 t ha^{-1}) than LCC value of 3 that produced grain yield of 2.21 t ha^{-1}. Soil test crop response based nitrogen application produced markedly lower grain yield (2.48 t ha^{-1}) than the LCC value 4 of N management. Among the different split doses of N, application of 150 kg N ha^{-1} in four splits-1/6 at flowering recorded higher grain yield (2.83 t ha^{-1}) over four equal splits where the grain yield was 2.67 t ha^{-1}. Four splits (1/5 at 15 DAS, 1/5 at tillering, 2/5 at PI, 1/5 at flowering) of 150 N ha^{-1} also recorded comparable yield of 2.78 t ha^{-1} than other split doses. Thus, N application with LCC value of 4 or application of 150 kg N ha^{-1} in four splits-1/6 at 15 DAS, 1/3 at tillering, 1/3 at PI, 1/6 at flowering is considered a suitable N management technique in aerobic rice cultivation.

Tari *et al.* (2009) showed that N fertilization levels had significant effect on grain yield. According to this research use of 138 kg N ha^{-1} for the best performance of agronomical attributes were recommended.

Hosseiny and Maftoun (2008) conducted an experiment to study the effects of varying sources and levels of N rate on the yield of rice. They reported that, N yield efficiency was reduced with increasing N rates and increased up to 200 mg N kg^{-1}. From the results it reported that, 200 mg N kg^{-1} is the most appropriate N level for lowland rice.

Hossain *et al.* (2008) reported that different nitrogen rates also significantly affected the aromatic rice varieties. All the yield components were significantly increased up to 90 kg N ha^{-1}. Nonetheless, maximum grain yield (3.62 t ha^{-1}) was observed from 60 kg N ha^{-1}. Islam *et al.* (2008) showed that the application of N fertilizer significantly influenced the grain yield. The highest grain yield 4.27 t ha^{-1} was recorded with the 100 kg N ha^{-1}.

Prudente *et al.* (2008) conducted a field experiment to determine the effect of different levels of N on yield components of *japonica* (*Hatsuboshi*) and *indica* (IR-13) rice varieties. Results showed an increasing trend in the rice yield with increased amount of applied N fertilizer. Sathiya *et al.* (2008) reported that the application of 175 kg N ha^{-1} resulted in higher yield attributes and grain yield as compared to 100 and 125 kg N ha^{-1}. Verma *et al.* (2008) revealed that grain yield of rice increased significantly with the application of 100 kg N ha^{-1} over 50 kg N ha^{-1}.

Bhuiyan (2007) stated that the highest grain yield (5.2 t ha^{-1}) was obtained from 100 kg N ha^{-1} followed by 120 kg N ha^{-1}. Hasan (2007) reported that grain yield was found to be the highest (5.20 t ha^{-1}) from the level of USG @ 3 pellets/4 hill or 90 kg N ha^{-1} as USG. Hossain *et al.* (2007b) reported that the highest grain yield was obtained from the application of 75 kg ha^{-1} of the recommended dose of N and the lowest from the control treatment (0 kg ha^{-1}) of rice cv. BRRI dhan32.

Kumar *et al.* (2007) reported that application of 120 kg N ha^{-1} produced significantly higher grain yield as compared to control but was at par grain yield obtained with 180 kg N ha^{-1}. Laroo *et al.* (2007) reported 49.5 and 48.5 % increase in basmati grain yield with the application of 100 and 150 kg N ha^{-1}, respectively over control.

Naw *et al.* (2007) reported the effect of N on the productivity of aromatic rice was increase in grain yield with the application of 100 and 150 kg N ha^{-1} over control (2.0 and 1.95 t ha^{-1}). It was 49.5 and 48.5 % more, respectively. The beneficial effect of N application on various yield attributing characters *viz.*, number of panicles hill^{-1}, panicle weight, panicle length, number of filled grains panicle^{-1} and 1000-grain weight led to increased grain yield with increasing levels of N.

Rahman *et al.* (2007) conducted an experiment to study the effect of different level of N on yield of T. *aman* rice. They reported the highest grain yield (5.34 t ha^{-1}) was found from 80 kg N ha^{-1}. Results showed that 80 kg N ha^{-1} was optimum to produce maximum yield of T. *aman* rice cv. BRRI dhan32.

Sharma *et al.* (2007) reported that application of 120 kg N ha^{-1} gave significantly higher grain yield over 40 kg N ha^{-1}. Singh and Tripati (2007) revealed that the successive increments of N significantly increased the grain yield up to 120 kg N ha^{-1} as compared to 160 kg N ha^{-1}. Singh *et al.* (2007) obtained response up to 120 kg N ha^{-1}, where applied N fertilizer increased grain yield of direct seeded rice by 62 % compared to control. Beyond 120 kg N ha^{-1}, no increase in grain yield was observed.

Tari *et al.* (2007) observed that the N rates had significant effect on grain yield. Xie *et al.* (2007) in his experiment found that the level of N application depends on the variety for obtaining the highest grain yield. They also reported Shanyou63 variety gave the highest yield (12 t ha^{-1}) with the application of 150 kg N ha^{-1} whereas 120 kg ha^{-1} for Xieyou46 variety (10 t ha^{-1}).

Castillo *et al.* (2006) revealed that application of N fertilizer increased grain yield of rice when the rice was exposed to water deficit. Dwivedi *et al.* (2006) were conducted a field experiment in Uttar Pradesh, India to evaluate the effect of N levels on growth yield of hybrid rice. They found 184.07 kg ha^{-1} was optimum in respect of yield.

Khan *et al.* (2006) reported linear increase in grain yield up to 180 kg N ha^{-1}. N dose of 180 kg ha^{-1} resulted in significantly higher grain yield of rice as compared to lower dose of 60, 120 and 150 kg N ha^{-1}. This was mainly attributed to the higher number of panicles m^{-2} and grains $panicle^{-1}$. Higher N dose of 240 kg ha^{-1} resulted in lodging of crop at maturity which declined the grain yield.

Manzoor *et al.* (2006) conducted a field experiment to find out the most appropriate level of N (0, 50, 75, 100, 125, 150, 175, 200 and 225 kg ha^{-1}) to get maximum paddy yield of rice variety, Super Basmati. Paddy yield showed increasing trend from 0 kg N ha^{-1} up to 175 kg N ha^{-1}. The paddy yield started declining at 200 kg N ha^{-1} level and above. Maximum paddy yield (4.24 t ha^{-1}) was obtained from 175 kg N ha^{-1}. Masud (2006) observed that application of N exerted positive effect on all crop characteristics. The rice genotypes differed significantly in yield contributing characters and grain yield.

2.1.2.12 Straw yield

Imrul *et al.* (2016) carried out a field experiment to investigate the influence of N on the growth and yield of BRRI dhan57. They reported that 120 kg N ha^{-1} treatment gave the highest straw yield (5.39 t ha^{-1}). Rahman *et al.* (2016a) conducted an experiment to evaluate the effect of levels of USG and depth of placement on the yield attributes of T. *aman* rice. USG levels showed non-significant effect on straw yield.

Rahman *et al.* (2016b) carried out a field experiment to assess the comparative advantages of using USG over normal urea and also predict the better performing transplanted Aus rice in the tidal ecosystem. They reported that straw yield was found highest when USG was applied with BRRI dhan48 and all the characters showed lowest value when absolute control with BRRI dhan55.

Chamely *et al.* (2015) conducted an experiment to study the effect of variety and rate of N on the performance of *boro* rice. The results of the experiment also indicate that straw yield was significantly affected by levels of N. Haque and Pervin (2015) conducted an experiment to study the effect of varieties and number of guti urea $hill^{-1}$ on the yield of T. *aman* rice. They found that, the higher straw yield (10.99 t ha^{-1}) was recorded in 2 guti $hill^{-1}$ of Shakorkura.

Kumar *et al.* (2015) conducted a field experiment to evaluate the effect of four N levels *i.e.* 0, 50, 100 and 150% recommended dose of N on growth, yield and yield attributes of four rice cultivars. Straw yield increased upto 150% recommended dose of N ha^{-1}. Singh *et al.* (2015) conducted a field experiment to study N management in direct seeded aerobic rice. They showed that straw yield were higher in 150 kg N ha^{-1}.

Sultana *et al.* (2015) conducted an experiment during T. *aman* season to determine the optimum dose of N on yield of BRRI dhan49. The highest straw yield (7.50 t ha^{-1}) was recorded in 90 kg N ha^{-1} treatment. Straw yield increased due to the different treatments by 21.02 to 65.93% over control. The results indicated that the use of 90 kg N ha^{-1} had better performance on the straw yield.

Ferdous *et al.* (2014) conducted a field experiment to evaluate the effects of PU, USG on yield performance of rice (BRRI dhan29). Application of N as PU and USG resulted in a significant increase in straw yield of BRRI dhan29. 52 kg N ha^{-1} from USG + 52 kg N ha^{-1} from PU gave the highest straw yield (7.28 t ha^{-1}).

Husan *et al.* (2014) conducted an experiment to examine the effect of PU, and USG alone or in combination with poultry manure or cowdung on the yield of rice (cv. BRRI dhan50). USG with poultry manure produced the highest straw yield and the lowest values were recorded from control. Malik *et al.* (2014) conducted a field trail to evaluate the effect of different levels of N on growth and yield attributes of different varieties of basmati rice. They found that, 120 kg N ha^{-1} was significantly different in straw yield of rice.

Mishu (2014) conducted a field experiment to evaluate the effect of USG on yield performance of T. *aman* rice. 1.8 g and 2.7 g weight of USG per pellets and 80 kg N ha^{-1} dose of PU were used in this experiment. Straw yield was found the highest (5.65 t ha^{-1}) from the 2.7 g weight of USG per pellets. BRRI dhan57 combined with 2.7 g weight of USG produced the highest straw yield. Singh *et al.* (2014) conducted a field experiment to study the effect of different

N levels on the growth and yield of direct-seeded hybrid rice. Different N levels showed significant difference in straw yield.

Hasanuzzaman *et al.* (2013) carried out a field experiment was to study the influence of PU and USG on the yield of hybrid rice Heera1. The highest straw yield (13.33 t ha^{-1}) was obtained from the application of USG showing 10% more better result than PU. Islam *et al.* (2013) conducted a field experiment to find out the varietal performance of *aman* rice as affected by different methods of urea application. The results showed that urea fertilizer application method significantly influenced straw yield.

Pramanik and Bera (2013) conducted a field experiment to investigate the optimization of N levels under different age of seedlings transplanted on yield of hybrid rice. 200 kg N ha^{-1} gave significant higher straw yield.

Akanda *et al.* (2012) conducted a pot experiment to study the effect of nitrogen (0, 25, 50 and 75 kg N ha^{-l}) and potassium and their interaction on morpho-physiological characteristics of fine grain aromatic rice cv. RM 100-16. The results revealed that straw weight $hill^{-1}$ increased till 75 kg N ha^{-l}. Hasanuzzaman *et al.* (2012) carried out an experiment to study the response of hybrid rice to different levels of N. Results indicated that, N showed significant variation in respect of yield contributing characters and yield. The maximum straw yield (13.33 t ha^{-1}) was obtained from the application of USG.

Miah *et al.* (2012) carried out a field experiment to study the effects of two slow release nitrogenous fertilizer named PU and USG on yield of BRRI dhan28. Results revealed that application of different forms and doses of urea had significant effect on straw yield of BRRI dhan28. The highest straw yield (12.11 t ha^{-1}) was found in USG_{300} and the lowest straw yield (8.33 t ha^{-1}) was found in control.

Awan *et al.* (2011) carried out an experiment to study the effect of different N levels on growth and yield of rice. They reported that, 156 kg N ha^{-1} gave the maximum values of straw yield (9.66 t ha^{-1}). Mannan *et al.* (2010) recorded that the straw yield increased with the increase of N levels up to 75 kg N ha^{-1}.

Hasan (2007) found that straw yield was found to be the highest (7.45 t ha^{-1}) from the level of USG @ 3 pellets/4 hill or 90 kg N ha^{-1} as USG. Rahman *et al.* (2007) conducted an experiment to study the effect of different level of N on growth and yield of T. *aman* rice. They found that the highest straw yield (6.98 t ha^{-1}) was obtained at the highest N level (100 kg N ha^{-1}). Sharma *et al.* (2007) reported that application of 120 kg N ha^{-1} gave significantly higher straw yield over 40 kg N ha^{-1}. Singh *et al.* (2007) obtained that beyond 120 kg N ha^{-1}, resulted in more production of rice straw.

2.1.2.13 Biological yield

Imrul *et al.* (2016) carried out a field experiment to investigate the influence of N on the growth and yield of BRRI dhan57. They reported that 120 kg N ha^{-1} treatment gave the highest biological yield (10.34 t ha^{-1}). Haque and Pervin (2015) conducted an experiment to study the effect of varieties and number of guti urea hill^{-1} on the yield of T. *aman* rice. They found that, the higher biological yield (16.49 t ha^{-1}) was recorded in 2 guti hill^{-1} of Shakorkura.

Jalali-Moridani and Amiri (2014) revealed that N had significant effect on biological yield. Malik *et al.* (2014) conducted a field trail to evaluate the effect of different levels of N on growth and yield attributes of different varieties of basmati rice. They found that, 120 kg N ha^{-1} was significantly different in biological yield of rice.

Islam *et al.* (2013) conducted a field experiment to find out the varietal performance of *aman* rice as affected by different methods of urea application. The results showed that urea fertilizer application method significantly influenced biological yield. Pramanik and Bera (2013) conducted a field experiment to investigate the optimization of N levels under different age of seedlings transplanted on yield of hybrid rice. 150 kg N ha^{-1} gave significant higher harvest index as compared to other N treatments. Yoseftabar (2013a) investigated the effect of N fertilizer on yield in rice. The results showed that biological yield increased significantly with N fertilizer.

Arman (2007) recorded the highest biological yield (8.14 t ha^{-1}) from 140 kg N ha^{-1}.

2.1.2.14 Harvest index

Rahman *et al.* (2016a) conducted an experiment to evaluate the effect of levels of USG and depth of placement on the growth of T. *aman* rice. USG levels showed non-significant effect on HI. Depth of placement of urea super granules had non-significant effect on HI of T. *aman* rice.

Chamely *et al.* (2015) conducted an experiment to study the effect of variety and rate of N on the performance of *boro* rice. The results of the experiment also indicate that harvest index was significantly affected by levels of N. Kumar *et al.* (2015) conducted a field experiment to evaluate the effect of four N levels *i.e.* 0, 50, 100 and 150% recommended dose of N on growth, yield and yield attributes of four rice cultivars. Harvest index decreased with increasing level of N.

Mollah *et al.* (2015) conducted a field experiment to study the response of *boro* rice (BRRI dhan29) to the different doses of fertilizers in Bangladesh. The result indicated significant variations in HI due to fertilizer management. Moro *et al.* (2015) conducted a study to determine the optimum N rate required for lowland rice production. The result significantly and positively reflected on harvest index in the order: $0.27 < 0.38 < 0.46 < 0.47 < 0.57 < 0.68$ for 0, 30, 60, 150, 120 and 90 kg N ha^{-1}, respectively.

Malik *et al.* (2014) conducted a field trail to evaluate the effect of different levels of N on growth and yield attributes of different varieties of basmati rice and found that, 120 kg N ha^{-1} was significantly different in HI of rice.

Rao *et al.* (2014) conducted a field experiment to find out suitable variety with optimum N level. Harvest index was progressively augmented by incremental levels of N.

Uddin *et al.* (2013) conducted an experiment to study the influence of N and plant spacing on yield of *boro* rice. Results revealed that HI was not responsive to higher rate of N application. But with the application of 200 kg N ha^{-1} with plant spacing of 25cm×15cm gave the highest HI (45.57%). Akanda *et al.* (2012) conducted a pot experiment to study the effect of nitrogen (0, 25, 50 and 75 kg N ha^{-l}) and potassium and their interaction on morpho-physiological characteristics of fine grain aromatic rice cv. RM 100-16. The results showed that the highest harvest index (43.54%) was recorded in 25 kg N ha^{-l}.

Ehsanullah *et al.* (2012) investigated that 100 and 125 kg N ha^{-1} resulted in maximum harvest index. Saha *et al.* (2012) reported that the effect of different rates of N fertilization on the yield performance and nitrogen nutrition under irrigated condition. Among the tested varieties/lines, BR7155-20-1-3 produced the significantly highest grain yield of 5.04 t ha^{-1} at N_{30} level followed by Swama (4.66 t ha^{-1}) at the same level of N.

Rahman *et al.* (2007) conducted an experiment to study the effect of different level of N on growth and yield of T. *aman* rice. They showed that the highest HI (44.50%) was observed at 80 kg N ha^{-1}.

2.2 Weed management

2.2.1 Effect of weed on yield of rice

Weeds are at present the major biotic constraint to increased rice production worldwide. The importance of their control has been emphasized in the past by various authors (Labrada, 1996; Zhang, 1996). The occurrence of weeds has become a serious problem and they limit the yield and quality of crops. It is often stated that some weeds cause total crop failure and that weeding practices are absolutely essential (De Datta and Haque, 1982). Unchecked weed compete with rice plants for light, nutrients and moisture resulting reduction of grain yield up-to 80 % (Sinha Babu *et al.*, 1992; Behera and Jha, 1992).

Estimation of yield losses caused by competition from weeds ranges from 30-100% (Dobermann and Fairhurst, 2000). Yield loss in rice crop due to weed range from 10-50 % (Singh and Singh, 1993). Unchecked weed growth caused 53% reduction in grain yield in puddled conditions, and 91% yield reduction in non-puddled conditions (Ali and Sankaran, 1984). In lowland or puddled conditions, broad-leafed weed are the main problem. Maximum grain yield (64 q ha^{-1}) was obtained in weed-free plots and minimum (35 q ha^{-1}) in weedy plots. Weed-free condition at early stage of growth was found more important than at later stages for getting higher yield of rice (Thapa and Jha, 1999). The loss in grain yield caused by weeds varies from 30-50% (Singh *et al.,* 1991; Brar *et al*., 1989). The yield loss occurs 25-30% due to unchecked weed growth (Upadhyay and Gogoi, 1993) in transplanted rice.

2.2.2 Effect of weed control

Weed is one of the limiting factors for successful rice production. Among various cultural practices, weeding play a vital role in the production and yield of rice through controlling the weeds as well as make the environment favorable for rice production. To justify the present study attempts have been made to incorporate some of the important findings of different scientists and research workers in this country and elsewhere of the world.

2.2.3 Effect of weed management on the yield of rice

2.2.3.1 Plant height

Ghosh *et al.* (2016) revealed that herbicidal treatments improved the plant height. Prasuna and Rammohan (2015) carried out a field experiment to examine the effect of different weed management practice on growth of aerobic rice. Among the different weed management practices, the result indicates that weed free or pretilachlor plus @ 0.75Kg ha^{-1} or pendimethalin 1.00 Kg ha^{-1} found to be best option for both growth of rice.

Khan and Tarique (2011) observed that the longest plant was observed in completely weed free condition throughout the crop growth period. On the other hand, plant height was highest in two HW treatment. However, lowest value was observed in no weeding treatment.

Hassan *et al.* (2010) carried out a field experiment on T. *aman* rice cv. BRRI dhan41 and observed that highest plant height was recorded from the three HW regimes in most of the evaluated traits. The weakest treatment was the no weeding. Usman *et al.* (2010) conducted an experiment to evaluate the impact of various tillage systems in combination with herbicides on weed density and some physiological traits under rice-wheat cropping system. Results showed that herbicides had significant effect on plant height.

Hasanuzzaman *et al.* (2008) conducted an experiment to study the efficacy of different herbicides over manual weeding in controlling weeds in transplanted rice. Plant height was influenced according to the effectiveness of the treatments, with Ronstar® 25EC @ 1.25 L ha^{-1} + IR5878® 50 WP @ 120 g ha^{-1}.

Hasanuzz*aman et al.* (2007) stated that plant height was significantly affected by different weeding treatments. Mahadi *et al.* (2006) conducted an experiment to evaluate the performance of weeding and some herbicides. The treatments were two HW and Butachlor @ 21 a.i ha^{-1} cinosulfuron @ 0.06 kg a.i ha^{-1}. All the treatments increase plant height.

2.2.3.2 Leaf area index

Usman *et al.* (2010) conducted an experiment to evaluate the impact of various tillage systems in combination with herbicides on weed density and some physiological traits under rice-wheat cropping system. Results showed that herbicides had significant effect on LAI.

2.2.3.3 Crop Growth Rate

Ali *et al.* (2008) conducted an experiment on the effect of integrated weed management and spacing on the weed flora and on the growth of transplanted *aman* rice to evaluate the weeding treatments *viz.*, no weeding, two HW at 15 and 40 DAT, one weeding with BRRI push weeder at 15 DAT + one HW at 40 DAT, pre-emergence application of M. Chlor 5G (Butachlor) at 5 DAT + one HW at 40 DAT, pre-emergence application of Oxastar 25 EC (Oxadiazon) at 5 DAT + one HW at 40 DAT, pre- emergence application of Rifit 500EC (Pretilachlor) at 5 DAT + one HW at 40 DAT and three plant spacing's *viz.*, 20 cm x 10 cm, 25 cm x 15 cm and 30 cm x 20 cm. It was evident that among the weed control treatments, Pretilachlor + one HW gave the highest CGR (0.71 g $hill^{-1}$ day^{-1}) at 45-60 DAT.

Remesan *et al.* (2007) conducted an experiment on wet land paddy weeding- A comprehensive comparative study from south India to evaluate the weeding tools quantitatively and qualitatively in terms of weeding performance. They concluded that CGR showed less variation with treatments *viz.* HW, rotary weeding + one HW, cono weeding + one HW, rotary weeding alone, cono weeding alone, even though those had higher values for HW which were followed by cono weeding + one HW, Rotary weeding + one HW, cono weeding and rotary weeding, respectively.

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

2.2.3.4 Relative Growth Rate

Remesan *et al.* (2007) conducted an experiment on wet land paddy weeding- A comprehensive comparative study from south India to evaluate the weeding tools quantitatively and qualitatively in terms of weeding performance. They concluded that RGR showed less variation with treatments *viz.* HW, rotary weeding + one HW, cono weeding + one HW, rotary weeding alone, cono weeding alone, even though those had higher values for HW which were followed by cono weeding + one HW, Rotary weeding + one HW, cono weeding and rotary weeding, respectively.

2.2.3.5 Number of effective tillers hill^{-1}

Sarker *et al.* (2015) revealed that all weed control methods treatments (one weeding at 30 DAT, two weeding at 30 and 50 DAT, Sunrice 50WG @ 100g ha^{-1} and Topstar 80WG @ 80g ha^{-1}) contributed to significantly higher number of tillers hill^{-1} than unweeded condition and that trend continued throughout the growing period.

Hossain and Rahman (2013) applied three herbicides on BR11 paddy field to control weeds and also to study the yield components. The effect of herbicides was found to be positive in controlling the weed species and in increasing the yield components. The maximum number of tillers was found at normal dose of Rifit 500 EC was applied.

Khan and Tarique (2011) observed that the total tillers plant^{-1} appeared next to the highest was found in two HW treatment. However, lowest value was observed in no weeding treatment. Hassan *et al.* (2010) carried out a field experiment on T. *aman* rice cv. BRRI dhan41 and observed that highest total effective tillers hill^{-1} was recorded from the three HW regimes in most of the evaluated traits. The weakest treatment was the no weeding.

Roy *et al.* (2009) carried out an experiment to investigate the effect of herbicides on weed infestation and yield performance of *boro* rice (cv. Iratom-24) in direct seeding method. It is evident from the study that pre-emergence application of Machete 5G herbicide at the rate of 25 kg ha^{-1} was more effective for controlling weeds than Ronstar 25EC herbicide. They recorded highest number of effective tillers $hill^{-1}$ (13.09) from Machete 5G herbicide.

Hasanuzzaman *et al.* (2008) conducted an experiment to study the efficacy of different herbicides over manual weeding in controlling weeds in transplanted rice. Number of effective tillers $hill^{-1}$ was influenced according to the effectiveness of the treatments, with Ronstar® 25EC @ 1.25 L ha^{-1} + IR5878® 50 WP @ 120 g ha^{-1}.

Ashraf *et al.* (2006) made an experiment for screening of herbicides for weed management in transplanted rice (cv. Basmati-2). In the second year the maximum control of weeds was 94.67% in the case of HW. Regarding the number of tillers $plant^{-1}$, HW resulted in 20.8 compared to 16.6 for the control in second year. Dhiman *et al.* (2006) showed that butachlor + one HW recorded significantly higher effective tillers (246.10 m^{-2}) than the other treatments.

2.2.3.6 Number of filled grains $panicle^{-1}$

Hossain and Rahman (2013) applied three herbicides on BR11 paddy field to control weeds and also to study the yield components. The effect of herbicides was found to be positive in controlling the weed species and in increasing the yield components. The maximum number of filled grains was found at normal dose of Rifit 500 EC was applied.

Roy *et al.* (2009) carried out an experiment to investigate the effect of herbicides on weed infestation and yield performance of *boro* rice (cv. Iratom-24) in direct seeding method. It is evident from the study that pre-emergence application of Machete 5G herbicide at the rate of 25 kg ha^{-1} was more effective for controlling weeds than Ronstar 25EC herbicide. They recorded highest number of total filled grains $panicle^{-1}$ (91.58) from Machete 5G herbicide.

Hasanuzzaman *et al.* (2008) conducted an experiment to study the efficacy of different herbicides over manual weeding in controlling weeds in transplanted rice. Number of filled grains was influenced according to the effectiveness of the treatments, with Ronstar® 25EC @ 1.25 L ha^{-1} + IR5878® 50 WP @ 120 g ha^{-1}.

Dhiman *et al.* (2006) showed that butachlor + one HW recorded significantly higher filled grains $panicle^{-1}$ (136.00) than the other treatments. Kalyanasundaram *et al.* (2006) conducted field experiments to determine the suitable integrated weed management practice without causing any phytotoxicity to rice seedlings. 1.5 kg Butachlor ha^{-1} with Safener at 4 DAS + HW at 30 DAS gave the highest number of filled grains $panicle^{-1}$.

Chandra and Solanki (2003) studied the effect of herbicides on the yield characteristics of direct sown flooded rice. The treatments were two HW, Butachlor 2.0 kg ha^{-1} and Oxadiazon 0.8 kg ha^{-1}. They found that two HW produced the highest number of grains $panicle^{-1}$. Raju *et al.* (2003) observed the effect of pre emergence application of Pretilachlor plus Safener 0.3 kg ha^{-1}, Butachlor 1 kg ha^{-1} and post emergence herbicide like Butanil 3.0 kg ha^{-1} on 4, 8 and 15 DAS. They found that Pretilachlor plus Safener 0.3 kg ha^{-1} gave the highest number of grains $panicle^{-1}$.

Nair *et al.* (2002) observed that application of Butachlor @ 1.25 kg ha^{-1} along with one HW 40 DAT recorded higher number of grains $panicle^{-1}$. Tamilselvan and Budhar (2001) studied the effects of pre emergence herbicides Pretilachlor 0.4 kg ha^{-1}, Pretilachlor 0.4 kg a.i. ha^{-1} on rice cv. ADT 43. The herbicides were applied 8 DAS. The number of filled grain $panicle^{-1}$ was the highest with Pretilachlor 0.40 kg a.i. ha^{-1} (126.3).

2.2.3.7 Panicle length

Hossain and Rahman (2013) applied three herbicides on BR11 paddy field to control weeds and also to study the yield components. The effect of herbicides was found to be positive in controlling the weed species and in increasing the yield components and yield. The maximum length of panicle was found at normal dose of Rifit 500 EC was applied.

Hasanuzzaman *et al.* (2008) conducted an experiment to study the efficacy of different herbicides over manual weeding in controlling weeds in transplanted rice. Panicle length was influenced according to the effectiveness of the treatments, with Ronstar® 25EC @ 1.25 L ha^{-1} + IR5878® 50 WP @ 120 g ha^{-1}. Aktaruzzaman (2007) reported that weeding regimes exerted non-significant influence on panicle length.

Chandra and Solanki (2003) studied the effect of herbicides on the yield characteristics of direct sown flooded rice. The treatments were two HW, Butachlor 2.0 kg ha^{-1} and Oxadiazon 0.8 kg ha^{-1}. They found that two HW produced the highest panicle length (23.49 cm). Nair *et al.* (2002) observed that application of Butachlor @ 1.25 kg ha^{-1} along with one HW 40 DAT recorded higher panicle length.

2.2.3.8 1000-grain weight

Kishore *et al.* (2016) showed that both chemical and mechanical methods of weed control were found superior over weedy check. The highest 1000-grain weight was recorded with two HW which was at par with Butachlor @ 1.0 kg ha^{-1} fb one HW over rest of the weed management practices.

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

Roy *et al.* (2009) carried out an experiment to investigate the effect of herbicides on weed infestation and yield performance of *boro* rice (cv. Iratom-24) in direct seeding method. It was observed that Machete 5G and Ronstar 25 EC herbicides had no significant on 1000-grain weight.

Dhiman *et al.* (2006) showed that all the other weed control methods recorded higher 1000-seed weight than the control. Kalyanasundaram *et al.* (2006) conducted reported that 1.5 kg Butachlor ha^{-1} with Safener at 4 DAS + HW at 30 DAS gave the highest 1000-grain weight.

Raju *et al.* (2003) observed the effect of pre emergence application of Pretilachlor plus Safener 0.3 kg ha^{-1}, Butachlor 1 kg ha^{-1} and post emergence herbicide like Butanil 3.0 kg ha^{-1} on 4, 8 and 15 DAS. They found that Pretilachlor plus Safener 0.3 kg ha^{-1} gave the highest 1000-grain weight. Nair *et al.* (2002) observed that application of Butachlor @ 1.25 kg ha^{-1} along with one HW 40 DAT recorded higher 1000-grain weight.

2.2.3.9 Grain yield

Ghosh *et al.* (2016) revealed that herbicidal treatments improved the grain yield (2.7 to 5.5 times) over weedy check. Besides, the early control of weeds is a better prescription to improve rice yield. Based on the grain yield and herbicidal WCE, it can be concluded that the combined application of pendimethalin or clomazone as pre emergence followed by bispyribac-sodium as post emergence or tank-mixture of clomazone + bispyribac sodium can effectively control different weed flushes throughout the crop growth period in DSR.

Kishore *et al.* (2016) showed that both chemical and mechanical methods of weed control were found superior over weedy check. The highest grain yield of 30.40 and 32.60 q ha^{-1} were recorded with two HW which was at par with Butachlor @ 1.0 kg ha^{-1} fb one HW over rest of the weed management practices.
Muhammad *et al.* (2016) set up a two year field study to evaluate the effect of various weed control measures on grain yield of DSR. They found that the extent of weed control (compared to a non-weeded control) ranged from 50-95%. The highest crop yield was obtained using hand weeding. Hand weeding, tine cultivation and herbicide treatment (Nominee 100 SC) raised the number of fertile rice tillers formed per unit area and the 1000-grain weight. Tine

cultivation provided an effective and economical level of weed control in the DSR crop.

Antralinaa *et al.* (2015) aimed to study the effect of difference weed control methods on rice yield. The results showed that weed control using herbicides containing Bispyribac sodium and 2, 4 D + Methyl metsulfuron showed similar results as manual weed control on rice yield. Chauhana *et al.* (2015) conducted a field study to evaluate the performance of five rice establishment methods and four weed control treatments on weed management, and rice yield. They observed that the weed-free plots and herbicide treatments produced 84-614% and 58-504% higher rice grain yield, respectively, than the weedy plots in 2012, and a similar trend was observed in 2013.

Chowdhury *et al.* (2015) reported that Sunrice® 150WG as pre-emergence herbicide controlled weeds very successfully which performed better in response of yield contributing characters of rice. Application of Sunrice® 150WG achieved highest grain yield which was 50.73%, 32.07%, 11.95% and 5.25% higher than the yield obtained from control, one HW, two HW and Topstar® 400SC treated plots, respectively.

Prasuna and Rammohan (2015) carried out a field experiment to examine the effect of different weed management practice on yield attributes of aerobic rice. Among the different weed management practices, the result indicates that weed free or pretilachlor plus @ 0.75Kg ha^{-1} or pendimethalin 1.00 Kg ha^{-1} found to be best option for both yield of rice. The study also advocated for chemical weed control under the labour scarcity situations. The combination of pre and post emergent herbicides application is recommended.

Ahmed and Chauhan (2014) conducted a field study to evaluate the performance of sequential applications of pre-emergence herbicides (oxadiargyl 80 g a.i. ha^{-1}, pendimethalin 850 g a.i. ha^{-1}, acetachlor + bensulfuran methyl 240 g a.i. ha^{-1}, and pyrazosulfuron 15 g a.i. ha^{-1}) followed by a post-emergence herbicide (ethoxysulfuron 18 g a.i. ha^{-1}) in dry-seeded rice. Compared with the partial weedy plots (hand weeded once), oxadiargyl followed by ethoxysulfuron (4.13 t ha^{-1}) provided a 62% higher yield in the boro season while oxadiargyl followed by a one-time HW (4.08 t ha^{-1}) provided a 37% higher yield in the *aman* season. Ahmed *et al.* (2014) conducted the experiments in the *aman* seasons of 2012 and 2013 in Bangladesh to evaluate the effect of weed infestation level (partially-weedy and weed-free) on weed and crop growth in DSR. Under weed-free conditions, higher crop yields (5.1 and 5.2 t ha^{-1} in the 2012 and 2013 seasons, respectively) were obtained at the seeding rate of 40 kg ha^{-1} and thereafter, yield decreased slightly beyond 40 kg seed ha^{-1}. Under partially-weedy conditions, yield increased by 30 to 33% (2.0-2.2 and 2.9-3.2 t ha^{-1} in the 2012 and 2013 seasons, respectively) with increase in seeding rate from 20 to 100 kg ha^{-1}.

Ehsanullah *et al.* (2014) conducted a field trial to evaluate the efficacy of different weed control methods and to determine an optimum sowing time for DSR. They found that HW and chemical weed control gave 97% and 84% weed control, respectively, over weedy check. Reduced weed intensity and biomass in hand-weeded plots resulted in better crop growth and ultimate yield.

Mubeen *et al.* (2014) conducted 2 year field experiments to determine the effects of three seeding dates and seven weed control methods in DSR. Amongst weed control methods, penoxsulam followed by hand-hoeing at 30 days after seeding (DAS) reduced weed density as low as ≤ 6 and ≤ 28 plants m^{-2} at 35 DAS and at harvest, respectively during both the years which was comparable with hand-hoeing at 15, 30 and 45 DAS. In addition, grain yield in this treatment was 70 and 61% higher compared to nontreated control during 2008 and 2009, respectively. They concluded that penoxsulam would be an additional chemical tool if integrated with hand-hoeing for weed control in DSR.

Parameswari and Srinivas (2014) reported that twice HW at 20 and 40 DAS/T in direct sown rice and transplanted rice and cono weeding thrice from 20 DAT with 10 days interval in SRI resulted in superior grain yield by rice and it was on par with bensulfuron methyl 60 g + pretilachlor 600 g a.i ha^{-1} *fb* mechanical weeding at 30 DAS/T due to better control of weeds.

Pournasrollah *et al.* (2014) found Londux had the highest effect on all of the weeds except *Cyperus globosus* Aublet. Hoe weeding effect was nearly same as Sunriceplus. All of the herbicides were effective on weeds in compare of weedy check. All the weed control treatments and hoe weeding significantly reduced weed growth and resulted in higher rice grain yields than the respective weedy check. Among the various herbicide treatments tested application of Sunriceplus (Anilofus + Auto oxisulforon), Stuff (Sinosulforon), Londux (Bensulforon-methyl) + Machete-EN (Botakolor), Londux (Bensulforon-methyl) and hoe weeded control consistently combined effective weed control with good crop growth and high grain yields with 2175, 2092/5, 1940, 1897/5 and 18 kg ha^{-1} comparable to the weedy check (1065 kg ha^{-1}).

Sale (2014) conducted an experiment to study the effect of weed management practices on the performance of *boro* rice. He found that weed removal by Panida (pre-emergence herbicide) + one HW at 35 DAT treatment resulted in the lowest weed population and weed dry weight (g m^{-2}). The highest grain yield was produced in application of Panida + one HW at 35 DAT treatment and followed by application of Manage (early post emergence herbicide) + one HW at 35 DAT treatment due to the production of highest number of effective tillers hill^{-1}, weight of 1000-grain. So, for controlling weeds in effective manner and in order to get the highest grain yield in *boro* rice, application of Panida + one HW at 35 DAT may be recommended.

Singh and Singh (2014) undertaken a field study to evaluate the crop establishment and weed management options for DSR. They found the maximum grain yield found with application pendimethalin 1000 g ha^{-1} (preem) *fb* azimsulfuron 35 g ha^{-1} at 15-20 DAS + one HW at 40 DAS and which was significantly superior over rest of the treatments during both the years of experimentation.

Hossain and Rahman (2013) applied three herbicides on BR11 paddy field to control weeds and also to study the yield components and yield. The effect of herbicides was found to be positive in controlling the weed species and in increasing the yield components and yield. The maximum grain yield was found at normal dose of Rifit 500 EC was applied. Different doses of Machete 5G were also found effective in controlling weeds and increasing in yield. Survase *et al.* (2013) revealed that, the highest grain yield of rice was recorded with two hoeing and two weeding at 20 and 40 DAT.

Pasha *et al.* (2012) carried out a field experiment to study the effect of several weed control methods on yield and yield components of rice. They showed that herbicide application + HW once had the highest grain yield (4584 kg ha^{-1}), while control treatment because of the high unfilled grains $panicle^{-1}$ and less panicle number m^{-2} had the lowest grain yield (2505 kg ha^{-1}).

Akbar *et al.* (2011) taken weed control methods including hand hoeing, mechanical and chemical control were tested for weed management in direct seeded rice. All the weed control methods were effective in decreasing the total weed density and dry weight over control and improving the rice yield. Higher weed suppression and increase in rice yield was resulted by hand pulling than by the mechanical hoeing. Both hand pulling and mechanical hoeing were better than herbicides in suppression of weed and increasing yield. Maximum increase of 30 % in grain yield over control was observed in hand pulling and that of 25 % in mechanical hoeing. Increase in rice yield due to application of herbicides was 7-19 %. The order of herbicides in suppressing the weeds as well as increasing rice yield was pretilachlor>butachlor>pendimethalin.

Al-Mamun *et al.* (2011) observed that the highest grain yield (6.96 t ha^{-1}) was obtained from Surjamoni when treated with Bouncer 10WP @ 150g ha^{-1}, which was 49% higher than control. BRRI dhan29 produced also the highest grain yield when treated with same treatment, which was 37% higher than control.

Ismail *et al.* (2011) conducted an experiment to determine the efficacy of different methods of weed control and their profitability in interspecific and intra-specific upland rice varieties (*Oryza sativa*). Results showed that three hoe weeding at 25, 45 and 65 DAS, twice at 25 and 45 and at 25 followed by orizo plus at 45 DAS gave better weed control than other treatments. However, hoe weeding at 25, 45 and 65 DAS gave significantly greater grain yield of 3.1 t ha^{-1} compared to other treatments.

Mamun *et al.* (2011) conducted an experiment to find out the efficacy of different post emergence herbicides and select cost effective herbicide as weed control option. They observed that herbicidal treatment Remover 10 WP at 187 g ha^{-1} produced similar yield as three HW but weeding cost of three HW was almost one-sixth of Remover 10 WP at 187 g ha^{-1}.

Ahmed and Bhuiyan (2010) conducted the experiments to study the effect of rice establishment methods and weed management practices on associated weeds and grain yield of rice. Different groups of herbicide + one HW gave statistically similar yield compared with weed free treatments except MCPA500 @ 500g a.i. ha^{-1} + one hand weeded treatments. Interaction effect of ethoxysulfuron 150WG @ 15g a.i. ha^{-1} + one HW in broadcasted method and pretilachlor 500EC @ 500g a.i. ha^{-1} + one HW under drum seeding produced higher grain yield, whereas other combinations of treatments produced intermediate grain yield.

Ali *et al.* (2010) conducted an experiment to evaluate weed control and yield of transplanted *aman* rice (cv. BRRI dhan37) as affected by integrated weed management and spacing and observed that among the weed control treatments Pretilachlor + one HW at 40 DAT performed best for controlling weeds at 30 DAT (79.53%) and moderate for controlling weeds at 60 DAT (75.65%) which ultimately contributed to the highest grain yield (3.60 t 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 (4.08 t ha^{-1}) was obtained from butachlor, while the lowest (2.83t ha^{-1}) grain production was harvested in the plots receiving MCPA @ 125% of the recommended rate.

Gnanavel and Anbhazhagan (2010) conducted a field experiment during 2008-09, to study the bio-efficacy of promising pre and post-emergence herbicides against weeds in transplanted aromatic basmati rice. They concluded that pre-emergence application of oxyfluorfen 0.25 kg ha^{-1} followed by post-emergence application of bispyribac sodium 0.05 kg + metsulfuron methyl @ 0.01 kg ha^{-1} recorded higher grain yield of aromatic rice (5.32 t ha^{-1}).

Jayadeva *et al.* (2010) revealed that application of azimsulfuron 27.5 g ha^{-1} + metsulfuron-methyl 2 g ha^{-1} + 0.2% surfactant was more effective in controlling weeds and recorded higher mean grain yield. Salam *et al.* (2010) carried out a field experiment to evaluate the effect of herbicide on growth and yield in *boro* rice (Bina dhan-5). The highest grain yield (7.15 t ha^{-1}) was found due to application of Machete 5G @ 25 kg ha^{-1}.

Suganthi *et al.* (2010) reported that pre-emergence application of pretilachlor 1.0 kg ha^{-1} and pretilachlor 0.75 kg ha^{-1} with a HW at 45 DAT offered better weed control and resulted in increased yield and economics of transplanted rice compared to the recommended weed control methods of butachlor 1.25 kg ha^{-1}, anilofos 0.4 kg/ha and pretilachlor 0.75 kg ha^{-1}, and HW twice.

Usman *et al.* (2010) conducted an experiment to evaluate the impact of various tillage systems in combination with herbicides on weed density and some physiological traits under rice-wheat cropping system. Results showed that herbicides had significant effect on grain yield.

Pacanoski and Glatkova (2009) conducted an experiment and observed that weed population in the trials was composed of 8 and 5 weed species in Kocani and Probistip locality, respectively. All applied herbicides showed high selectivity to rice, no visual injuries were determined at any rates in any year and locality. Herbicidal treatments in both localities significantly increased rice grain yield in comparison with untreated control.

Roy *et al.* (2009) carried out an experiment to investigate the effect of herbicides on weed infestation and yield performance of *boro* rice (cv. Iratom-24) in direct seeding method. It is evident from the study that pre-emergence application of Machete 5G herbicide at the rate of 25 kg ha^{-1} was more effective for controlling weeds than Ronstar 25EC herbicide. They recorded highest yield (4.65 t ha^{-1}) from Machete 5G herbicide.

Hasanuzzaman *et al.* (2008) conducted an experiment to study the efficacy of different herbicides over manual weeding in controlling weeds in transplanted rice. Ronstar® 25EC @ 1.25 L ha^{-1} + IR5878® 50 WP @ 120 g ha^{-1} was the highest yielding herbicide treatment, reaching the yield level of the two HW treatments. Malek (2008) conducted an experiment to study effect of weeding regime on performance of transplanted *aus* rice (cv. BR26). He obtained the highest grain yield due to two times weeding at 15 and 30 DAT and lowest value was obtained from no weeding treatment.

Aktaruzzaman (2007) reported that the highest grain yield was obtained from weed free treatment and the lowest value was obtained from no weeding treatment. Mukherjee and Malty (2007) conducted an experiment in transplanted rice, with Butachlor 1.0 kg ha^{-1} at 3 DAT + almix 20 WP (Chlorimuron-ethyl+ Metsulfuron-methyl) 4.0 g ha^{-1} at 20 DAT registered higher grain yield (3.17 and 3.50 t ha^{-1}) comparable with season long weed control weed-free condition.

Samar *et al.* (2007) conducted an experiment to evaluate the effects of herbicides for managing weeds and optimizing the yield of wet seeded rice. It was concluded that application of Pendimethalin (1000 g a.i. ha^{-1}) or Pretilachlor with Safener (500 g a.i. ha^{-1}) as pre-emergence applications followed by one hand-weeding were effective in controlling weeds, increasing grain yield of rice than the weed-free treatment.

Ashraf *et al.* (2006) made an experiment for screening of herbicides for weed management in transplanted rice (cv. Basmati-2). In the second year the maximum control of weeds was 94.67% in the case of HW. In terms of paddy yield, HW gave the highest grain yield but remained statistically at par with certain herbicides. Baloch *et al.* (2006) made an experiment to evaluate the effect of weed control practices on the productivity of transplanted rice. Among weed management tools, the maximum paddy yield was obtained in HW, closely followed by Butachlor (Machete 60EC) during both cropping seasons.

Dhiman *et al.* (2006) showed that butachlor + one HW gave the highest grain yield (70.61 q ha^{-1}). Kalyanasundaram *et al.* (2006) conducted field experiments to determine the suitable integrated weed management practice without causing any phytotoxicity to rice seedlings. 1.5 kg Butachlor ha^{-1} with Safener at 4 DAS + HW at 30 DAS gave the highest grain yield.

Khan and Ashraf (2006) conducted an experiment to evaluate the effects of herbicides on weed control and paddy yield in rice. The treatments were Machete @ 1.5 kg ha^{-1}, Ronstar @ 2.0 litre ha^{-1}; and Saturn @ 3.2 litre ha^{-1}. They found that Machete@ 1.5 kg ha^{-1} gives the highest grain yield (5.65 t ha^{-1}) than weedy plot (3.67 t ha^{-1}). Mahadi *et al.* (2006) conducted an experiment to evaluate the performance of weeding and some herbicides. The treatments were two HW and Butachlor @ 21 a.i ha^{-1} cinosulfuron @ 0.06 kg a.i ha^{-1}. All the treatments increase the rice grain yield.

Manish *et al.* (2006) said that *Alternanthera triandra, Echinochloa colona, Fimbristylis miliacea* and *Xanthium strumarium* were the dominant weeds associated with the transplanted rice. Results revealed that HW at 15 and 30 days after transplanting gave the highest grain yield. Other than weed free condition, the highest grain yield (5.9 t h^{-1}) was produced by BR 11 under two HW.

Subramanian *et al.* (2006) conducted an experiment to study the effect of integrated weed management practices on weed control and yield of wet seeded rice. The combination of pre-emergence herbicides + one HW at 25 DAT will reduced weed density, dry weight and higher weed control efficiency, resulting in higher grain yield (5.83 t ha^{-1}).

Tripathi and Lal (2006) conducted the experiment with different herbicides, their combination and dose, manual and cultural methods. As compared to weed free situation (7.4 t ha^{-1}) situation there was only 1.4, 1.3 and 9.0 per cent reduction in grain yield under Anilophos + 2,4-DEE (0.4 + 0.53 kg a.i. ha^{-1}), two HW and Butachlor (1.5 kg a.i. ha^{-1}). None of the herbicides were found significantly superior to the Butachlor (1.5 kg a.i. ha^{-1}) herbicide check.

2.2.3.10 Straw yield

Singh and Singh (2014) undertaken a field study to evaluate the crop establishment and weed management options for DSR. They found the maximum straw yield found with application pendimethalin 1000 g ha^{-1} (preem) *fb* azimsulfuron 35 g ha^{-1} at 15-20 DAS + one HW at 40 DAS and which was significantly superior over rest of the treatments during both the years of experimentation.

Hossain and Rahman (2013) applied three herbicides on BR11 paddy field to control weeds and also to study the yield components and yield and the maximum straw yield ha^{-1} was found at normal dose of Rifit 500 EC was applied. Survase *et al.* (2013) revealed that, the highest straw yield of rice was recorded with two hoeing and two weeding at 20 and 40 DAT.

Jayadeva *et al.* (2010) revealed that application of azimsulfuron 27.5 g ha^{-1} + metsulfuron-methyl 2 g ha^{-1} + 0.2% surfactant was more effective in controlling weeds and recorded higher mean straw yield. Salam *et al.* (2010) recorded the highest straw yield (7.37 t ha^{-1}) due to application of Machete 5G @ 25 kg ha^{-1}.

Dhiman *et al.* (2006) showed that butachlor + one HW gave the highest straw yield (84.13 q ha^{-1}). Manish *et al.* (2006) revealed that HW at 15 and 30 DAT (days after transplanting) gave the highest straw yield.

2.2.3.11 Biological yield

Singh and Singh (2014) undertaken a field study to evaluate the crop establishment and weed management options for DSR. They found the maximum biological yield found with application pendimethalin 1000 g ha^{-1} (preem) *fb* azimsulfuron 35 g ha^{-1} at 15-20 DAS + one HW at 40 DAS and which was significantly superior over rest of the treatments during both the years of experimentation.

2.2.3.12 Harvest index

Manish *et al.* (2006) revealed that HW at 15 and 30 DAT (days after transplanting) gave the highest harvest index. Dhiman (2005) made an experiment to see the efficacy of different preemergence herbicide for weed control in rice (cv. Sarju 52). The pre-emergence herbicides were applied at 8 DAT. HW and Almix + 2, 4-D registered the harvest index (44.88 and 44.90).

Chandra and Solanki (2003) studied the effect of herbicides on the yield characteristics of direct sown flooded rice. They found that two HW produced the highest harvest index (33.97%). Jena *et al.* (2002) reported that preemergence application of Oxadiazon supplemented with HW at 45 DAT recorded the highest harvest index.

2.3 Irrigation Management on rice

2.3.1 Yield response to water

Moutonnet (2002) stated that water is essential for crop production, and any shortage has an impact on final yield. Therefore, farmers have a tendency to over-irrigate, an approach that runs counter to the conservation of scarce resources. At present, owing to the global expansion of irrigated areas and the limited availability of irrigation water, there is a need to optimize WUE in order to maximize crop yields under frequently occurring situations of deficit irrigation (Kang *et al.*, 2000).

When water supply does not meet the crop water requirements, the crop evapotranspiration will decrease. Under this condition, water stress will develop in the plant, which will adversely affect crop growth and, ultimately, crop yield. The effect of water stress and crop growth and yield depends on the crop species and variety on one hand and the magnitude and the time of occurrence of water deficit on the other. The effect of the magnitude and the timing of water deficit on crop growth and yield are of major importance in scheduling available but limited water supply over growing periods of the crops, and in determining the priority of water supply amongst crops during the growing season (FAO, 1986).

According to Andreas and Karen (2002), the most common effect of water stress is a decreased rate of growth and development of foliage. This has a cumulative effect through the season as plant stress early in crop development results in a reduced leaf area. This means that light interception is reduced, carbon assimilation is reduced and therefore the rate of leaf growth is reduced.

2.3.2 Deficit irrigation

Deficit irrigation is a watering method that can be applied by different types of irrigation application methods. It is an optimization strategy in which irrigation is applied during drought-sensitive growth stages of a crop. Outside these periods, irrigation is limited or even unnecessary if rainfall provides a minimum supply of water. Water restriction is limited to drought-tolerant phenological stages, often the vegetative stages and the late ripening period. Total irrigation application is therefore not proportional to irrigation requirements throughout the crop cycle. While this inevitably results in plant drought stress and consequently in production loss, deficit irrigation maximizes irrigation water productivity, which is the main limiting factor (Zhang and Oweis, 1999). In other words, deficit irrigation aims at stabilizing yields and at obtaining maximum crop water productivity rather than maximum yields.

The correct application of deficit irrigation requires understanding of the yield response to water (crop sensitivity to drought stress) and of the economic impact of reductions in harvest. In regions where water resources are restrictive it can be more profitable for a farmer to maximize crop water productivity instead of maximizing the harvest per unit land (English, 1990). The saved water can be used for other purposes or to irrigate extra units of land (Fereres and Soriano, 2007). Deficit irrigation is sometimes referred to as incomplete supplemental irrigation (Kipkorir *et al.*, 2001).

The main objective of deficit irrigation is to increase the water use efficiency (WUE) of a crop by eliminating irrigations that have little impact on yield. The resulting yield reduction may be small compared with the benefits gained through diverting the saved water to irrigate other crops for which water would normally be insufficient under traditional irrigation practices. Crops or crop varieties that are most suitable for deficit irrigation are those with a short growing season and are tolerant of drought (Stewart and Musick, 1982).

2.3.3 Effect of irrigation water management on growth and yield of rice

Water is one of the most important factors in rice production. Many investigators and researchers have reported that water requirement in rice field varies with crop species and the growth stages of crop. Initially, crop needs less amount of water and reaches its peak at the reproductive stages to fulfill the crop demand. When supply of water is less than the demand, the crop faces the water stress. If the crop is subjected to water stress, it affects the physical characters of rice plant, growth, yield and nutrient status of the soil. So, it is necessary to determine the tolerable limit of drying duration of rice field to obtain satisfactory yield. Many scientists and researchers have also reported the influence of irrigation on the increase of yield and yield components of rice. Some of their findings are summarized below.

2.3.3.1 Plant height

Ghosh *et al.* (2015) showed that BRRI dhan27 gave the highest plant height (153.59cm) under irrigated condition. Under rainfed condition also the same variety showed the maximum plant height (147.37cm). Khairi *et al.* (2015a) showed that plant height gradually increased with increasing plant age but AWD treatment affected plant height after 49 DAP. Khairi *et al.* (2015b) showed AWD treatment significantly decreased plant height (9%) compared to the control.

Ghosh *et al.* (2016) conducted a field experiment to explore the potentiality of growing rice varieties under limited supply of irrigation water. Water management practices exerted significant influence on plant height of rice. Fonteh *et al.* (2013) carried out a study to compare the performance of local varieties of rice under different water management practices and reported that the various water management practice do not significantly affect plant height.

Shahriar (2013) conducted an experiment to study the influence of AWD irrigation system on the growth of *boro* rice (BRRI dhan29). Results revealed that the highest plant height (88.20 cm) was found from irrigation when start after disappearance of water by naked eyes. Talpur *et al.* (2013) conducted the study to evaluate the effect of different water depths on the growth rice crop. Result indicated that 5 cm is optimum water depth for vegetative and mid stage (transplanting to mid drainage) of the rice crop growth.

Tilahun-Tadesse *et al.* (2013) conducted a field experiment to determine appropriate water management practices for rainfed lowland rice production. Results of the experiment indicated that with continuous flooding, plant height was highly depressed but improved when drainage and aeration was practiced. Amiri *et al.* (2009) studied the effect of irrigation method on growth and yield of rice varieties. They showed that plant height in submerge and 5 day interval irrigation management are placed to one group, therefore it can be recommended that 5 day interval irrigation are placed on submerge irrigation.

Juraimi *et al.* (2009) conducted an experiment to evaluate the effect of different flooding treatments on rice growth and yield. The results showed that the response of rice plant to water soil availability varies with its growing stage. At an early stage of rice plant growth (15 and 30 DAS), flooding treatments were found to not affect the growth of rice plant significantly. All flooding regimes significantly favored rice plant height compared to non-flooded regimes condition. Oliver *et al.* (2008) revealed that reduced plant height was found with the increasing water stress.

2.3.3.2 Leaf area index

Ghosh *et al.* (2015) showed that BRRI dhan27 gave the highest LAI (3.11) under irrigated condition. Under rainfed condition also the same variety showed the maximum LAI (2.33). Tilahun-Tadesse *et al.* (2013) conducted a field experiment to determine appropriate water management practices for rainfed lowland rice production. Results of the experiment indicated that with continuous flooding, LAI was highly depressed but improved when drainage and aeration was practiced. Wang *et al.* (2010) investigated a field experiment consisting of three levels of 1, 4 and 7 cm irrigation water depth. They found that LAI increased as the irrigation water depth increased.

2.3.3.3 Dry matter content

Ghosh *et al.* (2015) showed that BRRI dhan27 gave the highest total dry matter (TDM) (883.35 g m^{-2}) under irrigated condition. Under rainfed condition also the same variety showed the maximum TDM (840.48 g m^{-2}). Sariam (2009) conducted a planthouse study to evaluate the effect of irrigation practice on rice root growth and yield. He found that shoot dry weight of rice did not differ significantly between flooded and non flooded-saturated, but significantly lower under non flooded-field capacity condition. Results suggested that reducing irrigation water and maintaining the soil at non flooded-saturated conditions will not affect shoot growth of irrigated rice.

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

2.3.3.4 Crop Growth Rate

Tilahun-Tadesse *et al.* (2013) conducted a field experiment to determine appropriate water management practices for rainfed lowland rice production. Results of the experiment indicated that with continuous flooding, CGR was highly depressed but improved when drainage and aeration was practiced.

Ghosh *et al.* (2015) found that BRRI dhan27 gave the highest CGR (41.36 g m^{-2} day^{-1}) under irrigated condition. Under rainfed condition also the same variety showed the maximum CGR (39.21 g m^{-2} day^{-1}).

2.3.3.5 Relative Growth Rate

Ghosh *et al.* (2015) reported that at 24-31 DAS, the highest RGR (0.244 g g^{-1} day^{-1}) was found in Nerika1 under irrigated treatment.

2.3.3.6 Net Assimilatiob Rate

Tilahun-Tadesse *et al.* (2013) conducted a field experiment to determine appropriate water management practices for rainfed lowland rice production. Results of the experiment indicated that with continuous flooding, NAR was highly depressed but improved when drainage and aeration was practiced. Ghosh *et al.* (2015) showed that at 24-31 DAS, the highest and NAR (0.0202 g m^{-2} day^{-1}) were found in Nerika1 under irrigated treatment.

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

Haque *et al.* (2015) conducted a field experiment in *boro* season with a view to find out the influence of water level on growth and yield of *boro* rice. They reported that stagnation of water and continuous 2-5 cm standing water in the field had no significant effect on number of effective tillers $hill^{-1}$ of *boro* rice. Khairi *et al.* (2015b) showed AWD treatment significantly decreased tillers number, compared to the control.

Karim *et al.* (2014) carried out an experiment to evaluate yield and resource use efficiency of transplanted boro rice under two tillage and three irrigation methods. Irrigation showed non-significant effect on number of tillers m^{-2}. Nasir *et al.* (2014) conducted an experiment to study the influence of AWD irrigation system on growth and yield of *boro* rice. Maximum number of effective tillers $hill^{-1}$ (21.5) was found from irrigation at water table in the porous tube at 10 cm. Jafari *et al.* (2013a) found that number of total tillers $hill^{-1}$ was decreased with flooding. Shahriar (2013) conducted an experiment to study the influence of AWD irrigation system on the growth and yield of *boro* rice (BRRI dhan29). Results revealed that the highest number of effective tillers $hill^{-1}$ (21.50) was found irrigation when start at water table in the porous tube at 5cm.

Tilahun-Tadesse *et al.* (2013) conducted a field experiment to determine appropriate water management practices for rainfed lowland rice production. Results of the experiment indicated that with continuous flooding, number of productive tillers was highly depressed but improved when drainage and aeration was practiced.

Oliver *et al.* (2008) revealed that reduced the number of effective tillers $hill^{-1}$ was found with the increasing water stress. Wang *et al.* (2010) investigated a field experiment consisting of three levels of 1, 4 and 7 cm irrigation water depth. The trends were found that tiller numbers $hill^{-1}$ increased as the irrigation water depth increased.

Juraimi *et al.* (2009) conducted an experiment to evaluate the effect of different flooding treatments on rice growth and yield. The results showed that all flooding regimes significantly favored rice the number of tillers as compared to non-flooded regimes. Gani *et al.* (2002) reported that intermittent (AWD) irrigation consistently performed better than CF irrigation that is it produced more effective tillers.

2.3.3.8 Number of filled grains panicle^{-1}

Haque *et al.* (2015) conducted a field experiment in *boro* season with a view to find out the influence of water level on growth and yield of *boro* rice. They reported that stagnation of water and continuous 2-5 cm standing water in the field had no significant effect on number of filled grains panicle^{-1} of *boro* rice.

Khairi *et al.* (2015a) recorded that AWD treatment significantly reduced total grains panicle^{-1} compared to other treatments. Filled grains panicle^{-1} was found to be similar trend with total grain panicle^{-1}. Khairi *et al.* (2015b) showed AWD treatment significantly decreased filled grains compared to the control.

Karim *et al.* (2014) carried out an experiment to evaluate yield and resource use efficiency of transplanted boro rice under two tillage and three irrigation methods. Irrigation had non-significant on number of filled grains panicle^{-1}. Nasir *et al.* (2014) studied the influence of AWD irrigation system on growth and yield of *boro* rice. Maximum number of grains panicle^{-1} (215.5) was found from irrigation at water table in the porous tube at 10 cm.

Jafari *et al.* (2013a) found that total spikelets number hill^{-1} in flooding irrigation was higher than deficit irrigation. Shahriar (2013) conducted an experiment to study the influence of AWD irrigation system on the growth and yield of *boro* rice (BRRI dhan29). Results revealed that the maximum number of grain panicle^{-1} (215.73) was found irrigation started when water table in the porous tube at 5 cm which were closely followed by continuous submergence (1 to 7 cm standing water).

Tilahun-Tadesse *et al.* (2013) conducted a field experiment to determine appropriate water management practices for rainfed lowland rice production. Results of the experiment indicated that with continuous flooding, number of filled spiklets was highly depressed but improved when drainage and aeration was practiced.

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

2.3.3.9 Number of unfilled grains panicle^{-1}

Haque *et al.* (2015) conducted a field experiment in *boro* season with a view to find out the influence of water level on growth and yield of *boro* rice. They reported that stagnation of water and continuous 2-5 cm standing water in the field had no significant effect on number of unfilled grains panicle^{-1} of *boro* rice. Khairi *et al.* (2015b) showed AWD treatment significantly increased unfilled grains compared to the control.

Karim *et al.* (2014) carried out an experiment to evaluate yield and resource use efficiency of transplanted boro rice under two tillage and three irrigation methods. Irrigation had non-significant on number of unfilled grains panicle^{-1}.

2.3.3.10 Panicle length

Haque *et al.* (2015) conducted a field experiment in *boro* season with a view to find out the influence of water level on growth and yield of *boro* rice. They reported that stagnation of water and continuous 2-5 cm standing water in the field had no significant effect on panicle length of *boro* rice. Nasir *et al.* (2014) conducted an experiment to study the influence of AWD irrigation system on growth and yield of *boro* rice. Maximum panicle length (31.5 cm) was found from irrigation at water table in the porous tube at 10 cm.

Shahriar (2013) conducted an experiment to study the influence of AWD irrigation system on the growth and yield of *boro* rice (BRRI dhan29). Results revealed that the highest panicle length (31.53 cm) was found in irrigation when started water table in the porous tube at 5 cm which were closely followed by continuous submergence (1 to 7 cm standing water).

Amiri *et al.* (2009) studied the effect of irrigation method on growth and yield of rice varieties. They showed that panicle length in submerge and 5 day interval irrigation management are placed to one group, therefore it can be recommended that 5 day interval irrigation are placed on submerge irrigation.

2.3.3.11 1000-grain weight

Haque *et al.* (2015) conducted a field experiment in *boro* season with a view to find out the influence of water level on growth and yield of *boro* rice. They reported that stagnation of water and continuous 2-5 cm standing water in the field had no significant effect on 1000-grain weight of *boro* rice. Khairi *et al.* (2015a) reported that 1000-seed weight insignificantly differed.

Karim *et al.* (2014) carried out an experiment to evaluate yield and resource use efficiency of transplanted *boro* rice under two tillage and three irrigation methods. Irrigation had non-significant effect on 1000-grain weight. Nasir *et al.* (2014) conducted an experiment to study the influence of AWD irrigation system on growth and yield of *boro* rice. Maximum 1000-grain weight (24.0 g) was found from irrigation at water table in the porous tube at 10 cm.

Shahriar (2013) conducted an experiment to study the influence of AWD irrigation system on the growth and yield of *boro* rice (BRRI dhan29). Results revealed that the highest 1000-grain weight (24.00 g) was found when irrigation was started water table in the porous tube at 5 cm which were closely followed by continuous submergence (1 to 7 cm standing water).

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

2.3.3.12 Grain yield

Pascual and Wang (2017) conducted a field experiment to determine the most suitable ponded water depth for enhancing water saving in paddy rice irrigation.

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

Haque *et al.* (2015) conducted a field experiment in *boro* season with a view to find out the influence of water level on growth and yield of *boro* rice. They reported that stagnation of water and continuous 2-5 cm standing water in the field had no significant effect on grain yield of *boro* rice. Khairi *et al.* (2015a) showed whether low input water affects yield and yield parameters of salinity rice variety. They found that AWD treatment significantly ($P<0.04$) reduced rice yield. Khairi *et al.* (2015b) showed AWD treatment significantly decreased grain yield compared to the control.

Khan *et al.* (2015) conducted an experiment to investigate the effect of irrigation water management practices and rice productivity during *boro* season. They observed that AWD (irrigated at 5cm depth, 3 day in a week and 4 days drying) treatment gave highest yield 5.76 t ha^{-1} and 6.713 t ha^{-1}, respectively in BRRI dhan28 and BINA Dhan-8. Timon *et al.* (2015) showed that there were significant differences in grain yield of rice.

Ghosh *et al.* (2016) conducted a field experiment to explore the potentiality of growing rice varieties under limited supply of irrigation water. Water management practices exerted significant influence on grain yield and the highest grain yield (3.38 t ha^{-1}) was recorded under continuously flooded water regime (CF). Limited supply of irrigation water at different stages of growth decreased grain yield ranging from 27.5 to 43.5 % compared to that in CF. Rice genotypes exhibited differential response to water management practices. Though UPLRi -7 produced the highest grain yield (4.39 t ha^{-1}) under CF, under limited water supply IR -36 was still the best variety producing the highest average grain yield (3.31 t ha^{-1}).The present research work pointed out that without ensuring adequate supply of irrigation water rice cultivation during *boro* season may not be profitable in the Red and Laterite zone of West Bengal.

Karim *et al.* (2014) carried out an experiment to evaluate yield and resource use efficiency of transplanted boro rice under two tillage and three irrigation methods. Grain yield was 7.62% higher in sprinkler and 4.72% higher in AWD irrigation method over flood irrigation method. Nasir *et al.* (2014) conducted an experiment to study the influence of AWD irrigation system on growth and yield of *boro* rice. The highest grain yield (7.8 t ha^{-1}) was found from irrigation at water table in the porous tube at 10 cm.

Rahman and Bulbul (2014) conducted a field experiment to find out possible effect of AWD on the yield of *boro* rice. The study revealed that application of 5 cm irrigation water when water level in the pipe fell 15 cm below the ground level, gave the highest yield (5.69 t ha^{-1}) compared to continuous submergence (1 to 5 cm standing water). The yields in application of 5 cm irrigation water when water level in the pipe fell 20 cm below the ground level (5.45 t ha^{-1}) and application of 5 cm irrigation water when water level in the pipe fell 25 cm below the ground level (5.27 t ha^{-1}) were significantly lower at 1% level of significance compared to continuous submergence (1 to 5 cm standing water).
Devkota *et al.* (2013) conducted field experiments in a rice-wheat cropping system to evaluate irrigation technologies and to identify the underlying processes responsible for possible reductions in rice yield. They stated that, the use of AWD reduced irrigation amount to only 30% of the amount of water applied to continuously flooded rice. However, yield of residue removed AWD

treatments was lower than yield of the continuously flooded treatment by 27% in 2008 and by 40% in 2009. The significant reduction in rice yield in all treatments with AWD was caused by reduced growth rate, resulting in lower biomass, leaf area, panicle density, number of florets panicle^{-1}and floret fertility, with significant differences in the second year. In 2008, this appeared to be due to water deficit stress in the AWD treatments. In 2009, the reduction in growth and yield with AWD was greater and more.

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

Jafari *et al.* (2013a) found that grain yield in flooding irrigation was 31 kg ha^{-1} higher than that of deficit system. Shahriar (2013) conducted an experiment to study the influence of AWD irrigation system on the growth and yield of *boro* rice (BRRI dhan29). Results revealed that different levels of irrigation had significant effect on the yield and yield parameters. The highest grain yield (7.70 t ha^{-1}) was found in irrigation when started water table in the porous tube at 5 cm which were followed by continuous submergence (1 to 7 cm standing water).

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

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

Akter (2012) conducted an experiment to evaluate the effect of irrigation and moisture retainer on the growth and yield of *boro* rice (BRRI dhan29). It was observed that the highest grain yield (7.08 t ha^{-1}) was obtained from eight irrigations. Chapagain *et al.* (2011) revealed that AWDI treatment reduced pest and disease incidence, shortened crop cycle, and reduced lodging. However, slightly higher grain yields were observed in all sub-plots of the conventional irrigation treatment than were observed in the same combinations under AWD.

Faruki *et al.* (2011) took an initiative to promote Alternate Wetting and Drying (AWD) technology of *boro* rice to reduce water loss and saving the cost of irrigation for rice production. The study showed that on average 21 numbers/frequencies of irrigation used in AWD technology practice from 15-20 DAT to reproductive stage, whereas farmers practiced was 26 numbers. The average five irrigation applications were saved during the *boro* rice season. So yield increased 62 kg/acre (2.7%) in AWD plot compare to control plots.

Thakur *et al.* (2011) observed that system of rice intensification practices with AWD improve rice plants morphology and it benefits physiological processes that results in higher grain yield water productivity. Lin *et al.* (2011) reported that intermittent water application with system of rice intensification (SRI) management, grain yield increased by 10.5 and 11.3%, compared to standard irrigation practice (continuous flooding). They also reported that intermittent irrigation with organic material application improved the functioning of rhizosohere and increased yield of rice.

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

Wang *et al.* (2010) reported that yields of 1, 4 and 7 cm irrigation water depth treatments were 0.62, 1.38 and 2.62 t ha^{-1}, respectively. They concluded that increasing water depth up to 7 cm increased rice grain yield mainly by increasing rice spikelets $panicle^{-1}$ and percent filled spikelet and alleviating the tillering inhibition.

Amiri *et al.* (2009) studied the effect of irrigation method on growth and yield of rice varieties. They showed that grain yield in submerge and 5 day interval irrigation management are placed to one group, therefore it can be recommended that 5 day interval irrigation are placed on submerge irrigation.

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

Sariam (2009) conducted a planthouse study to evaluate the effect of irrigation practice on rice root growth and yield. He found that grain yield of rice did not differ significantly between flooded and non flooded-saturated, but significantly lower under non flooded-field capacity condition. Results suggested that reducing irrigation water and maintaining the soil at non flooded-saturated conditions will not affect yield of irrigated rice.

Oliver *et al.* (2008) revealed that reduced grain yield was found with the increasing water stress. Islam *et al.* (2005) conducted a study to see the effect of water stress on the growth and yield of three drought tolerant T. *aman* rice and treatment with 3 cm standing water and then stress up to 80% field capacity was the optimum water stress condition which produced the highest yield.

2.3.3.13 Straw yield

Haque *et al.* (2015) conducted a field experiment in *boro* season with a view to find out the influence of water level on growth and yield of *boro* rice. They reported that stagnation of water and continuous 2-5 cm standing water in the field had no significant effect on straw yield of *boro* rice.

Ghosh *et al.* (2016) conducted a field experiment to explore the potentiality of growing rice varieties under limited supply of irrigation water. Water management practices exerted significant influence on height, grain and straw yield and the highest grain yield (3.38 t ha^{-1}) was recorded under CF. Limited supply of irrigation water at different stages of growth decreased grain yield ranging from 27.5 to 43.5 % compared to that in CF. Rice genotypes exhibited differential response to water management practices. Though UPLRi -7 produced the highest grain yield (4.39 t ha^{-1}) under CF, under limited water supply IR -36 was still the best variety producing the highest average grain yield (3.31 t ha^{-1}).The present research work pointed out that without ensuring adequate supply of irrigation water rice cultivation during *boro* season may not be profitable in the Red and Laterite zone of West Bengal.

Karim *et al.* (2014) carried out an experiment to evaluate yield and resource use efficiency of transplanted boro rice under two tillage and three irrigation methods. Irrigation had non-significant effect on straw yield. Nasir *et al.* (2014) conducted an experiment to study the influence of AWD irrigation system on growth and yield of *boro* rice. Maximum straw yield (7.5 t ha^{-1}) was found from irrigation at water table in the porous tube at 10 cm.

Shahriar (2013) conducted an experiment to study the influence of AWD irrigation system on the growth and yield of *boro* rice (BRRI dhan29). Results revealed that the highest straw yield (7.53 t ha^{-1}) was found in irrigation when started water table in the porous tube at 5 cm which were closely followed by continuous submergence (1 to 7 cm standing water). Akter (2012) conducted an experiment to evaluate the effect of irrigation and moisture retainer on the growth and yield of *boro* rice (BRRI dhan29). It was observed that the highest straw yield (6.71 t ha^{-1}) was obtained from ten irrigations. Oliver *et al.* (2008) revealed that reduced straw yield was found with the increasing water stress.

2.3.3.14 Biological yield

Haque *et al.* (2015) conducted a field experiment in *boro* season with a view to find out the influence of water level on growth and yield of *boro* rice. They reported that stagnation of water and continuous 2-5 cm standing water in the field had no significant effect on biological yield of *boro* rice.

Tilahun-Tadesse *et al.* (2013) conducted a field experiment to determine appropriate water management practices for rainfed lowland rice production. Results of the experiment indicated that with continuous flooding, biomass yield was highly depressed but improved when drainage and aeration was practiced. Oliver *et al.* (2008) revealed that reduced biological yield was found with the increasing water stress.

2.3.3.15 Harvest index

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

Timon *et al.* (2015) showed that there were significant differences in harvest index of rice. Oliver *et al.* (2008) revealed that reduced harvest index was found with the increasing water stress.

Sarkar *et al.* (2002) conducted field experiments in two consecutive years on T. *aman* rice to assess the need and amount of supplemental irrigation for its cultivation at two agro-ecological zones of Bangladesh (Mymensingh and Rangpur). The results revealed that in most of the cases, highest harvest index was obtained with continuous standing water.

2.4 Weeds responses to fertilizers

Weeds show variety of responses to different fertilizers under different tillage systems depending upon rate and method of application. Sensitivity of weeds to fertilization depends on their responding ability in terms of weed growth and nitrogen assimilation. As reported by Blackshaw and Brandt (2008), some weed species (e.g. Persian darnel and Russian thistle) exhibited minimal response to N, few (e.g. Redroot pigweed) showed high response as N application rate increases, while very few weed species like wild oat did not affected by any N fertilization level. Nutrients availability influences weed crop competition (Evans *et al.,* 2003), however response varies with type of weed species, crop and nutrient status of soil. Weaver *et al.* (1992) reported nutrients availability as one dynamic approach that can influence duration and extent of competition. Moreover, environmental factors influencing the efficacy and efficiency of fertilizers affect weed dynamics and distribution.

Lindsey *et al.* (2013) examined the aggressiveness of Redroot pigweed and Lambsquarter towards nitrogen assimilation at various N levels. Sweeney *et al.* (2008) studied the effect of N on weeds emergence and growth parameters. Results have shown that N influenced the germination, emergence and competitiveness of different weeds. In some reports, nitrogen fertilizer efficiency was recorded as lower, a result of microorganisms tying up the nitrogen in the residue. However, in other longer-term experiments, release of nutrients increased with time because of more active microbial activity and nutrient recycling (Carpenter-Boggs *et al.,* 2003). Fertilizers may increase the biomass of weeds in fields where its density is already high or they may enhance the density directly through provision of essential nutrients for germination, emergence and establishment of weeds (Alkamper and Long, 1978). But some long term studies have shown contradictory results showing that increased nutrients level reduced the weed abundance but increased their dry matter (Mohammaddoust-e-Chamanadad *et al.,* 2006).

2.4.1 Fertilizer use efficiency and weed management

The fertilizer use efficiency (FUE) in an agricultural system is based on four factors, namely accurate dose of fertilizer having balanced nutrient percentage, safe and precise method of fertilizer application, appropriate timing for application and crop specific fertilizer selection. As suggested by DiTomaso (1995), manipulating fertilization strategies reduces weed interference in crops. Varying fertilizer doses (Cathcart and Swanton, 2003), application timings (Blackshaw *et al.*, 2004) and methods (Mesbah and Miller, 1999) can modify weed crop competition.

2.4.2 Effect of N and weed management on rice growth and yield

2.4.2.1 Plant height

Kumar *et al.* (2015) conducted a field experiment to study the effect of N scheduling and weed management in DSR under irrigated condition. The results indicated that the maximum crop growth was recorded under four N splits. The various weed management treatments significantly increased the growth characters compared with the weedy check. Application of pendimethalin 1.0 kg ha^{-1} fb bispyribac + carfentrazone (25+20 g) ha^{-1} and pendimethalin 1.0 kg ha^{-1} fb bispyribac + ethoxysulfuron (25+18 g) ha^{-1} increased the growth characters comparable to other treatments.

Sahu *et al.* (2015) conducted a field experiment to evaluate the effect of N application and weed management on transplanted rice and associated weeds. Butachlor 1.5 kg ha^{-1} followed by cono-weeding at 20 and 40 DAT recorded significantly higher plant height compared to pretilachlor 0.75 kg ha^{-1} followed by azimsulfuron 35 g ha^{-1} at 15 DAT, and butachlor 1.5 kg ha^{-1} followed by azimsulfuron 35 g ha^{-1} at 15 DAT.

Talukder (2010) carried out a research work to determine the suitable N dose and weeding method to cultivate T. *aman* rice and experimental results indicated that N doses had the significant effect on plant height.

2.4.2.2 Leaf area index

Sahu *et al.* (2015) conducted a field experiment to evaluate the effect of N application and weed management on transplanted rice and associated weeds. Butachlor 1.5 kg ha^{-1} followed by cono-weeding at 20 and 40 DAT recorded significantly higher leaf area index compared to pretilachlor 0.75 kg ha^{-1} followed by azimsulfuron 35 g ha^{-1} at 15 DAT, and butachlor 1.5 kg ha^{-1} followed by azimsulfuron 35 g ha^{-1} at 15 DAT.

2.4.2.3 Dry matter content

Sahu *et al.* (2015) conducted a field experiment to evaluate the effect of N application and weed management on transplanted rice and associated weeds. Butachlor 1.5 kg ha^{-1} followed by cono-weeding at 20 and 40 DAT recorded significantly higher dry matter accumulation compared to pretilachlor 0.75 kg ha^{-1} followed by azimsulfuron 35 g ha^{-1} at 15 DAT, and butachlor 1.5 kg ha^{-1} followed by azimsulfuron 35 g ha^{-1} at 15 DAT.

Awan *et al.* (2014) reported that rice biomass increased by 92-229%, with the application of 50-150 kg N ha^{-1}. Added N favored rice biomass production more than it did the weed. Rice interference reduced the biomass of *I. rugosum*, but did not suppress its growth completely. *I. rugosum* showed the ability to reduce the effects of rice interference by increasing leaf area, leaf weight ratio, and specific leaf area, and by decreasing the root-shoot weight ratio in comparison to the weed plants grown alone. The results suggest that rice crop interference alone may reduce *I. rugosum* growth but may not provide complete control of this weed.

Seema *et al.* (2014) conducted a field experiment to assess the effect of N and weed management practices on yield of rice under direct seeded aerobic rice. The result of the experiment indicated that increment of N dry matter accumulation by the plant also increased. Talukder (2010) carried out a research work to determine the suitable N dose and weeding method to cultivate T. *aman* rice with higher yield harvest. Experimental results indicated that N doses had the significant effect on weight of dry matter hill^{-1}.

2.4.2.4 Number of effective tillers hill^{-1}

Kumar *et al.* (2015) conducted a field experiment to study the effect of N scheduling and weed management in DSR under irrigated condition. N scheduling significantly increased the yield attributing characters and yield of crop. The results indicated that the yield attributing characters were recorded under four N splits.The various weed management treatments significantly increased the yield attributing characters compared with the weedy check. Application of pendimethalin 1.0 kg ha^{-1} fb bispyribac + carfentrazone (25+20 g) ha^{-1} and pendimethalin 1.0 kg ha^{-1} fb bispyribac + ethoxysulfuron (25+18 g) ha^{-1} increased the yield attributing characters comparable to other treatments.

Sahu *et al.* (2015) conducted a field experiment to evaluate the effect of N application and weed management on transplanted rice and associated weeds. Butachlor 1.5 kg ha^{-1} followed by cono-weeding at 20 and 40 DAT recorded significantly higher number of tillers hill^{-1} compared to pretilachlor 0.75 kg ha^{-1} followed by azimsulfuron 35 g ha^{-1} at 15 DAT, and butachlor 1.5 kg ha^{-1} followed by azimsulfuron 35 g ha^{-1} at 15 DAT. Significantly higher yield components were recorded with the application of 1/4 at 10 DAT, 1/2 at tillering and 1/4 N at panicle initiation as compared to conventional scheduling of N application.

Talukder (2010) carried out a research work to determine the suitable N dose and weeding method to cultivate T. *aman* rice with higher yield harvest. Experimental results indicated that N doses had the significant effect on effective tillers hill^{-1}.

2.4.2.5 Number of filled grains panicle^{-1}

Sahu *et al.* (2015) conducted a field experiment to evaluate the effect of N application and weed management on transplanted rice and associated weeds.

Butachlor 1.5 kg ha^{-1} followed by cono-weeding at 20 and 40 DAT recorded significantly higher number of grains panicle^{-1} compared to pretilachlor 0.75 kg ha^{-1} followed by azimsulfuron 35 g ha^{-1} at 15 DAT, and butachlor 1.5 kg ha^{-1} followed by azimsulfuron 35 g ha^{-1} at 15 DAT.

Latheef *et al.* (2011) conducted a study to find out the effect of irrigation schedules, weed management practices and N levels on yield attributes of aerobic rice. Pre-emergence application of pendimethalin @ 1 kg ha^{-1} fb cono weeding at 30 DAS and one HW at 45 DAS recorded significantly higher filled grains panicle^{-1} than that of pre-emergence application of pendimethalin @ 1 kg ha^{-1} fb 2,4-D Na salt @ 1 kg ha^{-1} at 40 DAS and HW at 20 and 45 DAS. Filled grains panicle^{-1} was significantly higher at 180 kg N ha^{-1} during both the years.

Talukder (2010) carried out a research work to determine the suitable N dose and weeding method to cultivate T. *aman* rice the results indicated that N doses had the significant effect on filled grains panicle^{-1}.

2.4.2.6 Panicle length

Talukder (2010) carried out a research work to determine the suitable N dose and weeding method to cultivate T. *aman* rice and experimental results indicated that N doses had the significant effect on panicle length.

2.4.2.7 1000-seed weight

Sahu *et al.* (2015) conducted a field experiment to evaluate the effect of N application and weed management on transplanted rice and associated weeds. Butachlor 1.5 kg ha^{-1} followed by cono-weeding at 20 and 40 DAT recorded significantly higher 1000-grain weight compared to pretilachlor 0.75 kg ha^{-1} followed by azimsulfuron 35 g ha^{-1} at 15 DAT, and butachlor 1.5 kg ha^{-1} followed by azimsulfuron 35 g ha^{-1} at 15 DAT.

2.4.2.8 Grain yield

Ahmed *et al.* (2015) conducted field experiments to evaluate the effect of N rates and weed control methods [one hand weeding (HW); pendimethalin 1000 g ai ha^{-1} followed by (fb) ethoxysulfuron 20 g ai ha^{-1}; pendimethalin fb ethoxysulfuron fb one HW; and weed-free] on weed growth and crop yield in DSR. The highest grain yield (5.3 to 5.5 t ha^{-1}) was recorded in the season-long manual weed-free treatment when N rate was160 kg ha^{-1}; however, because of the high cost of labor, this method was not profitable. The use of pendimethalin fb ethoxysulfuron fb one HW effectively controlled weeds and produced a similar yield with the weed-free treatment. However, weed management cost was also higher because of the involvement of one HW. Although pendimethalin fb ethoxysulfuron treatment had always lower yielded than the pendimethalin fb ethoxysulfuron fb one HW, grain yield increased and net profit was similar when N rate increased from 120 to 160 kg ha^{-1}. However, if laborers are not available for hand weeding, pendimethalin fb ethoxysulfuron with 160 kg N ha^{-1} is the best option to achieve high yield in DSR.

Sahu *et al.* (2015) reported that utachlor 1.5 kg ha^{-1} followed by cono-weeding at 20 and 40 DAT recorded significantly higher grain yield as compared to pretilachlor 0.75 kg ha^{-1} followed by azimsulfuron 35 g ha^{-1} at 15 DAT, and butachlor 1.5 kg ha^{-1} followed by azimsulfuron 35 g ha^{-1} at 15 DAT. Significantly higher yield components and rice grain yield were recorded with the application of 1/4 at 10 DAT, 1/2 at tillering and 1/4 N at panicle initiation as compared to conventional scheduling of N application.

Aminpanah (2014) conducted field experiments to determine if increased rice plant density improves weed control and reduces herbicide application rate. Results showed that rice grain yield increased significantly from 1927 kg ha^{-1} to 3217 kg ha^{-1} as the rate of pretilachlor increased from 0 to 1.5 L ha^{-1}, but there was no further increase in yield above this rate. Grain yield increased significantly as the rate of pretilachlor increased from 0 to 2 L ha^{-1}. In plots treated with recommended rate of pretilachlor (2 L ha^{-1}), there were no significant differences for grain yield, whereas in untreated plots, the grain yield increased by 51%.

Seema *et al.* (2014) conducted a field experiment to assess the effect of N and weed management practices on yield of rice under direct seeded aerobic rice. The result of the experiment indicate that increased N level from 75 to 100 kg ha^{-1} had increased the grain yield significantly (5%) though further increase in N dose (125 kg ha^{-1}) increased the grain yield but that was found non-significant. Among weed management all the weed management practices were found to be equally effective in producing higher grain yield as compare to weedy check.

Chauhan and Abugho (2013a) conducted a study to evaluate the effect of fertilizer placement method on weed growth and grain yield in a DSR system. Non-treated plots yielded 700 to 2080 kg ha^{-1}. Grain yield was similar between the herbicide treated (2660-3250 kg ha^{-1}) and weed free (2620-3430 kg ha^{-1}) plots. Grain yield was not influenced when basal fertilizer was banded within (2390-2500 kg ha^{-1}) or between rows (2530-2650 kg ha^{-1}). However, grain yield decreased when basal fertilizer was broadcast on the soil surface (2200 kg ha^{-1}).

Jafari *et al.* (2013b) revealed that weed control increased grain yield (40.73%) because of less inter-specific competition and increase panicle length. Weeds control treatment and nitrogen treatments (69 and 92 kg ha^{-1}) were best treatments because of increase in grain yield.

Parvin *et al.* (2013) conducted an experiment to investigate the effect of weeding and foliar application of urea on the yield and yield components of *boro* rice cv. BRRI dhan29. Weeding had significant influence on yield and yield contributing characters of *boro* rice cv. BRRI dhan29. Three weedings produced the highest number of total tillers $hill^{-1}$, effective tillers $hill^{-1}$ and grains $panicle^{-1}$, which eventually contributed to the highest grain yield in this treatment. All the yield contributing characters were the most inferior in case of no weeding and thus this treatment gave the lowest grain yield as well as straw yield.

Prakash *et al.* (2013) conducted a field experiment to study the effect of N levels and weed control methods on yield of rice. The results revealed that the rice variety IR-64 recorded maximum grain yield (3.46 t ha^{-1}) with the application of 125 kg N ha^{-1} under aerobic conditions which was statistically at par with application of 100 kg N ha^{-1}. On the other hand, different weed control practices also gave significantly higher grain yield of aerobic rice. The application of Pendimethalin @ 1.0 kg a.i. ha^{-1} at 2 DAS + Rice : Dhaincha (1:1) + 2,4-D Na salt @ 0.80 kg a.i. ha^{-1} at 25 DAS recorded excellent performance and contributed grain yield of 9.53 t ha^{-1}.

Sarker (2013) conducted an experiment to study the efficacy of different levels of N and methods of weeding on the growth and yield of hybrid *boro* rice (Heera 4). Significant highest grain yield (9.48 t ha^{-1}) was found from the combination of USG with Sunrice 150 WG and the lowest (4.66 t ha^{-1}) was from combination of no nitrogen and no weeding.

Latheef *et al.* (2011) conducted a study to find out the effect of irrigation schedules, weed management practices and N levels on yield of aerobic rice. Pre-emergence application of pendimethalin @ 1 kg ha^{-1} fb cono weeding at 30 DAS and one HW at 45 DAS recorded significantly higher grain yield than that of pre-emergence application of pendimethalin @ 1 kg ha^{-1} fb 2,4-D Na salt @ 1 kg ha^{-1} at 40 DAS and HW at 20 and 45 DAS. Grain yield was significantly higher at 180 kg N ha^{-1} during both the years.

Talukder (2010) carried out a research work to determine the suitable N dose and weeding method to cultivate T. *aman* rice with higher yield harvest. Experimental results indicated that N doses had the significant effect on grain yield. N dose 25 % higher than recommended dose showed the highest grain yield (5.34 t ha^{-1}) that mainly attributed by the highest effective tillers $hill^{-1}$ and highest filled grains $panicle^{-1}$. Among the weeding methods HW treatment gave the highest grain yield (4.73 t ha^{-1}) and it was mainly attributed by the highest effective tillers $hill^{-1}$, filled grains $panicle^{-1}$ and 1000-seed weight.

Begum *et al.* (2009) conducted the study to investigate the severity of competition between rice and *Fimbristylis miliacea* with application of different levels of N and different density of *F. miliacea*. The interaction between weed density and N fertilization had a pronounced influence on rice yield. At low weed densities (500 plants m^{-2}), rice yields increased with higher N fertilization. On the other hand, at the higher weed density (1000 plants m^{-2}), increasing N fertilization to 170 kg ha^{-1} had no significant effect on yield. However, rice yield at this level of N fertilization with the lowest weed density of 250 plants m^{-2}, was similar to the weed-free treatment.

Das *et al.* (2007) conducted an experiment to evaluate the effect of N level (0, 60, 90, 120 kg ha^{-1}) and weed control method (no weeding, 3 HW, Rifit 500EC @ 0.5 L ha^{-1}, Rifit 500EC @ 0.75 L ha^{-1}, Rifit 500EC @ 1.0 L ha^{-1}) on the control of weeds and yield of BRRI dhan29. Among the N levels, 120 kg ha^{-1} performed as the best in terms of grain yield (5.47 t ha^{-1}) followed in order of 90 kg ha^{-1} (4.22 t ha^{-1}), 60 kg ha^{-1} (3.29 t ha^{-1}) and 0 kg ha^{-1} (2.45 t ha^{-1}). The highest grain yield (4.77 t ha^{-1}) was achieved from the application of Rifit 500EC @ 1.0 L ha^{-1} followed by 3 HW (4.42 t ha^{-1}). No weeding treatment produced the lowest grain yield (2.69 t ha^{-1}). The highest N level of 120 kg ha^{-1} interacted favourably with Rifit 500EC @ 1.0L ha^{-1} to produce the highest grain yield (6.62 t ha^{-1}) which was statistically similar to that produced by the treatment combination of 120 kg N ha^{-1} and 3 HW. Therefore, higher yield of BRRI dhan29 under drum seeded condition and better weed control could be achieved by the application of 120 kg N ha^{-1} and Rifit 500EC @ 1L ha^{-1}.

2.4.2.9 Straw yield

Prakash *et al.* (2013) revealed that the rice variety IR-64 recorded maximum straw yield (4.84 t ha^{-1}) with the application of 125 kg N ha^{-1} under aerobic conditions which was statistically at par with application of 100 kg N ha^{-1}. The application of Pendimethalin @ 1.0 kg a.i. ha^{-1} at 2 DAS + Rice : Dhaincha (1:1)

+ 2,4-D Na salt @ 0.80 kg a.i. ha^{-1} at 25 DAS recorded excellent performance and contributed straw yield of 5.55 t ha^{-1}.

Talukder (2010) carried out a research work to determine the suitable N dose and weeding method to cultivate T. *aman* rice and the results indicated that N doses had the significant effect on straw yield.

2.4.2.10 Biological yield

Prakash *et al.* (2013) conducted a field experiment to study the effect of N levels and weed control methods on yield of rice. The results revealed that the rice variety IR-64 recorded maximum biological yield (8.30 t ha^{-1}) with the application of 125 kg N ha^{-1} under aerobic conditions which was statistically at par with application of 100 kg N ha^{-1}. On the other hand, different weed control practices also gave significantly higher grain yield of aerobic rice. The application of Pendimethalin @ 1.0 kg a.i. ha^{-1} at 2 DAS + Rice:Dhaincha (1:1) + 2,4-D Na salt @ 0.80 kg a.i. ha^{-1} at 25 DAS recorded excellent performance and contributed biological yield of 9.53 t ha^{-1}.

2.4.2.11 Harvest index

Talukder (2010) carried out a research work to determine the suitable N dose and weeding method to cultivate T. *aman* rice with higher yield harvest. Experimental results indicated that N doses had the significant effect on harvest index. Inamura *et al.* (2003) reported that HI of paddy rice was not suppressed by competition with weeds.

2.5 Water use and N interaction

Gupta (2002) stated that the primary objective of studying soil and plant relations with water is to be able to use water more efficiently in the production of our crops. One way to determine the WUE of a crop is to calculate its productivity per unit of its water requirement.

To increase the WUE of a crop there are two mechanisms we should to apply. The first mechanism is by increasing yield without increasing crop water requirements. These should be achieved through adopting good crop husbandry through proper choice of crops, timely sowing, maintain recommended plant populations, adequate control of weeds, control of insect pests and plant disease, adequate use of fertilizers and controlling surface evaporation through applying crop stubbles, practicing conservation tillage, zero tillage and applying soil mulching. The second mechanism is restricting water requirements of crops. These mechanism achieved through irrigating at critical crop growth stage, choosing right method of irrigation and extensive versus intensive use of irrigation water (Gupta, 2002).

Deficit irrigation is an optimizing strategy under which crops are deliberately allowed to sustain some degree of water deficit and yield reduction. The fundamental goal of deficit irrigation is to increase WUE or water productivity (WP), either by reducing irrigation adequacy or by eliminating the list productive irrigations. It is widely recognized that when water supplies are limited or water costs are high, the economic optimum level of irrigation will be something less than would be required for maximum yield. Where there are constraints on capital, energy, labour or other essential resources, or when cost of any of these resources are particularly high, deficit irrigation can be used as a strategy to increase profits. This approach can also be used to maximize profits or stabilize regional crop production (Tavakoli and Oweis, 2004). Optimum allocation of irrigation water and nitrogen fertilizer is very important for agricultural purpose, especially in arid regions or regions where contaminated water is the prime concern in agriculture (Trimmer, 1990).

Therefore, irrigation and fertilization provide effective means to increase crop yield (Wienhold *et al.*, 1995; Norwood, 2000). However, improper irrigation and fertilization management is also a major contributor to water contamination and water shortages (Ludwick *et al.*, 1976; Al-Kaisi *et al.*, 1997, 1999).

2.5.1 Effect of N and irrigation on rice growth and yield

2.5.1.1 Plant height

Sumei (2016) showed that N fertilization had significantly influence on rice growth. Compared with the conventional irrigation, the plant height increased under control irrigation. Hatamifar *et al.* (2013) performed an experiment to study the effects of irrigation techniques and application of nitrogen on rice cultivar, Hashemi. Results indicated that the influence of N on plant height was significant.

Rahman *et al.* (2013) revealed that rice growth did not differ between the treatments during the early growth stages in response to the differences in water management. Azarpour (2011) observed that plant height was significantly influenced by irrigation and N management. Jemberu (2011) reported that plant height was significantly affected with the main effect of both deficit irrigation and N fertilizer rates.

2.5.1.2 Dry matter content

Fallah (2011) showed that interaction of N and irrigation methods was significant on the total dry weight.

2.5.1.3 Number of effective tillers hill^{-1}

Hatamifar *et al.* (2013) performed an experiment to study the effects of irrigation techniques and application of nitrogen on rice cultivar, Hashemi. Results indicated that the influence of N on effective tiller number m^{-2} was significant. Golduost (2013) indicated that the irrigation and N fertilizer had a significant effect on the number of fertile tillers. The results found that the interaction effect of irrigation and N levels was significantly different in all of the traits of the fertile tillers.

Azarpour (2011) observed that number of effective tillers was significantly influenced by irrigation and N management. Fallah (2011) showed that interaction of N and irrigation methods was significant on maximum tillering. Jemberu (2011) reported that number of effective tillers m^{-2} was significantly affected with the main effect of both deficit irrigation and N fertilizer rates. Ghanbari-Malidareh (2011) showed that deficit irrigation had higher number of fertile tillers $hill^{-1}$ than flooding irrigation.

2.5.1.4 Number of filled grains panicle^{-1}

Sumei (2016) showed that N fertilization had significantly influence on rice yield attributes. Compared with the conventional irrigation, grain number $panicle^{-1}$ increased under control irrigation. With the increment of N application rates, grain number $panicle^{-1}$ increased.

Mallareddy and Padmaja (2013) conducted a field experiment to compare the performance of popular rice varieties under aerobic and flooded methods of water management and their response to levels of N. Filled grains $panicle^{-1}$ was significantly affected by aerobic method. Jemberu (2011) reported that number of grains $panicle^{-1}$ was significantly affected with the main effect of both deficit irrigation and N fertilizer rates.

2.5.1.5 Number of unfilled grains panicle^{-1}

Pirmoradian (2004) indicated that intermittent flooding irrigation at 2-day intervals was as effective as continuous flooding for grain yield. Under sprinkler irrigation, percentage of unfilled grain was high.

2.5.1.6 Panicle length

Hatamifar *et al.* (2013) performed an experiment to study the effects of irrigation techniques and application of nitrogen on rice cultivar, Hashemi. Results indicated that the influence of N on panicle length was significant. Golduost (2013) revealed that the interaction effect of irrigation and N levels was significantly different in all of the traits of the panicle length.

2.5.1.7 1000-grain weight

Mallareddy and Padmaja (2013) reported that 1000-seed weight was not influenced by the method of water management. Azarpour (2011) observed that 1000-grain weight was significantly influenced by irrigation and N management. Jemberu (2011) reported that interaction effect of deficit irrigation with N fertilizer showed significant difference on 100-grain weight, biomass. Ghanbari-Malidareh (2011) found that high N application decreased 1000-grain weight.

2.5.1.8 Grain yield

Sumei (2016) showed that yield reached 11489 kg hm^{-2} and 10126 kg hm^{-2} when the treatments were with 180 kg hm^{-2} and 270 kg hm^{-2}. Das *et al.* (2015) conducted an experiment to evaluate the effect of deep placement of N fertilizers on rice yield under two different water regimes (CF, AWD). Deep placement of N fertilizers increased grain yield under AWD compared to CF condition and the maximum value was obtained in USG 78 kg N ha^{-1} + PM 3 t ha^{-1} which was statistically similar with USG, 156 kg N ha^{-1}. The results revealed that the deep placement of USG with poultry manure performed better in terms yield by BRRI dhan29 under AWD condition.

Hatamifar *et al.* (2013) performed an experiment to study the effects of irrigation techniques and application of nitrogen on rice cultivar, Hashemi. Results indicated that the influence of N on grain yield was significant. Maximum yield was achieved by applying 90 kg ha^{-1} and maximum mean of grain yield equal to 4343 kg ha^{-1} was related to this treatment. Golduost (2013) indicated that the irrigation and N fertilizer had a significant effect on the seed yield. The results revealed that the water logging treatment along with the consumption of 150 kg of N resulted in the highest increase in the total yield.

Mallareddy and Padmaja (2013) conducted a field experiment to compare the performance of popular rice varieties (‘MTU 1001’, ‘WGL 32100’, ‘WGL 14 ‘and ‘WGL 3825’) (check) under aerobic and flooded methods of water management and their response to levels of N (120. 180 and 240 kg ha^{-1}). Cultivation of rice with aerobic method (3.49 t ha^{-1}) resulted in 29% yield reduction compared with flooded method (4.93 t ha^{-1}). ‘WGL 32100’ gave highest grain yield under aerobic (3.94 t ha^{-1}) with the least yield reduction (17%) compared to flooded method, while yield gap was high (40%) in ‘MTU 1001’. Application of 240 kg N ha^{-1} resulted in increased yield (4.50 t ha^{-1}).

Ashouri (2012) indicated that not only grain yield was statistically the same under continuous submergence and 8 days interval but also water consumption decreased 18%. Mannan *et al.* (2012) done an experiment to determine the critical growth stage where water stress affect on yield reduction and to find out optimum level of N (0, 70, 105 and 140 kg ha^{-1}) and to select stress tolerance N responsive rice variety. The highest grain yield was observed in stress free crop irrespective of N levels. However, grain yield increased with the increase of N levels irrespective of water stress.

Azarpour (2011) observed that the highest grain yield was found from submerge irrigation with 90 kg ha^{-1} N fertilizer consumption. Fallah (2011) showed that the highest yield was obtained in the permanent and interval irrigation with using of 300 kg urea fertilizer with tree times.

Jemberu (2011) reported that interaction effect of deficit irrigation with N fertilizer showed significant difference on grain yield. The analysis of variance revealed that application of 69 kg ha^{-1} N gave the highest HI (0.419). The highest grain yield was obtained with 115, 92 and 69 kg ha^{-1} N which gave 3476, 3423, and 3428 kg ha^{-1}, respectively. The interaction effect of 25% deficit irrigation with 92 kg ha^{-1} N gave the highest grain yield (3333 kg ha^{-1}). Whereas, the lowest grain yield were recorded from application of 50% deficit irrigation with 69 and 92 kg ha^{-1} N which were 2397 and 2287 kg ha^{-1}, respectively.

Ghanbari-Malidareh (2011) conducted a field experiment with irrigation system include continues flooding and deficit as main plots and nitrogen rates N_0, N_{46}, N_{92}, and N_{138} kg ha^{-1} as sub plots. Results indicated that grain yield had not significant difference between irrigation systems. Flooding irrigation had no significant difference in grain yield. N application increased grain yield.

Huan *et al.* (2010) reported that grain yields varied from 6.19 to 6.46 t ha^{-1} in 2008 dry season and from 4.21 to 4.41 t ha^{-1} in 2008 wet season at AWD, while lower grain yields attained at CF in which it got the grain yields from 6.06 to 6.37 t ha^{-1} and from 4.10 to 4.26 t ha^{-1}, respectively. The AWD did not only get higher grain yield (increased of 3.6% in 2008 dry season and 2.6% in 2008 wet season) but also reduce the irrigation water inputs compared to those of CF. Rezaei *et al.* (2009) conducted an experiment to investigate the best irrigation method and N application. They found that the best N practice was 60 kg ha^{-1}, using N more than 60 kg ha^{-1} did not increase rice yield.

Xue *et al.* (2008) reported that the application of fertilizer N either reduced yield or kept it at the same level as 0 N. With the highest water application, five splits of N gave higher yield than three splits, whereas three splits gave higher yield than five splits with lower water applications.

El-Refaee (2007) showed that grain yield significantly decreased as increasing irrigation intervals up to 8 days. The highest grain yield of 10.43 t ha^{-1} was recorded with three equal doses as basal + mid tillering (MT) + PI in 2002 season and it was 10.01 t ha^{-1} with four equal doses, as basal + MT + PI + flowering in 2003 season. Generally, kept the soil at saturation condition with SK 2025H hybrid rice and splitting N application gave similar grain yield as the yield of continuous flooding for both hybrid and inbred rice with only 2-3% reduction in grain yield of rice.

2.5.1.9 Straw yield

Hatamifar *et al.* (2013) performed an experiment to study the effects of irrigation techniques and application of nitrogen on rice cultivar, Hashemi. Results indicated that the influence of N on straw yield was significant.

Jemberu (2011) reported that biomass was significantly affected with the main effect of both deficit irrigation and N fertilizer rates. Ghanbari-Malidareh (2011) reported that flooding irrigation had no significant difference in straw yield. N application increased straw yield.

2.5.1.10 Biological yield

Azarpour (2011) observed that biological yield was significantly influenced by irrigation and N management. Ghanbari-Malidareh (2011) found that flooding irrigation had higher biological yield than deficit irrigation N application increased biological yield.

2.5.1.11 Harvest index

Mallareddy and Padmaja (2013) found that HI was not influenced by the method of water management. Azarpour (2011) observed that harvest index was significantly influenced by irrigation and N management.

Ju *et al.* (2009) reported that water and/or N management system that could increase growth rate during grain growth and/or enhance the remobilization of assimilates from vegetative tissues to grains during the grain-filling period usually leads to a higher HI within a crop.

2.6 Effect of weed management and irrigation

2.6.1 Number of effective tillers hill^{-1}

Pramanik (2014) showed the highest number of effective tillers hill^{-1} in the plot with application of herbicide Pyrazosulfuron-ethyl (Manage 10WP) only.

2.6.2 Number of filled grains panicle^{-1}

Pramanik (2014) reported the maximum number of grains panicle^{-1} was observed in the plot with application of herbicide Pyrazosulfuron-ethyl (Manage 10WP) only. Murthy and Reddy (2013) conducted a study on irrigation and weed management effect on aerobic rice, scheduling the irrigation with IW/CPE of 1.2 produced significantly higher number of filled grains.

2.6.3 1000-seed weight

Pramanik (2014) found the highest 1000-grain weight was observed in the plot with application of herbicide Pyrazosulfuron-ethyl (Manage 10WP) only.

2.6.4 Grain yield

Pramanik (2014) recorded the highest grain yield was obtained in treatment herbicide Pyrazosulfuron-ethyl (Manage 10WP) + one HW at 40 DAT. Herbicide Pyrazosulfuron-ethyl (Manage 10WP) was effective and economic than the other weed control treatments to obtained higher grain yield. The highest grain yield was obtained from AWD and herbicide Pyrazosulfuron-ethyl (Manage 10WP) + one HW at 40 DAT. Murthy and Reddy (2013) reported that weed management practices exerted significant influence on yield (5761 and 5595 kg ha^{-1}), were at their highest with hand weeding at 20 and 40 days, which were comparable with oxadiargyl 0.07 kg ai ha^{-1} supplemented with hand weeding at 40 days and the yield of rice were the lowest with unweeded check.

2.6.5 Straw yield

Murthy and Reddy (2013) reported that the irrigation with IW/CPE of 1.2 produced significantly higher straw yield (4547 kg ha^{-1}).

2.7 Effect of nitrogen, weed management and irrigation

2.7.1 Dry matter content

Latheef *et al.* (2013) conducted a field study to find out the effect of irrigation schedules, weed management practices and N levels on growth and yield attributes of aerobic rice. Pre emergence application of pendimethaiin @ 1 kg a.i. ha^{-1} followed by (fb) cono weeding at 30 DAS and one HW at 45 DAS recorded significantly higher dry matter production than pre emergence application of pendimethalin @ 1 kg a.i. ha^{-1} fb 2, 40 Na salt @ 1 kg a.i. ha^{-1} at 40 DAS and HW at 20 and 45 DAS.

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

Latheef *et al.* (2013) conducted a field study to find out the effect of irrigation schedules, weed management practices and N levels on yield attributes of aerobic rice. Pre emergence application of pendimethaiin @ 1 kg a.i. ha^{-1} followed by (fb) cono weeding at 30 DAS and one HW at 45 DAS recorded significantly higher tiller number than pre emergence application of pendimethalin @ 1 kg a.i. ha^{-1} fb 2, 40 Na salt @ 1 kg a.i. ha^{-1} at 40 DAS and HW at 20 and 45 DAS. Pooled data of yield attributes was not much varied among N levels.

2.7.3 Number of filled grains $panicle^{-1}$

Latheef *et al.* (2013) conducted a field study to find out the effect of irrigation schedules, weed management practices and N levels on yield attributes of aerobic rice. Pre emergence application of pendimethaiin @ 1 kg a.i. ha^{-1} followed by (fb) cono weeding at 30 DAS and one HW at 45 DAS recorded significantly higher filled grains $panicle^{-1}$ than pre emergence application of pendimethalin @ 1 kg a.i. ha^{-1} fb 2, 40 Na salt @ 1 kg a.i. ha^{-1} at 40 DAS and HW at 20 and 45 DAS. Pooled data of yield attributes was not much varied among N levels.

2.7.4 Grain yield

Brim-DeForest *et al.* (2017) reported that yields did not differ across treatments when weeds were controlled; in the absence of herbicides, yields in the WS-AWD were equivalent to the WS-Control (ranging from 40 to 65% of the herbicide-treated yields) and zero in the DS-AWD due to weed pressure.

Latheef *et al.* (2013) reported that the pre emergence application of pendimethaiin @ 1 kg a.i. ha^{-1} followed by (fb) cono weeding at 30 DAS and one HW at 45 DAS recorded significantly higher grain yield (4991 kg ha^{-1}) than pre emergence application of pendimethalin @ 1 kg a.i. ha^{-1} fb 2, 40 Na salt @ 1 kg a.i. ha^{-1} at 40 DAS and HW at 20 and 45 DAS. Pooled data of grain yield was not much varied among N levels.

Pasha *et al.* (2011) reported that rrigation scheduled at seven days interval during vegetative stage and four days interval during reproductive stage resulted in significantly higher grain yield than that of irrigation scheduled once in two days. Pre-emergence application of pendimethalin @ 1 kg ha^{-1} fb cono weeding at 30 DAS and one HW at 45 DAS recorded significantly higher grain yield than that of pre-emergence application of pendimethalin @ 1 kg ha^{-1} fb 2, 4-D Na salt @ 1 kg ha^{-1} at 40 DAS and HW at 20 and 45 DAS. Grain yield was significantly higher at 180 kg N ha^{-1} during both the years.

From the review of literature cited above it is clear that both irrigation, N and weed management have tremendous influence on the growth and yield components of rice specially boro rice. Therefore, research on aforesaid issues emerges as an integrate part for better crop production.

CHAPTER III

MATERIALS AND METHODS

Field experiments were conducted on nitrogen, weed and irrigation management for maximizing growth and yield of *boro* rice (BRRI dhan29). The details of the materials and methods i.e. experimental period, location, soil characteristics and climatic condition of the experimental area, planting materials, treatments, sources of nitrigen, herbicides, AWD method, design and layout of the experiment, growing of crops, data collection and data analysis procedure that followed in this experiment has been presented under the following headings:

3.1 Description of the experimental site

3.1.1 Experimental period

The field experiments were conducted during the period of 2014 -2015 and 2015 -2016.

3.1.2 Experimental location

Two field experiments were conducted consecutively at the Suapur Union of Dhamrai Upazila, Dhaka. Geographically the experimental field is located at $23^{0}88'$N latitude and $90^{0}14'$E longitude at an altitude of 11.7 meter above the sea level belonging to the Agro-ecological Zone "AEZ-12" of Low Ganges River Floodplain. The location of the experimental site has been shown in Appendix I.

3.1.3 Soil characteristics

The soil of the experimental site Suapur, Dhamrai area belongs to the Low Ganges River Floodplain (UNDP, 1988) corresponding AEZ No. 12 and is Calcareous Dark Grey and calcareous Brown Floodplain soils. According to the textural class the soil is silty clay loam in nature and pH 6.9 and 6.3. The land was above flood level and sufficient sunshine was available during the experimental period. Soil samples from 0-15 cm depths were collected from experimental field. The analyses were done at Soil Resource and Development Institute (SRDI), Dhaka. The soil analysis results are presented in Appendix II.

3.1.4 Climatic condition

The area has subtropical climate, characterized by high temperature, high relative humidity and heavy rainfall with occasional gusty winds in Kharif season (April-September) and scanty rainfall associated with moderately low temperature during the Rabi season (October-March).The weather data during the study period at the experimental site are shown in Appendix III.

3.2 Experimental details

3.2.1 Planting material

BRRI dhan29 was used as the test crop in this experiments. This variety was developed Bangladesh Rice Research Institute from the cross between BG 90-2 and BR51-46-5 in 1994. It is recommended for *boro* season.

3.2.2 Treatment of the experiment

The experiment comprised of three factors as mentioned below:

Factor A: Nitrogen management (4 levels)

i. N_0: No urea (control)
ii. N_1: Urea super granules (77 kg N ha^{-1})
iii. N_2: Prilled urea at recommended dose (150 kg N ha^{-1})
iv. N_3= ½ of the recommended dose (75 kg N ha^{-1})

Factor B: Weed management (4 levels)

i. W_0: No weeding (control)
ii. W_1: Two hand weeding (20 and 40 DAT)
iii. W_2: Pre emergence herbicide (Butachor)
iv. W_3: Post emergence herbicide (Prityloclor)

Factor C: Irrigation Management (4 levels)

i. I_1: Irrigating all time
ii. I_2: Irrigating 3 days after drying
iii. I_3: Irrigating 5 days after drying
iv. I_4: Alternate wetting and drying (AWD) method

As such there were 64 (4×4×4) treatments combinations and they were $N_0W_0I_1$, $N_0W_1I_1$, $N_0W_2I_1$, $N_0W_3I_1$, $N_1W_0I_1$, $N_1W_1I_1$, $N_1W_2I_1$, $N_1W_3I_1$, $N_2W_0I_1$, $N_2W_1I_1$, $N_2W_2I_1$, $N_2W_3I_1$, $N_3W_0I_1$, $N_3W_1I_1$, $N_3W_2I_1$, $N_3W_3I_1$, $N_0W_0I_2$, $N_0W_1I_2$, $N_0W_2I_2$, $N_0W_3I_2$, $N_1W_0I_2$, $N_1W_1I_2$, $N_1W_2I_2$, $N_1W_3I_2$, $N_2W_0I_2$, $N_2W_1I_2$, $N_2W_2I_2$, $N_2W_3I_2$, $N_3W_0I_2$, $N_3W_1I_2$, $N_3W_2I_2$, $N_3W_3I_2$, $N_0W_0I_3$, $N_0W_1I_3$, $N_0W_2I_3$, $N_0W_3I_3$, $N_1W_0I_3$, $N_1W_1I_3$, $N_1W_2I_3$, $N_1W_3I_3$, $N_2W_0I_3$, $N_2W_1I_3$, $N_2W_2I_3$, $N_2W_3I_3$, $N_3W_0I_3$, $N_3W_1I_3$, $N_3W_2I_3$, $N_3W_3I_3$, $N_0W_0I_4$, $N_0W_1I_4$, $N_0W_2I_4$, $N_0W_3I_4$, $N_1W_0I_4$, $N_1W_1I_4$, $N_1W_2I_4$, $N_1W_3I_4$, $N_2W_0I_4$, $N_2W_1I_4$, $N_2W_2I_4$, $N_2W_3I_4$, $N_3W_0I_4$, $N_3W_1I_4$, $N_3W_2I_4$ and $N_3W_3I_4$.

3.2.3 Description of the sources of nitrogen

Ordinary or PU and USG were used as the sources of nitrogen fertilizer.

3.2.3.1 Prilled Urea

Ordinary or prilled urea is the most common form of urea available in the market. It contains 46% N.

3.2.3.2 Urea super granules

Urea super granules (USG) fertilizer was manufactured from a physical modification of ordinary urea fertilizer. The International Fertilizer Development Centre (IFDC), Muscle Shoals, Alabama 35660, USA, has developed it. Its nature and properties are similar to that of urea. But its granule size is bigger and condensed with some conditions for slow hydrolysis.USG is spherical in shape containing 46 % N. It is not a slow release fertilizer but can be considered as a slowly available N fertilizer. The super granules are made by compressing prilled or granular urea in small machines with indented pocket rollers that, depending on the size of the pocket, produce individual briquettes varying in weight from 0.9 to 2.7 g. Within a week after transplanting rice, the super granules are inserted into the puddled soil by hand, being placed to a depth of 7-10 cm in the middle of alternating squares of four hills of rice. Often refer to as urea deep placement (UDP).

3.2.4 Description of herbicides

The description of the weeding treatments is given below:

1. No weeding: Weeds were allowed to grow in the plots from transplanting to harvesting of the crop. No weeding was done.
2. Two hand weeding: Two hand weedings were done at 20 and 40 DAT, respectively.
3. Vichete 5G (Butacholor): Vichete was applied @ 100 g ha^{-1} at 2-3 DAT in 1-2 cm standing water for 5-7 days as systematic pre-emergence herbicide.
4. Top (Prityloclor): Top was applied @ 185 ml ha^{-1} at 10 DAT when weeds were 3-5 leaf stage as systematic post-emergence herbicide.

3.2.5 Description of AWD Method

In each main-plot a 10 cm diameter and 30 cm long Polyvinyl chloride (PVC) pipe was installed at one corner of the main-plot keeping 10 cm above the soil and the remaining 15 cm which was perforated underneath to measure the depletion of soil water in the main-plot. The treatments were randomly distributed within each block.

When the water level inside the tube drops to 15 cm below ground level, then it is time to re-flood the field to a depth of about 5 cm. This cycle is done repeatedly except during flowering stage of crop growth when the plants are very sensitive to dry conditions and field is kept in flooded conditions, topping up to a depth of 5 cm as needed. After flowering, during grain filling and ripening, the water level can be allowed to drop again to 15 cm below the soil surface before re-irrigation.

Figure 3.1 Water at 15 cm depth in porous tube

Figure 3.2 Field in flooded condition

3.2.6 Experimental design and layout

The three factors experiment was laid out in split-split-plot design with three replications. The size of the individual plot was 5.0 m × 2.25 m and total numbers of plots were 192. There were 64 treatment combinations. Each block was divided into 64 unit plots. Irrigation management was placed along the main plot, nitrogen management was placed in the sub plot and weeding treatments were placed in the sub-sub plot. Layout of the experiment was done with inter plot spacing of 0.50 m and inter block spacing of 0.75 m.

3.3 Growing of crops

3.3.1 Seed collection, sprouting and seedling raising

Seed of BRRI dhan29 was collected from Bangladesh Agricultural Development Corporation (BADC), Gabtali, Dhaka. Initially seed soaking was done in water for 24 hours and after wards they were kept tightly in jute sack for 2 days. When about 90% of the seeds were sprouted, they were sown uniformly in well prepared wet nursery bed on January 25, 2015 and January 12, 2016 for first and second year experiment, respectively. Seed bed size was 10 m long and 1.5 m wide. During seedling growth no fertilizer was used. Proper water and pest management practices were followed whenever required.

3.3.2 Land preparation

The plot selected for conducting the experiment was opened in the 2^{nd} week of February, 2015 and 1^{st} week of 2016 with a power tiller and left exposed to the sun for a week. After one week the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain good puddle condition. Weeds and stubbles were removed. The experimental plot was partitioned into unit plots in accordance with the experimental design. Organic and inorganic manures as indicated below were mixed with the soil of each unit plot.

3.3.3 Fertilizers and manure application

Nitrogen fertilizer was applied as per treatments of the experiment.The field wasfertilized with phosphate, potash, sulphur and zinc at the rate of 130, 120, 70 and 10 kg ha^{-1} respectively in the form of triple super phosphate, muriate of potash, gypsum and zinc sulphate. The whole amount of all the fertilizers were applied at the time of final land preparation and thoroughly incorporated with soil with the help of a spade (BRRI, 2014). The USG weighing 2.7 g each were placed at 5-10 cm soil depth at 10 DAT in the center of four hills in alternate rows @ 1 granule in one spot to supply 77 kg N ha^{-1}.

3.3.4 Transplanting of seedling

For both year experiments, the seedbeds were made wet by the application of water both in the morning and evening on the previous day before uprooting on February 20, 2015 and February 07, 2016, respectively. The seedlings were then uprooted carefully to minimize mechanical injury to the roots and kept on soft mud in shade before they were transplanted. For first and second year experiment, 25 days old seedlings were transplanted on the well puddled experimental plots on February 20, 2015 and February 07, 2016, respectively by using two seedlings hill^{-1}.

3.3.5 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.

3.3.5.1 Gap filling

Seedlings in some hills were died off and those were replaced by healthy seedling within 10 days of transplantation.

3.3.5.2 Weeding

During the study period several types of weeds were observed in the experimental plot and they were presented in Table 3.1 with their local name, common name, scientific name, family, life cycle and type. Treatment wise diffrent weed control measures were applied.

Table 3.1 Different weed that was observed in the experimental plot

SL. No.	Local name	Common name	Scientific name	Family	Life cycle	Type
01	Angta	Bullet Grass	*Panicum repens*	Gramineae	Perennial	Grass
02	Chechra	Grass Weed	*Scirpus juncoides Roxb.*	Cyperaceae	Annual	Sedge
03	Arail	Southern cutgrass	*Leersia hexandra*	Poaceae	Annual	Grass
04	Joina	Hoorahgrass	*Fimbristylis miliaceae*	Cyperaceae	Annual	Sedge
05	Durba	Bermuda grass	*Cynodon dactylon*	Gramineae	Perennial	Grass
06	Panee kachu	Pickerel Weed	*Monochoria vaginalis L. solms*	Pontederiaceae	Perennial	Broadleaf
07	Sabuj Nakphulee	Small-flowered nut sedge	*Cyperus difformis*	Cyperaceae	Annual	Sedge
08	Shushni shak	4leaved water clover	*Marsilea crenata*	Marsileace	Annual	Broadleaf
09	Mutha	Nut Sedge	*Cyperus rotundus*	Cyperaceae	Annual	Sedge
10	Boroshama	Burnyard grass	*Echinochloa crussgalli*	Gramineae	Annual	Grass
11	Topapana	Pistia	*Pistia stratiotes L.*	Araceae	Perennial	Broadleaf
12	Mati cheich	Umbrella Sedge	*Cyperus iria*	Cyperaceae	Perennial	Sedge
13	Behua	Small flowered Umbrella Plant	*Cyperus difformis*	Cyperaceae	Perennial	Sedge
14	Keshordarn	Creeping Water Primrose	*Jussiaea repens*	Onagraceae	Perennial	Herb
15	Kanaibashi	Spider Wort	*Commelina benghalensis*	Commelinaceae	Perennial	Herb
16	Boro cheich	Acute spikerush	*Eleocharis acutangula*	Cyperaceae	Perennial	Sedge

3.3.5.3 Irrigation

Irrigation was applied as per experiment treatments. Irrigation was stopped before 2 weeks of harvesting. For providing irrigation as per treatment solar energy was used for operating motors.

3.3.5.4 Plant protection measures

There were negligible infestations of insect-pests during the crop growth period. Yet to keep the crop growth in normal, Basudin was applied at tillering stage @ 17 kg ha^{-1} while Diazinon 60 EC @ 850 ml ha^{-1} were applied to control stem borer and rice bug.

3.4 Harvesting, threshing and cleaning

The maturity of crop was determined when 85% to 90% of the grains become golden yellow in color. From the centre of each plot 1 m^2 area was harvested to determine yield of individual treatment and converted into t ha^{-1}. The harvested crop of each plot was bundled separately, tagged properly and brought to threshing floor. The bundles were dried in open sunshine, threshed and then grains were cleaned. The grain and straw weights for each plot were recorded after proper drying in sun. Before harvesting, five hills were selected randomly from outside the sample area of each plot and cut at the ground level for collecting data on yield contributing characters.

3.5 Data recording

3.5.1 Plant height

The height of plant was recorded in centimeter (cm) at 30, 50, 70 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 or flag leaf.

3.5.2 Number of tillers

Number of tillers $hill^1$ was recorded at 30, 50, 70 DAT and harvest. Data were recorded as the average of 5 plants selected at random from the inner rows of each plot.

3.5.3 Leaf area index

Leaf area index (LAI) measured manually at the time of 30, 50 and 70 DAT. Data were recorded as the average of 05 plants selected at random the inner rows of each plots. The final data calculated multiplying by a correction factor 0.75 as per Yoshida (1981).

3.5.4 Total dry matter

Total dry matter (TDM) $hill^{-1}$ was recorded at 30, 50 and 70 DAT by drying plant sample. Data were recorded as the average of 5 sample $hill^{-1}$ collected at random from the inner rows of each plot and expressed in gram (g).

3.5.5 Crop Growth Rate

Crop Growth Rate (CGR) was calculated using the following formula-

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

Where,

A = Ground area (m^2)

W_1 = Total dry weight at time T_1 (g)

W_2 = Total dry weight at time T_2 (g)

T_1 = Initial time (day)

T_2 = Final time (day)

3.5.6 Relative Growth Rate

Relative Growth Rate (RGR) was calculated using the following formula

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

Where,

W_1 = Total dry weight at time T_1 (g)

W_2 = Total dry weight at time T_2 (g)

T_1 = Initial time (day)

T_2 = Final time (day)

L_n = Natural logarithm

3.5.7 Net Assimilation Rate

Net Assimilation Rate (NAR) was calculated using the following formula

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

Where,

W_1 = Total dry weight at time T_1 (g)

W_2 = Total dry weight at time T_2 (g)

T_1 = Initial time (day)

T_2 = Final time (day)

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

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

L_n = Natural logarithm

3.5.8 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.

3.5.9 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.

3.5.10 Panicle length

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

3.5.11 Filled grains panicle^{-1}

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

3.5.12 Unfilled grains panicle^{-1}

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

3.5.13 Total grains panicle^{-1}

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

3.5.14 Weight of 1000-grains

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

3.5.15 Grain yield

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

3.5.16 Straw yield

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

3.5.17 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.

3.5.18 Harvest index

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

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

3.6 Statistical Analysis

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

CHAPTER IV

RESULTS AND DISCUSSION

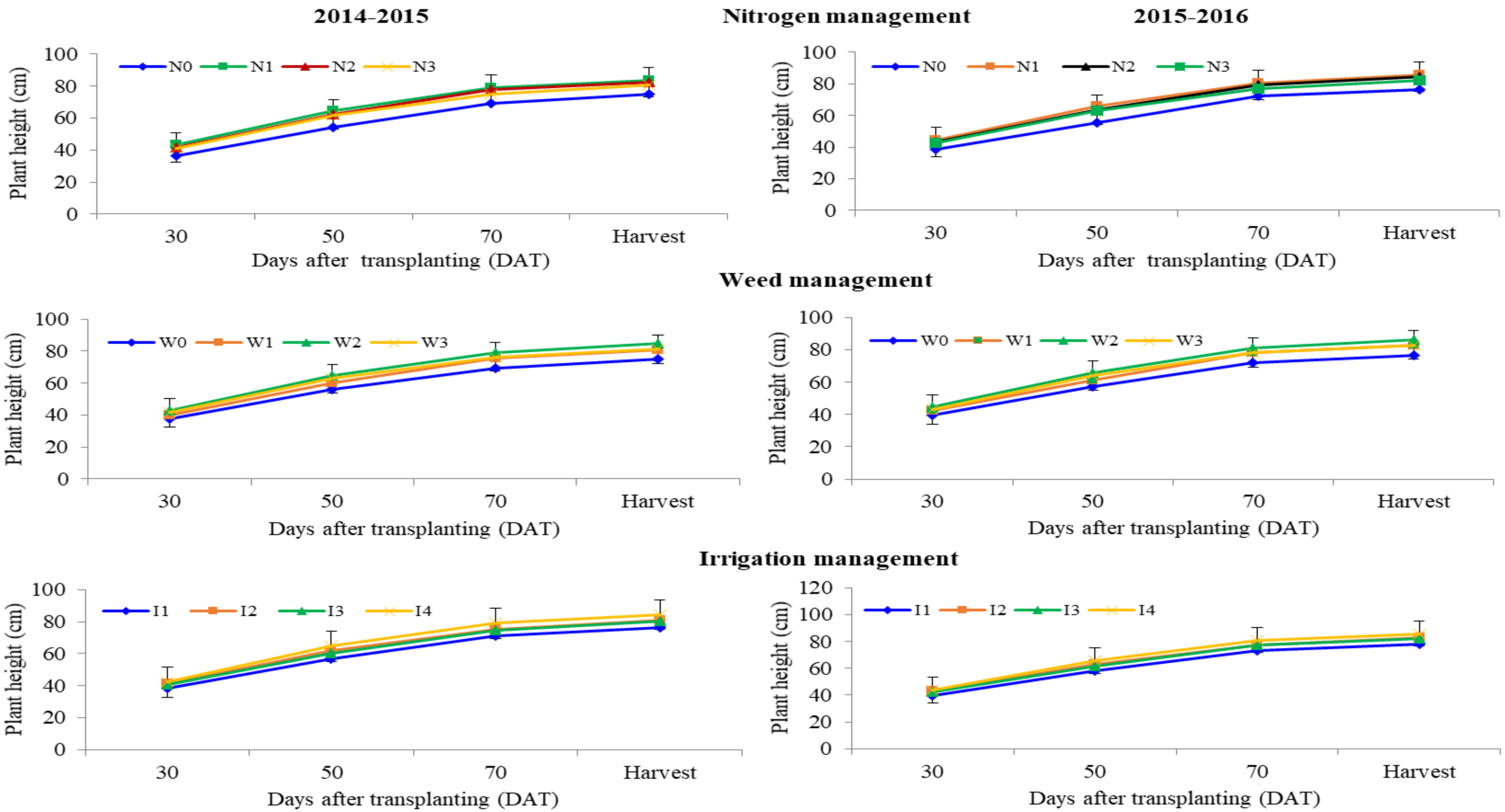
The experiment was conducted to find out the effect of different levels of irrigation, nitrogen and weed management on BRRI dhan29. The analysis of variance (ANOVA) of the data on different yield contributing characters and yield of BRRI dhan29 are presented in Appendix IV-XI. The results have been presented with the help of table possible interpretations given under the following headings:

4.1 Plant height

Plant height of BRRI dhan29 at 30, 50, 70 DAT and at harvest for the year 2014-15, 2015-16 showed statistically significant variation due to different nitrogen, weed and irrigation management, and also their combined effect (Appendix IV). In general irrespective of treatments and their combined effects, more than 90% of the plant height was attained at 70 DAT and thereafter at harvest plant height remained more or less constant (Figure 4.1.1 and Table 4.1.1 to 4.1.4).

4.1.1 Effect of nitrogen management

Data revealed that, different levels of nitrogen management influenced plant height of BRRI dhan29 at 30, 50, 70 DAT and harvest during 2014-15 and 2015-16 (Figure 4.1.1). Plant height was significantly higher in N applied treatments compared to control condition in all data recording days for the two subsequent years. The tallest plant (43.04, 64.66, 78.75, 83.73, 44.54, 65.68, 80.42 and 85.37 cm, respectively) was recorded from N_1 (USG-77 kg N ha^{-1}) at 30, 50, 70 DAT and harvest, which was statistically identical (77.72, 82.60, 79.20 and 84.24 cm, at 70 DAT and hervest respectively) to N_2 (PU at recommended dose-150 kg N ha^{-1} as 325 kg urea ha^{1}), while the shortest plant (36.68, 54.36, 69.08, 75.21, 38.58, 55.54, 72.38 and 76.47cm, respectively) from N_0 (no urea-control). Data reveal that urea super granule-77 kg N ha^{-1} influences the better growth and development of rice plant and this level of N fertilizer gave the longest plant. Ferdous *et al.* (2014) reported that application of N as PU and USG resulted in a significant increase in plant height of BRRI dhan29.



N_0: No urea (control), N_1: Urea super granules (77 kg N ha^{-1}), N_2: Prilled urea at recommended dose (150 kg N ha^{-1}) as 325 kg urea ha^{-1} and N_3= ½ of the recommended dose (75 kg N ha^{-1}) as163 kg urea ha^{-1}
W_0: No weeding (control), W_1: Two hand weeding (20 DAT and 40 DAT), W_2: Pre emergence herbicide (Butachor) and W_3: Post emergence herbicide (Prityloclor)
I_1: Irrigating all time, I_2: Irrigating 3 days after drying, I_3: Irrigating 5 days after drying and I_4: Alternate wetting and drying (AWD) method

Figure 4.1.1 Effect of different levels of nitrogen, weed and irrigation mangement on plant height at different DAT and harvest of BRRI dhan29

4.1.2 Effect of weed management

Plant height of BRRI dhan29 at 30, 50, 70 DAT and harvest showed statistically significant differences for different weed management in all data recording days for the two subsequent years (Figure 4.1.1). The tallest plant (42.95, 64.61, 79.32, 84.85, 44.40, 65.72, 81.06 and 86.44 cm, respectively) were recorded from W_2 (pre emergence herbicide-Butachor) at 30, 50, 70 DAT and harvest, which was closely followed (41.44, 62.76, 76.39, 81.36, 42.84, 63.96, 78.07 and 83.01 cm, respectively) by W_3 (post emergence herbicide-prityloclor) and (40.25, 60.09, 75.66, 80.93, 42.13, 61.24, 78.02 and 82.69 cm, respectively) by W_1 (two hand weeding-20 DAT and 40 DAT), whereas the shortest plant (37.71, 55.85, 69.22, 74.99, 39.67, 57.21, 71.86 and 76.33 cm, respectively) was found from W_0 (no weeding-control condition). It was revealed that pre emergence herbicide-Butachor was better than the other weed management practices for plant height of BRRI dhan29.

4.1.3 Effect of irrigation management

Data revealed that, different irrigation management influenced plant height of BRRI dhan29 at 30, 50, 70 DAT and harvest (Figure 4.1.1). Plant height was significantly higher compared to control condition in all data recording days for the two subsequent years. The tallest plant (42.11, 64.57, 79.13, 84.37, 43.70, 65.83, 81.05 and 85.82 cm, respectively) was found from I_4 AWD method at 30, 50, 70 DAT and harvest, which was closely followed (41.26, 62.06, 75.38, 80.95, 62.96, 77.42 and 82.60 cm respectively and 43.06 was statistically identical at 30 DAT) by I_2 (irrigation 3 days after drying) and (40.74, 60.07, 74.85, 80.37, 42.59, 61.35, 77.22 and 81.99 cm, respectively) by I_3 (irrigation 5 days after drying) and those were statistically similar, whereas the shortest plant (38.23, 56.61, 71.24, 76.44, 39.70, 57.99, 73.32 and 78.07 cm, respectively) from I_1 (irrigation all time). Generally plant height is a genetical character and it is controlled by the genetic make up of the varieties but management practices influenced it. Khairi *et al.* (2015a) reported that AWD treatment affected plant height after 49 days after planting.

4.1.4 Combined effect of nitrogen and weed management

Plant height of BRRI dhan29 at 30, 50, 70 DAT and harvest varied significantly for the combined effect of different nitrogen and weed management in terms of in all data recording days of 2014-2015 and 2015-2016 (Table 4.1.1). The tallest plant (48.88, 71.64, 87.15, 93.49, 50.10, 72.57, 88.89 and 94.89 cm, respectively) was recorded from N_1W_2 (USG-77 kg N ha^{-1} + Butachor), at 30, 50, 70 DAT and harvest. whereas the shortest plant (31.26, 43.06, 61.42, 68.24, 33.69, 44.13, 66.80 and 68.33 cm, respectively) from N_0W_0 (no urea-control + no weeding-control). Among the different combination of nitrogen and weed management under the present trials USG-77 kg N ha^{-1} + pre emergence herbicide-Butachor was superior in terms of plant height

4.1.5 Combined effect of nitrogen and irrigation management

Combined effect of different nitrogen and irrigation management varied significantly in terms of plant height of BRRI dhan29 at 30, 50, 70 DAT and harvest in all data recording days for the two subsequent years (Table 4.1.2). The tallest plant (43.77, 69.28, 82.85,87.73,45.52,70.61,84.57 and 89.10 cm, respectively) was recorded from N_1I_4 (USG-77 kg N ha^{-1} + AWD method) at 30, 50, 70 DAT and harvest, whereas the shortest plant (31.98, 48.73, 64.63, 70.63, 33.57, 49.89, 67.35 and 71.62 cm, respectively) from N_0I_1 (no urea-control + irrigation all time).

4.1.6 Combined effect of weed and irrigation management

Different irrigation and weed management varied significantly due to combined effect in terms of plant height of BRRI dhan29 at 30, 50, 70 DAT and harvest in all data recording days for the two subsequent years (Table 4.1.3). The tallest plant (45.13, 70.50, 84.11, 89.67, 46.57, 71.68, 85.94 and 91.11 cm, respectively) were recorded from W_2I_4 (pre emergence herbicide-Butachor + AWD method) at 30, 50, 70 DAT and harvest, whereas the shortest plant (35.83, 51.75, 64.56, 70.33, 37.34, 53.56, 66.20 and 71.69 cm, respectively) from W_0I_1 (no weeding-control + irrigation all time).

Table 4.1.1 Combined effect of different levels of nitrogen and weed management on plant height at different DAT and harvest of BRRI dhan29.

Treatments	Plant height (cm) during 2014-2015				Plant height (cm) during 2015-2016			
	30 DAT	50 DAT	70 DAT	Harvest	30 DAT	50 DAT	70 DAT	Harvest
N_0W_0	31.26 h	43.06 f	61.42 i	68.24 i	33.69 h	44.13 g	66.80 h	68.33 h
N_0W_1	36.28 g	54.40 e	68.03 h	74.26 h	38.37 g	55.49 f	72.40 fg	75.93 g
N_0W_2	39.21 f	60.61 cd	75.06 e	80.99 de	41.14 f	61.65 de	76.92 de	82.84 de
N_0W_3	39.95 ef	59.38 d	71.79 g	77.35 fg	41.14 f	60.89 e	73.42 fg	78.78 f
N_1W_0	39.30 f	61.02 cd	72.14 fg	77.01 g	40.99 f	61.83 de	73.75 fg	78.67 f
N_1W_1	41.71 b-d	61.32 cd	77.82 cd	81.99 c-e	43.59 bc	62.59 c-e	79.42 cd	83.78 c-e
N_1W_2	48.88 a	71.64 a	87.15 a	93.49 a	50.10 a	72.57 a	88.89 a	94.89 a
N_1W_3	42.26 bc	64.67 b	77.88 cd	82.40 c-e	43.50 b-d	65.72 bc	79.62 cd	84.15 c-e
N_2W_0	40.70 d-f	61.15 cd	74.53 ef	79.91 ef	42.18 c-f	62.57 c-e	75.43 ef	81.67 e
N_2W_1	42.00 b-d	63.59 bc	81.13 b	86.28 b	43.72 bc	64.69 b-d	82.76 b	87.96 b
N_2W_2	40.54 d-f	61.35 cd	76.53 c-e	80.92 de	41.90 d-f	62.60 c-e	78.15 c-e	82.38 de
N_2W_3	42.99 b	63.90 bc	78.68 c	83.29 cd	44.35 b	64.94 b-d	80.48 bc	84.94 cd
N_3W_0	39.58 ef	58.17 d	68.78 h	74.78 gh	41.83 ef	60.32 e	71.49 g	76.65 fg
N_3W_1	40.99 c-e	61.03 cd	75.64 de	81.19 c-e	42.85 b-e	62.19 de	77.51 c-e	83.09 c-e
N_3W_2	43.18 b	64.86 b	78.54 c	84.00 bc	44.46 b	66.05 b	80.29 bc	85.67 bc
N_3W_3	40.56 d-f	63.11 bc	77.20 c-e	82.41 c-e	42.36 c-f	64.29 b-d	78.76 cd	84.16 c-e
SE value	0.481	1.029	0.867	0.920	0.523	1.007	0.996	0.877
Level of significance	*	*	*	*	*	*	*	*
CV (%)	3.13	3.53	5.21	4.70	3.73	3.77	5.08	4.31

*: Significant at 0.05 level of probability

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

N_0: No urea (control), N_1: Urea super granules (77 kg N ha^{-1}), N_2: Prilled urea at recommended dose (150 kg N ha^{-1}) as 325 kg urea ha^{-1} and N_3= ½ of the recommended dose (75 kg N ha^{-1}) as163 kg urea ha^{-1}

W_0: No weeding (control), W_1: Two hand weeding (20 DAT and 40 DAT), W_2: Pre emergence herbicide (Butachor) and W_3: Post emergence herbicide (Prityloclor)

Table 4.1.2 Combined effect of different levels of nitrogen and irrigation management on plant height at different DAT and harvest of BRRI dhan29.

Treatments	Plant height (cm) during 2014-2015				Plant height (cm) during 2015-2016			
	30 DAT	50 DAT	70 DAT	Harvest	30 DAT	50 DAT	70 DAT	Harvest
N_0I_1	31.98 h	48.73 j	64.63 i	70.63 h	33.57 f	49.89 j	67.35 h	71.62 i
N_1I_1	41.79 cd	60.76 f	76.03 d-f	81.26 b-e	43.20 c	62.14 f	77.80 c-f	83.01 c-e
N_2I_1	39.70 e	58.54 g	74.61 e-g	79.41 ef	40.97 de	59.84 g	75.51 e-g	81.20 e-g
N_3I_1	39.46 ef	58.41 g	69.67 h	74.47 g	41.06 d	60.07 g	72.61 g	76.45 h
N_0I_2	38.68 e-g	56.25 hi	71.75 gh	77.68 fg	40.64 de	57.29 hi	75.27 e-g	79.27 f-h
N_1I_2	42.49 bc	66.97 b	78.00 b-f	83.35 b-d	43.97 bc	67.66 b	79.62 b-d	85.25 b-d
N_2I_2	41.27 d	63.22 de	77.01 c-f	82.34 b-e	42.77 c	64.01 d-f	78.53 c-e	83.80 b-e
N_3I_2	42.60 bc	61.80 ef	74.74 e-g	80.42 c-f	44.84 ab	62.87 ef	76.27 d-g	82.06 d-f
N_0I_3	37.56 g	54.61 i	68.24 h	74.84 g	39.83 de	55.86 i	72.73 g	76.31 h
N_1I_3	44.10 a	64.62 cd	78.11 b-e	82.56 b-e	45.48 a	65.55 b-d	79.67 b-d	84.13 b-e
N_2I_3	43.56 ab	63.38 de	78.69 b-d	83.88 bc	45.53 a	64.71 c-e	80.46 bc	85.49 bc
N_3I_3	37.75 g	57.66 gh	74.35 fg	80.18 d-f	39.52 e	59.30 gh	76.03 d-g	82.04 d-f
N_0I_4	38.48 fg	57.86 gh	71.69 gh	77.69 fg	40.29 de	59.12 gh	74.20 fg	78.69 gh
N_1I_4	43.77 a	69.28 a	82.85 a	87.73 a	45.52 a	70.61 a	84.57 a	89.10 a
N_2I_4	41.69 cd	64.86 cd	80.57 a-c	84.77 ab	42.89 c	66.24 bc	82.31 ab	86.45 ab
N_3I_4	44.49 a	66.29 bc	81.41 ab	87.31 a	46.07 a	67.36 b	83.14 ab	89.03 a
SE value	0.367	0.620	1.130	1.092	0.455	0.675	1.133	1.023
Level of significance	*	*	*	*	*	*	*	*
CV (%)	4.11	5.86	4.00	3.96	4.28	5.63	4.46	3.70

*: Significant at 0.05 level of Probability

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

N_0: No urea (control), N_1: Urea super granules (77 kg N ha^{-1}), N_2: Prilled urea at recommended dose (150 kg N ha^{-1}) as 325 kg urea ha^{-1} and N_3= ½ of the recommended dose (75 kg N ha^{-1}) as163 kg urea

I_1: Irrigating all time, I_2: Irrigating 3 days after drying, I_3: Irrigating 5 days after drying and I_4: Alternate wetting and drying (AWD) method

Table 4.1.3 Combined effect of weed management and irrigation on plant height at different DAT and harvest of BRRI dhan29.

Treatment	Plant height (cm) during 2014-2015				Plant height (cm) during 2015-2016			
	30 DAT	50 DAT	70 DAT	Harvest	30 DAT	50 DAT	70 DAT	Harvest
W_0I_1	35.83 g	51.75 h	64.56 i	70.33 j	37.34 h	53.56 j	66.20 h	71.69 i
W_1I_1	38.37 f	56.26 fg	71.52 gh	76.85 hi	40.15 g	57.43 hi	74.54 fg	78.82 gh
W_2I_1	40.02 de	59.58 de	75.45 d-f	80.49 e-g	41.40 e-g	60.73 e-g	77.36 d-f	82.08 ef
W_3I_1	38.71 ef	58.86 ef	73.42 fg	78.10 g-i	39.91 g	60.22 f-h	75.17 e-g	79.68 f-h
W_0I_2	38.20 f	58.58 ef	70.39 h	76.31 hi	40.47 g	59.59 g-i	73.70 g	77.90 h
W_1I_2	40.93 d	62.16 cd	76.41 de	81.57 d-f	42.96 de	63.15 d-f	78.04 de	83.30 de
W_2I_2	43.50 b	63.29 bc	79.70 bc	85.55 bc	45.03 b	64.07 b-d	81.39 bc	87.27 bc
W_3I_2	42.41 bc	64.22 bc	75.00 ef	80.36 e-g	43.76 b-d	65.02 b-d	76.57 d-g	81.91 ef
W_0I_3	38.71 ef	55.19 g	70.42 h	75.93 i	40.88 fg	56.46 i	73.44 g	77.29 h
W_1I_3	40.25 d	58.01 e-g	73.25 fg	78.96 f-h	42.33 d-f	59.11 g-i	76.51 d-g	80.69 e-g
W_2I_3	43.15 b	65.08 bc	78.03 cd	83.69 b-d	44.60 bc	66.38 bc	79.55 cd	85.31 b-d
W_3I_3	40.87 d	61.98 cd	77.69 cd	82.89 c-e	42.54 de	63.47 c-e	79.39 cd	84.68 cd
W_0I_4	38.09 f	57.88 e-g	71.52 gh	77.37 hi	40.00 g	59.23 g-i	74.12 g	78.44 gh
W_1I_4	41.43 cd	63.91 bc	81.45 b	86.35 b	43.08 cd	65.28 b-d	83.00 b	87.95 b
W_2I_4	45.13 a	70.50 a	84.11 a	89.67 a	46.57 a	71.68 a	85.94 a	91.11 a
W_3I_4	43.77 b	66.00 b	79.44 bc	84.11 b-d	45.13 ab	67.13 b	81.15 bc	85.75 b-d
SE value	0.481	1.029	0.867	0.920	0.523	1.007	0.996	0.877
Level of significance	*	*	*	*	*	*	*	*
CV (%)	4.11	5.86	4.00	3.96	4.28	5.63	4.46	3.70

*: Significant at 0.05 level of Probability

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

W_0: No weeding (control), W_1: Two hand weeding (20 DAT and 40 DAT), W_2: Pre emergence herbicide (Butachor) and W_3: Post emergence herbicide (Prityloclor)

I_1: Irrigating all time, I_2: Irrigating 3 days after drying, I_3: Irrigating 5 days after drying and I_4: Alternate wetting and drying (AWD) method

4.1.7 Combined effect of nitrogen, weed and irrigation management

Combined effect of different nitrogen, weed and irrigation management showed significant differences in terms of plant height of BRRI dhan29 at 30, 50, 70 DAT and harvest for the two subsequent years (Table 4.1.4). The tallest plant (52.15, 74.79, 92.13, 98.18, 54.19, 75.63, 93.88 and 99.10 cm, respectively) were recorded from $N_1W_2I_4$ (USG-77 kg N ha^{-1} + pre emergence herbicide-Butachor + AWD method) at 30, 50, 70 DAT and harvest, while the shortest plant (30.22, 41.01, 54.45, 61.29, 31.68, 41.59, 56.02 and 60.49 cm, respectively) from N_0W_0 I_1 (no urea-control + no weeding-control + irrigation all time). Latheef *et al.* (2013) reported that plant height of rice varied between irrigation scheduled at 7 days interval during vegetative stage and 4 days interval during reproductive stage and irrigation once in 2 days.

4.2 Number of tillers $hill^{-1}$

Statistically significant variation was observed in terms of number of tillers $hill^{-1}$ of BRRI dhan29 at 30, 50, 70 DAT and harvest due to different nitrogen, weed and irrigation management and also their combined effect (Appendix V). In general irrespective of treatments and their combined effects, number of tillers $hill^{-1}$ showed an increasing trend (Figure 4.2.1 and Table 4.2.1 to 4.2.4).

4.2.1 Effect of nitrogen management

Statistically significant variation was observed in terms of number of tillers $hill^{-1}$ of BRRI dhan29 at 30, 50, 70 DAT and harvest for different nitrogen management for the two subsequent years of 2014-2015 and 2015-2016. (Figure 4.2.1). The highest number of tillers $hill^{-1}$ (7.15, 14.57, 15.90, 17.10, 7.43, 15.24, 16.60 and 17.86, respectively) was recorded from N_1 at 30, 50, 70 DAT and harvest, which was statistically similar (15.62, 16.81, 16.32 and 17.57 at 70 DAT and hervest respectively) to N_2 and followed (6.82, 13.76, 14.90, 16.27, 7.15, 14.57, 15.69 and 17.08, respectively) by N_3, while the minimum number (6.08, 12.20, 13.38, 14.82, 6.43, 12.81, 14.51 and 15.50, respectively) was found from N_0.

Table 4.1.4 Combined effect of different levels of nitrogen, weed management and irrigation on plant height at different DAT and harvest of BRRI dhan29.

Treatment	Plant height (cm) during 2014-2015				Plant height (cm) during 2015-2016			
	30 DAT	50 DAT	70 DAT	Harvest	30 DAT	50 DAT	70 DAT	Harvest
$N_0W_0I_1$	30.22 t	41.01 v	54.45 y	61.29 y	31.68 z	41.59 v	56.02 x	60.49 y
$N_0W_1I_1$	30.79 st	47.05 uv	63.50 wx	69.55 x	32.73 yz	47.86 uv	69.41 u-w	71.58 wx
$N_0W_2I_1$	33.31 rs	51.79 tu	72.89 l-u	79.10 l-t	35.72 v-y	53.11 tu	74.63 m-v	80.75 l-t
$N_0W_3I_1$	33.61 rs	55.07 q-t	67.67 t-x	72.55 u-x	34.14 w-z	57.00 o-t	69.33 u-w	73.66 u-x
$N_1W_0I_1$	38.35 l-q	53.58 r-t	70.33 p-v	75.72 p-x	39.98 l-t	54.58 r-t	72.01 q-w	77.17 p-w
$N_1W_1I_1$	40.88 f-m	56.40 n-t	76.67 f-o	81.44 i-p	43.02 h-n	58.36 l-t	78.13 g-r	83.39 i-o
$N_1W_2I_1$	46.26 bc	70.06 a-e	84.11 b-d	90.23 b-e	47.14 b-f	71.05 a-d	86.25 b-e	91.82 b-e
$N_1W_3I_1$	41.66 f-l	62.98 e-o	73.00 k-u	77.64 n-v	42.66 h-p	64.58 d-m	74.82 l-v	79.64 m-t
$N_2W_0I_1$	37.33 o-q	56.88 m-t	69.22 q-w	74.47 q-x	38.64 r-v	58.67 l-t	67.55 w	76.33 q-x
$N_2W_1I_1$	40.40 h-o	60.82 g-q	79.56 c-i	84.84 d-l	41.65 j-s	61.89 f-q	81.30 b-m	86.97 d-k
$N_2W_2I_1$	39.90 j-o	56.27 o-t	71.67 n-v	75.64 p-x	40.59 k-t	57.45 n-t	73.42 o-w	77.19 p-w
$N_2W_3I_1$	41.18 f-m	60.19 g-r	78.00 e-m	82.70 g-o	42.98 h-n	61.35 h-r	79.75 d-o	84.32 h-o
$N_3W_0I_1$	37.44 n-q	55.52 p-t	64.23 wx	69.86 x	39.06 p-v	59.40 k-t	69.21 vw	72.77 v-x
$N_3W_1I_1$	41.41 f-m	60.76 g-q	66.34 v-x	71.55 v-x	43.19 g-m	61.62 g-q	69.31 u-w	73.36 v-x
$N_3W_2I_1$	40.62 g-o	60.19 g-r	73.11 k-u	76.98 o-w	42.13 i-r	61.33 h-r	75.16 l-v	78.57 n-v
$N_3W_3I_1$	38.38 k-q	57.18 k-t	75.00 h-q	79.49 l-t	39.85 m-t	57.93 m-t	76.77 j-t	81.11 k-s
$N_0W_0I_2$	30.73 st	45.20 v	63.89 wx	70.33 x	33.08 x-z	46.41 v	72.63 p-w	71.35 wx
$N_0W_1I_2$	40.67 f-n	60.27 g-r	71.67 n-v	76.72 o-w	42.86 h-n	61.00 h-r	73.21 o-w	78.57 n-v
$N_0W_2I_2$	40.87 f-m	57.84 j-t	77.00 f-o	83.15 g-o	42.96 h-n	59.00 k-t	78.99 g-q	84.95 g-m
$N_0W_3I_2$	42.48 d-j	61.68 f-q	74.45 i-r	80.51 i-r	43.67 e-k	62.76 e-p	76.24 j-u	82.22 j-r
$N_1W_0I_2$	41.04 f-m	67.08 b-g	73.89 i-s	79.46 l-t	42.32 i-q	67.39 c-i	75.47 l-v	81.09 k-s
$N_1W_1I_2$	42.49 d-j	65.94 c-h	76.22 g-p	80.83 i-q	44.41 d-j	67.36 c-i	78.08 g-r	82.87 i-p
$N_1W_2I_2$	45.42 b-d	68.59 a-f	86.56 b	93.03 ab	46.70 b-g	68.88 b-f	87.97 b	94.65 ab
$N_1W_3I_2$	41.01 f-m	66.29 b-h	75.34 g-p	80.09 j-s	42.45 i-q	67.02 c-i	76.96 i-s	82.40 j-q
$N_2W_0I_2$	41.67 f-l	64.99 c-j	75.67 g-p	81.29 i-p	42.94 h-n	65.92 d-k	77.30 h-s	83.04 i-p
$N_2W_1I_2$	39.63 j-o	61.86 f-q	83.37 b-e	88.82 b-g	41.57 j-s	62.35 e-q	84.63 b-g	90.24 b-h
$N_2W_2I_2$	40.11 i-o	61.52 f-q	72.78 l-u	77.85 m-u	41.73 j-s	62.54 e-q	74.48 m-v	79.42 m-u
$N_2W_3I_2$	43.67 c-h	64.53 d-j	76.23 g-p	81.40 i-p	44.82 c-j	65.21 d-l	77.72 h-r	82.51 j-p
$N_3W_0I_2$	39.37 j-p	57.05 l-t	68.11 s-x	74.18 r-x	43.55 f-l	58.65 l-t	69.41 u-w	76.14 r-x
$N_3W_1I_2$	40.94 f-m	60.57 g-r	74.38 i-r	79.91 k-s	43.00 h-n	61.88 f-q	76.23 j-u	81.52 k-s
$N_3W_2I_2$	47.61 b	65.22 c-i	82.45 b-f	88.17 b-h	48.71 b	65.88 d-k	84.09 b-h	90.05 b-h
$N_3W_3I_2$	42.49 d-j	64.38 e-k	74.00 i-s	79.44 l-t	44.11 d-k	65.08 d-l	75.36 l-v	80.52 l-t
$N_0W_0I_3$	32.20 st	43.22 v	63.23 x	70.35 x	36.30 u-x	44.47 v	69.42 u-w	70.82 x
$N_0W_1I_3$	36.10 qr	52.40 s-u	63.49 wx	71.76 u-x	38.25 s-v	53.55 s-u	71.75 r-w	73.13 v-x
$N_0W_2I_3$	40.92 f-m	64.27 e-l	72.34 m-u	77.84 m-u	42.20 i-r	65.10 d-l	74.17 n-w	80.24 l-t

Cont'd

Treatment	Plant height (cm) during 2014-2015				Plant height (cm) during 2015-2016			
	30 DAT	50 DAT	70 DAT	Harvest	30 DAT	50 DAT	70 DAT	Harvest
$N_0W_3I_3$	41.02 f-m	58.55 i-t	73.89 i-s	79.44 l-t	42.58 i-p	60.32 i-s	75.57 l-v	81.05 k-s
$N_1W_0I_3$	41.53 f-m	62.77 f-o	75.67 g-p	78.94 l-t	42.70 h-o	63.32 e-p	77.09 i-s	80.62 l-t
$N_1W_1I_3$	41.91 e-j	59.06 h-s	73.45 j-t	76.79 o-w	43.69 e-k	59.70 j-t	74.88 l-v	78.48 n-v
$N_1W_2I_3$	51.69 a	73.11 ab	85.78 b	92.53 bc	52.37 a	74.72 ab	87.45 bc	93.98 a-c
$N_1W_3I_3$	41.28 f-m	63.54 e-n	77.56 e-n	81.97 h-p	43.15 g-m	64.45 d-n	79.27 f-p	83.44 i-o
$N_2W_0I_3$	45.60 b-d	61.17 g-q	75.56 g-p	81.09 i-p	47.22 b-e	62.55 e-q	77.39 h-r	82.85 i-p
$N_2W_1I_3$	45.42 b-d	65.06 c-j	79.08 c-k	84.64 d-l	47.98 bc	66.55 c-j	80.94 c-n	86.04 e-l
$N_2W_2I_3$	39.54 j-o	60.51 g-r	79.33 c-j	83.84 f-n	41.70 j-s	61.95 f-q	80.81 c-n	85.13 g-m
$N_2W_3I_3$	43.67 c-h	66.76 b-g	80.78 b-h	85.96 d-k	45.20 c-j	67.79 c-h	82.72 b-k	87.96 d-j
$N_3W_0I_3$	35.51 qr	53.59 r-t	67.22 u-x	73.32 t-x	37.30 t-w	55.51 q-t	69.86 t-w	74.87 t-x
$N_3W_1I_3$	37.57 n-q	55.51 p-t	76.97 f-o	82.67 g-o	39.41 n-u	56.63 p-t	78.48 g-r	85.11 g-m
$N_3W_2I_3$	40.44 h-o	62.45 f-p	74.67 i-r	80.56 i-r	42.15 i-r	63.75 e-o	75.77 k-v	81.89 j-s
$N_3W_3I_3$	37.50 n-q	59.08 h-s	78.55 d-l	84.18 e-m	39.21 o-u	61.32 h-r	80.02 d-o	86.27 e-l
$N_0W_0I_4$	31.88 st	42.80 v	64.13 wx	70.99 wx	33.70 x-z	44.06 v	69.11 vw	70.68 x
$N_0W_1I_4$	37.59 n-q	57.88 j-t	73.46 j-t	79.00 l-t	39.62 m-u	59.55 j-t	75.24 l-v	80.45 l-t
$N_0W_2I_4$	41.74 f-k	68.53 a-f	78.02 e-m	83.89 f-n	43.68 e-k	69.38 a-e	79.88 d-o	85.41 f-m
$N_0W_3I_4$	42.70 d-j	62.22 f-q	71.16 o-v	76.90 o-w	44.18 d-k	63.47 e-p	72.56 p-w	78.21 o-v
$N_1W_0I_4$	36.26 p-r	60.64 g-r	68.68 r-x	73.93 s-x	38.95 q-v	62.02 f-q	70.41 s-w	75.80 s-x
$N_1W_1I_4$	41.57 f-l	63.86 e-m	84.94 bc	88.91 b-g	43.23 g-m	64.94 d-m	86.58 b-d	90.39 b-g
$N_1W_2I_4$	52.15 a	74.79 a	92.13 a	98.18 a	54.19 a	75.63 a	93.88 a	99.10 a
$N_1W_3I_4$	45.08 b-e	65.86 c-h	85.64 b	89.91 b-f	45.71 b-i	66.83 c-i	87.42 bc	91.12 b-f
$N_2W_0I_4$	38.19 m-q	61.57 f-q	77.68 e-n	82.80 g-o	39.93 l-t	63.14 e-p	79.46 e-p	84.46 g-n
$N_2W_1I_4$	42.54 d-j	66.63 b-g	82.51 b-f	86.84 c-i	43.68 e-k	67.97 c-h	84.17 b-h	88.61 c-i
$N_2W_2I_4$	42.61 d-j	67.11 b-g	82.35 b-f	86.34 d-j	43.59 f-l	68.48 b-g	83.88 b-i	87.76 d-j
$N_2W_3I_4$	43.43 c-i	64.11 e-m	79.73 c-i	83.09 g-o	44.38 d-j	65.39 d-l	81.74 b-l	84.96 g-m
$N_3W_0I_4$	46.02 bc	66.50 b-g	75.57 g-p	81.76 i-p	47.41 b-d	67.70 c-h	77.48 h-r	82.84 i-p
$N_3W_1I_4$	44.03 c-f	67.28 b-g	84.88 bc	90.65 b-d	45.78 b-i	68.65 b-g	86.02 b-f	92.35 b-d
$N_3W_2I_4$	44.03 c-f	71.57 a-d	83.94 b-d	90.29 b-e	44.84 c-j	73.23 a-c	86.13 b-e	92.18 b-d
$N_3W_3I_4$	43.86 c-g	71.79 a-c	81.24 b-g	86.53 c-i	46.26 b-h	72.85 a-c	82.90 b-j	88.73 c-i
SE value	0.962	2.057	1.734	1.840	1.045	2.015	1.991	1.754
Level of significance	*	*	*	*	*	*	*	*
CV (%)	4.11	5.86	4.00	3.96	4.28	5.63	4.46	3.70

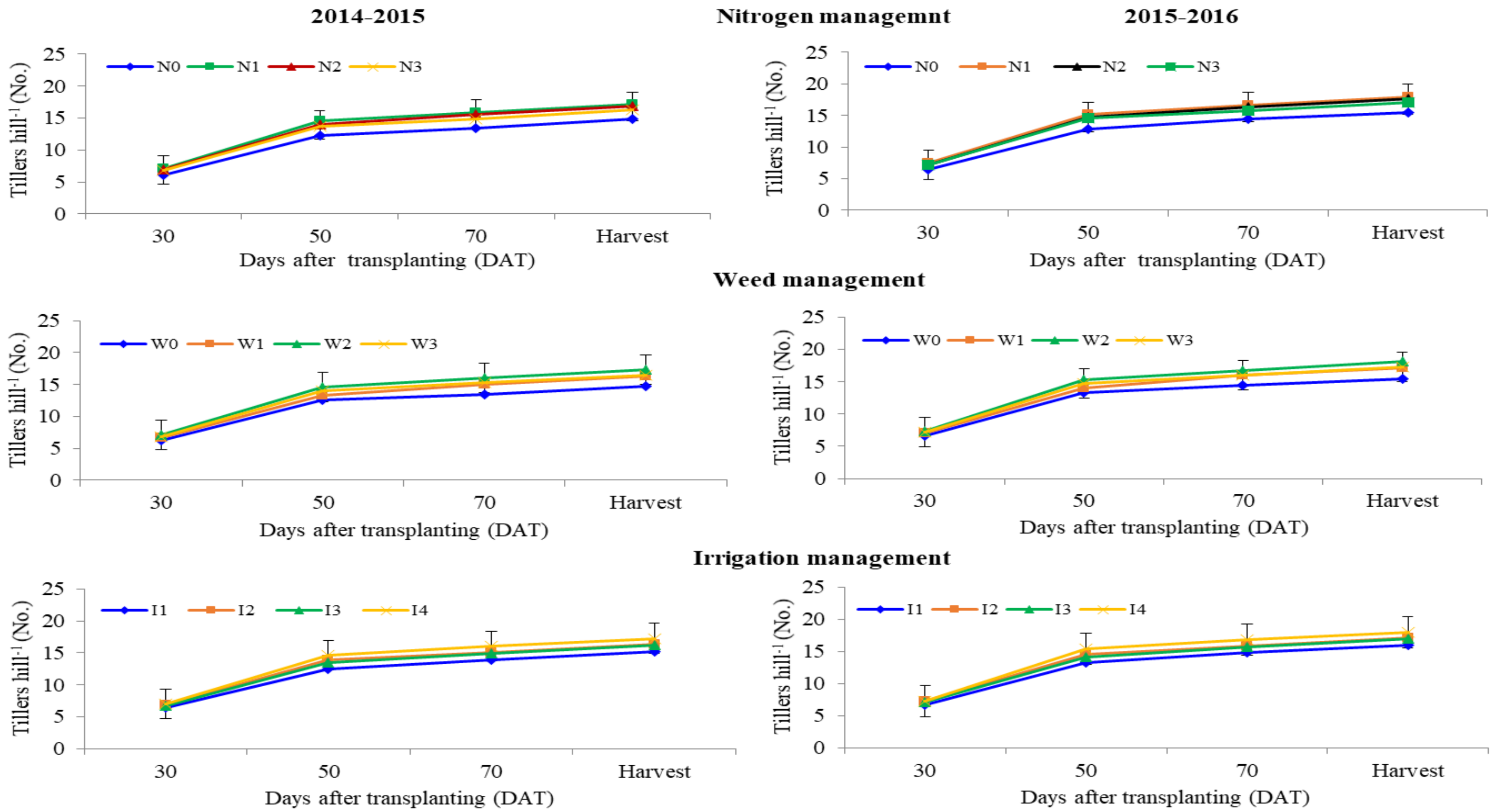
*: Significant at 0.05 level of Probability

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

N_0: No urea (control), N_1: Urea super granules (77 kg N ha^{-1}), N_2: Prilled urea at recommended dose (150 kg N ha^{-1}) as 325 kg urea ha^{-1} and N_3= ½ of the recommended dose (75 kg N ha^{-1}) as163 kg urea ha^{-1}

W_0: No weeding (control), W_1: Two hand weeding (20 DAT and 40 DAT), W_2: Pre emergence herbicide (Butachor) and W_3: Post emergence herbicide (Pritylocor)

I_1: Irrigating all time, I_2: Irrigating 3 days after drying, I_3: Irrigating 5 days after drying and I_4: Alternate wetting and drying (AWD) method



N_0: No urea (control), N_1: Urea super granules (77 kg N ha^{-1}), N_2: Prilled urea at recommended dose (150 kg N ha^{-1}) as 325 kg urea ha^{-1} and N_3= ½ of the recommended dose (75 kg N ha^{-1}) as163 kg urea ha^{-1}

W_0: No weeding (control), W_1: Two hand weeding (20 DAT and 40 DAT), W_2: Pre emergence herbicide (Butachor) and W_3: Post emergence herbicide (Prityloclor)
I_1: Irrigating all time, I_2: Irrigating 3 days after drying, I_3: Irrigating 5 days after drying and I_4: Alternate wetting and drying (AWD) method

Figure 4.2.1 Effect of different levels of nitrogen, weed management and irrigation on number of tillers hill^{-1} at different DAT and harvest of BRRI dhan29.

4.2.2 Effect of weed management

Number of tillers hill^{-1} of BRRI dhan29 at 30, 50, 70 DAT and harvest showed statistically significant differences for different weed management for the two subsequent years (Figure 4.2.1). The highest number of tillers hill^{-1} (7.12, 14.55, 16.05, 17.37, respectively) were found at 30, 50, 70 DAT and harvest during 2014-2015, similarly higher numbers (7.39, 15.27, 16.78 and 18.17) were obtained during 2015-2016 by W_2 and followed (6.88, 14.05, 15.26, 16.48) and (7.15, 14.78, 15.99 and 17.23 respectively) by W_3, while the minimum number (6.27, 12.56, 13.42, 14.78) and (6.62, 13.25, 14.38 and 15.45, respectively) were found from W_0.

4.2.3 Effect of irrigation management

Number of tillers hill^{-1} of BRRI dhan29 at 30, 50, 70 DAT and harvest showed statistically significant differences due to different irrigation management (Figure 4.2.1). Number of tillers hill^{-1} was significantly higher in irrigated tretments compared to control condition in all data recording days for the two subsequent years. The highest number of tillers hill^{-1} (6.99, 14.66, 16.00,17.27, 7.30, 15.39, 16.78 and 17.98, respectively) were found from I_4 which was statitically similar (6.84 and 7.18, respectively at 30 DAT) by I_2 and follwed (6.76, 13.42, 14.85, 16.19, 7.09, 14.13, 15.74 and 16.98, respectively) by I_3, whereas the lowest number (6.36, 12.53, 13.95, 15.18, 6.62, 13.27, 14.78 and 15.91, respectively) were recorded from I_1, during 2014-2015 and 2015-2016. Nasir *et al.* (2014) conducted an experiment to study the influence of AWD irrigation system on growth and yield of *boro* rice and recoded the highest number of tillers from AWD irrigation management compared to others.

4.2.4 Combined effect of nitrogen and weed management

Number of tillers hill^{-1} of BRRI dhan29 at 30, 50, 70 DAT and harvest varied significantly for the combined effect of different nitrogen and weed management in terms of in all data recording days for the two subsequent years (Table 4.2.1). The higher number of tillers hill^{-1} (8.12, 16.50, 18.15, 19.67, 8.33, 17.17, 18.85 and 20.42, respectively) was recorded from N_1W_2, whereas the minimum number (5.22, 10.33, 11.57, 13.00, 5.63, 10.63, 13.13 and 13.33, respectively) at 30, 50, 70 DAT and harvest, from N_0W_0.

Table 4.2.1 Combined effect of different levels of nitrogen and weed management on number of tillers hill^{-1} at different DAT and harvest of BRRI dhan29.

Treatments	Number of tillers hill^{-1} during 2014-2015				Number of tillers hill^{-1} during 2015-2016			
	30 DAT	50 DAT	70 DAT	Harvest	30 DAT	50 DAT	70 DAT	Harvest
N_0W_0	5.22 h	10.33 g	11.57 j	13.00 h	5.63 f	10.63 h	13.13 h	13.33 h
N_0W_1	6.00 g	11.90 f	13.03 i	14.57 g	6.40 e	12.55 g	14.47 g	15.35 g
N_0W_2	6.48 f	13.45 c-e	14.90 ef	16.35 de	6.83 d	14.12 ef	15.70 de	17.20 de
N_0W_3	6.63 ef	13.12 de	14.02 h	15.37 f	6.85 d	13.93 f	14.75 fg	16.12 f
N_1W_0	6.53 ef	13.57 c-e	14.13 gh	15.30 f	6.83 d	14.17 d-f	14.82 fg	16.07 f
N_1W_1	6.95 b-d	13.65 c-e	15.67 cd	16.63 c-e	7.27 bc	14.37 c-f	16.35 cd	17.42 c-e
N_1W_2	8.12 a	16.50 a	18.15 a	19.67 a	8.33 a	17.17 a	18.85 a	20.42 a
N_1W_3	7.00 bc	14.57 b	15.67 cd	16.78 c-e	7.27 bc	15.25 bc	16.37 cd	17.55 c-e
N_2W_0	6.75 c-f	13.60 c-e	14.77 fg	16.10 e	7.03 cd	14.40 c-f	15.40 ef	16.88 e
N_2W_1	6.97 b-d	14.25 bc	16.53 b	17.78 b	7.27 bc	14.97 b-e	17.22 b	18.58 b
N_2W_2	6.72 d-f	13.68 cd	15.30 c-f	16.33 de	6.98 cd	14.42 c-f	16.00 c-e	17.07 de
N_2W_3	7.15 b	14.37 bc	15.88 c	17.02 cd	7.40 b	15.07 b-d	16.65 bc	17.73 cd
N_3W_0	6.58 ef	12.75 e	13.22 i	14.73 fg	6.97 cd	13.80 f	14.18 g	15.53 fg
N_3W_1	6.80 c-e	13.55 c-e	15.07 d-f	16.42 c-e	7.15 bc	14.27 d-f	15.82 c-e	17.27 c-e
N_3W_2	7.17 b	14.58 b	15.83 c	17.15 bc	7.42 b	15.37 b	16.57 bc	17.98 bc
N_3W_3	6.72 d-f	14.15 bc	15.48 c-e	16.77 c-e	7.08 cd	14.87 b-e	16.18 c-e	17.52 c-e
SE value	0.086	0.283	0.228	0.243	0.093	0.278	0.264	0.233
Level of significance	*	*	*	*	*	*	*	*
CV (%)	3.73	4.52	7.13	6.08	3.73	4.32	6.40	5.63

*: Significant at 0.05 level of probability

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

N_0: No urea (control), N_1: Urea super granules (77 kg N ha^{-1}), N_2: Prilled urea at recommended dose (150 kg N ha^{-1}) as 325 kg urea ha^{-1} and N_3= ½ of the recommended dose (75 kg N ha^{-1}) as163 kg urea ha^{-1}

W_0: No weeding (control), W_1: Two hand weeding (20 DAT and 40 DAT), W_2: Pre emergence herbicide (Butachor) and W_3: Post emergence herbicide (Prityloclor)

4.2.5 Combined effect of nitrogen and irrigation

Combined effect of different irrigation and nitrogen management significantly influenced the number of tillers hill^{-1} of BRRI dhan29 at 30, 50, 70 DAT and harvest for the two subsequent years (Table 4.2.2). The higher number of tillers hill^{-1} (7.38, 15.78, 17.02, 18.20, 7.68, 16.68, 17.68 and 18.85, respectively) were recorded from N_1I_4, whereas the lowest number (5.30, 10.88, 12.40, 13.62, 5.60, 11.53, 13.32 and 14.20 respectively) at 30, 50, 70 DAT and harvest, from N_0I_1.

4.2.6 Combined effect of irrigation and weed management

The number of tillers hill^{-1} at 30, 50, 70 DAT and harvest varied significantly due to the combined application of differents levels at irrigation and weed management during 2014-2015 and 2015-2016 (Table 4.2.3). The heighest numbers of tillers hill^{-1} (7.47, 16.18, 17.35, 18.67, 7.78, 16.92, 18.10 and 19.42, respectively) was recorded from W_2I_4, which was statistically similar with 7.28 and 7.53 at 30 DAT, whereas the lowest number (5.97, 11.52, 12.38, 13.57, 6.25, 12.38, 13.15 and 14.20, respectively) from W_0I_1.

4.2.7 Combined effect of nitrogen, weed and irrigation management

Statistically significant differences was observed for the combined effect of different nitrogen, weed management and irrigation in terms of number of tillers hill^{-1} of BRRI dhan 29 at 30, 50, 70 DAT and harvest for the two subsequent years (Table 4.2.5). The highest number of tillers hill^{-1} (8.67, 17.40, 19.53, 20.93, 9.07, 18.00, 20.13 and 21.53, respectively) were recorded from N_1W_2 I_4 , at 30, 50, 70 DAT and harvest, while the lowest number (5.00, 10.07, 10.53, 11.13, 5.33, 10.60, 10.87 and 11.20 respectively) from $N_0W_0I_{1.}$

Table 4.2.2 Combined effect of different levels of nitrogen and irrigation on number of tillers hill^{-1} at different DAT and harvest of BRRI dhan29.

Treatments	Number of tillers hill^{-1} during 2014-2015				Number of tillers hill^{-1} during 2015-2016			
	30 DAT	50 DAT	70 DAT	Harvest	30 DAT	50 DAT	70 DAT	Harvest
N_0I_1	5.30 h	10.88 k	12.40 h	13.62 h	5.60 g	11.53 l	13.32 j	14.20 i
N_1I_1	6.95 d	13.48 fg	15.18 de	16.47 b-e	7.18 c	14.25 gh	15.90 d-g	17.23 c-e
N_2I_1	6.63 e	12.90 hi	14.78 ef	15.98 ef	6.83 de	13.62 ij	15.43 e-h	16.70 e-g
N_3I_1	6.55 ef	12.85 hi	13.45 g	14.67 g	6.87 d	13.70 i	14.48 i	15.52 h
N_0I_2	6.40 fg	12.50 ij	14.00 fg	15.48 fg	6.77 d-f	13.12 jk	15.25 f-i	16.25 f-h
N_1I_2	7.03 cd	15.20 b	15.70 b-e	16.97 b-d	7.32 bc	15.80 b	16.42 cd	17.83 b-d
N_2I_2	6.85 d	14.13 de	15.45 c-e	16.73 b-e	7.13 c	14.82 ef	16.12 d-f	17.48 b-e
N_3I_2	7.07 b-d	13.77 ef	14.83 ef	16.22 c-f	7.48 ab	14.43 fg	15.47 e-h	16.98 d-f
N_0I_3	6.23 g	12.23 j	13.08 gh	14.70 g	6.62 ef	12.82 k	14.52 hi	15.48 h
N_1I_3	7.33 a	14.58 cd	15.72 b-e	16.75 b-e	7.58 a	15.20 c-e	16.38 c-e	17.53 b-e
N_2I_3	7.20 a-c	14.22 de	15.88 b-d	17.13 bc	7.57 a	15.00 de	16.60 b-d	17.92 bc
N_3I_3	6.27 g	12.63 h-j	14.72 ef	16.17 d-f	6.58 f	13.48 ij	15.45 e-h	16.97 d-f
N_0I_4	6.40 fg	13.18 gh	14.03 fg	15.48 fg	6.73 d-f	13.77 hi	14.97 g-i	16.07 gh
N_1I_4	7.38 a	15.78 a	17.02 a	18.20 a	7.68 a	16.68 a	17.68 a	18.85 a
N_2I_4	6.90 d	14.65 cd	16.37 a-c	17.38 ab	7.15 c	15.42 b-d	17.12 a-c	18.17 ab
N_3I_4	7.28 ab	15.02 bc	16.60 ab	18.02 a	7.62 a	15.70 bc	17.35 ab	18.83 a
SE value	0.073	0.178	0.308	0.285	0.076	0.179	0.292	0.276
Level of significance	*	*	*	*	*	*	*	*
CV (%)	4.39	7.20	5.29	5.17	4.56	6.73	5.80	4.75

*: Significant at 0.05 level of Probability

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

N_0: No urea (control), N_1: Urea super granules (77 kg N ha^{-1}), N_2: Prilled urea at recommended dose (150 kg N ha^{-1}) as 325 kg urea ha^{-1} and N_3= ½ of the recommended dose (75 kg N ha^{-1}) as163 kg urea ha^{-1}

I_1: Irrigating all time, I_2: Irrigating 3 days after drying, I_3: Irrigating 5 days after drying and I_4: Alternate wetting and drying (AWD) method

Table 4.2.3 Combined effect of weed management and irrigation on number of tillers hill^{-1} at different DAT and harvest of BRRI dhan29.

Treatments	Number of tillers hill^{-1} during 2014-2015				Number of tillers hill^{-1} during 2015-2016			
	30 DAT	50 DAT	70 DAT	Harvest	30 DAT	50 DAT	70 DAT	Harvest
W_0I_1	5.97 h	11.52 g	12.38 j	13.57 j	6.25 h	12.38 h	13.15 i	14.20 j
W_1I_1	6.37 g	12.47 f	13.97 hi	15.30 hi	6.68 g	13.08 f-h	15.02 f-h	16.10 hi
W_2I_1	6.67 ef	13.17 d-f	15.00 e-g	16.23 e-g	6.90 e-g	13.88 ef	15.78 d-f	17.02 e-g
W_3I_1	6.43 fg	12.97 ef	14.47 gh	15.63 g-i	6.65 g	13.75 e-g	15.18 e-h	16.33 g-i
W_0I_2	6.33 g	13.12 d-f	13.68i	15.15 hi	6.73 g	13.78 e-g	14.78 gh	15.88 i
W_1I_2	6.80 de	13.87 cd	15.28 d-f	16.50 d-f	7.17 c-e	14.53 de	15.98 de	17.35 d-f
W_2I_2	7.20 bc	14.17 bc	16.12 bc	17.53 bc	7.50 b	14.80 cd	16.88 bc	18.37 bc
W_3I_2	7.02 cd	14.45 bc	14.90 fg	16.22 e-g	7.30 b-d	15.05 b-d	15.60 d-g	16.95 fg
W_0I_3	6.45 fg	12.40 f	13.65 i	15.02 i	6.80 fg	12.98 gh	14.72 h	15.73 i
W_1I_3	6.67 ef	12.73 f	14.43 gh	15.80 f-h	7.05 d-f	13.42 fg	15.53 d-h	16.62 gh
W_2I_3	7.15 bc	14.70 bc	15.72 cd	17.07 b-d	7.38 bc	15.47 bc	16.35 cd	17.87 b-d
W_3I_3	6.77 de	13.83 c-e	15.60 c-e	16.87 c-e	7.12 c-e	14.63 c-e	16.35 cd	17.68 c-e
W_0I_4	6.33 g	13.22 d-f	13.97 hi	15.40 hi	6.68 g	13.85 e-g	14.88 gh	16.00 hi
W_1I_4	6.88 de	14.28 bc	16.62 b	17.80 b	7.18 c-e	15.12 b-d	17.32 b	18.55 b
W_2I_4	7.47 a	16.18 a	17.35 a	18.67 a	7.78 a	16.92 a	18.10 a	19.42 a
W_3I_4	7.28 ab	14.95 b	16.08 bc	17.22 b-d	7.53 ab	15.68 b	16.82 bc	17.95 b-d
SE value	0.086	0.283	0.228	0.681	0.093	0.278	0.264	0.233
Level of significance	*	*	*	*	*	*	*	*
CV (%)	4.39	7.20	5.29	5.17	4.56	6.73	5.80	4.75

*: Significant at 0.05 level of Probability

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

W_0: No weeding (control), W_1: Two hand weeding (20 DAT and 40 DAT), W_2: Pre emergence herbicide (Butachor) and W_3: Post emergence herbicide (Prityloclor)

I_1: Irrigating all time, I_2: Irrigating 3 days after drying, I_3: Irrigating 5 days after drying and I_4: Alternate wetting and drying (AWD) method

Table 4.2.4 Combined effect of different levels of nitrogen, weed management and irrigation on number of tillers hill^{-1} at different DAT and harvest of BRRI dhan29.

Treatments	Number of tillers hill^{-1} during 2014-2015				Number of tillers hill^{-1} during 2015-2016			
	30 DAT	50 DAT	70 DAT	Harvest	30 DAT	50 DAT	70 DAT	Harvest
$N_0W_0I_1$	5.00 s	10.07 v	10.53 y	11.13 z	5.33 u	10.60 w	10.87 s	11.20 z
$N_0W_1I_1$	5.07 rs	10.47 t-v	11.80 xy	13.33 yz	5.47 tu	10.87 vw	13.67 qr	14.20 xy
$N_0W_2I_1$	5.53 p-s	11.07 s-v	14.33 m-u	15.87 l-u	5.93 r-t	11.73 u-w	15.07 j-r	16.67 k-s
$N_0W_3I_1$	5.60 p-r	11.93 o-v	12.93 t-x	14.13 v-z	5.67 s-u	12.93 p-u	13.67 qr	14.73 u-y
$N_1W_0I_1$	6.40 j-o	11.53 p-v	13.67 p-v	15.00 q-z	6.67 k-p	12.13 s-w	14.40 m-r	15.67 q-x
$N_1W_1I_1$	6.80 e-l	12.33 l-t	15.33 h-o	16.53 i-r	7.13 f-m	13.20 m-u	16.00 e-n	17.33 h-p
$N_1W_2I_1$	7.67 bc	16.00 a-e	17.33 b-e	18.80 b-e	7.80 b-e	16.73 a-d	18.13 b-d	19.60 b-e
$N_1W_3I_1$	6.93 e-k	14.07 e-m	14.40 l-t	15.53 n-v	7.13 f-m	14.93 d-o	15.07 j-r	16.33 m-t
$N_2W_0I_1$	6.27 l-n	12.47 l-s	13.33 q-w	14.67 s-z	6.47 n-r	13.27 l-u	13.80 p-r	15.40 r-y
$N_2W_1I_1$	6.73 e-m	13.53 g-o	16.13 c-k	17.47 d-l	6.93 i-o	14.13 g-r	16.80 b-j	18.20 d-k
$N_2W_2I_1$	6.67 f-m	12.27 m-t	14.00 n-v	14.93 r-z	6.80 j-p	13.00 o-u	14.73 k-r	15.67 q-x
$N_2W_3I_1$	6.87 e-k	13.33 g-q	15.67 g-m	16.87 g-p	7.13 f-m	14.07 g-r	16.40 d-k	17.53 h-p
$N_3W_0I_1$	6.20 m-o	12.00 n-u	12.00 wx	13.47 yz	6.53 m-q	13.53 j-u	13.53 r	14.53 w-y
$N_3W_1I_1$	6.87 e-k	13.53 g-o	12.60 vx	13.87 w-z	7.20 e-l	14.13 g-r	13.60 qr	14.67 v-y
$N_3W_2I_1$	6.80 e-l	13.33 g-q	14.33 m-u	15.33 o-w	7.07 g-n	14.07 g-r	15.20 i-r	16.13 n-v
$N_3W_3I_1$	6.33 k-o	12.53 k-s	14.87 k-q	16.00 l-u	6.67 k-p	13.07 n-u	15.60 h-p	16.73 k-s
$N_0W_0I_2$	5.13 rs	10.27 uv	11.93 w-y	13.60 yz	5.53 tu	10.73 vw	14.47 l-r	14.13 xy
$N_0W_1I_2$	6.73 e-m	13.33 g-q	14.00 n-v	15.20 p-y	7.13 f-m	13.93 h-s	14.73 k-r	16.07 o-w
$N_0W_2I_2$	6.73 e-m	12.60 j-s	15.33 h-o	16.87 g-p	7.13 f-m	13.40 j-u	16.27 e-l	17.73 f-n
$N_0W_3I_2$	7.00 d-j	13.80 f-o	14.73 k-r	16.27 i-s	7.27 d-k	14.40 e-r	15.53 h-p	17.07 i-q
$N_1W_0I_2$	6.80 e-l	15.20 b-g	14.60 k-s	15.93 l-u	7.00 h-n	15.73 c-i	15.33 i-r	16.73 k-s
$N_1W_1I_2$	7.07 d-i	14.93 c-h	15.27 i-o	16.27 i-s	7.40 c-j	15.73 c-i	16.07 e-n	17.20 h-q
$N_1W_2I_2$	7.53 b-d	15.67 a-f	17.93 b	19.53 b	7.80 b-e	16.13 b-f	18.60 b	20.33 ab
$N_1W_3I_2$	6.73 e-m	15.00 c-h	15.00 j-p	16.13 j-t	7.07 g-n	15.60 c-i	15.67 h-o	17.07 i-q
$N_2W_0I_2$	6.87 e-k	14.53 d-j	15.13 i-p	16.47 i-r	7.13 f-m	15.33 d-j	15.73 g-n	17.27 h-q
$N_2W_1I_2$	6.60 g-m	13.73 f-o	17.13 b-g	18.47 b-g	6.93 i-o	14.33 e-r	17.73 b-e	19.27 b-f
$N_2W_2I_2$	6.67 f-m	13.73 f-o	14.33 m-u	15.53 n-v	6.93 i-o	14.40 e-r	15.07 j-r	16.27 m-u
$N_2W_3I_2$	7.27 c-f	14.53 d-j	15.20 i-p	16.47 i-r	7.53 b-i	15.20 d-l	15.93 e-n	17.13 i-q
$N_3W_0I_2$	6.53 h-n	12.47 l-s	13.07 s-x	14.60 s-z	7.27 d-k	13.33 k-u	13.60 qr	15.40 r-y
$N_3W_1I_2$	6.80 e-l	13.47 g-p	14.73 k-r	16.07 k-t	7.20 e-l	14.13 g-r	15.40 i-q	16.87 k-s
$N_3W_2I_2$	7.87 b	14.67 c-i	16.87 b-h	18.20 b-h	8.13 b	15.27 d-k	17.60 b-f	19.13 b-g
$N_3W_3I_2$	7.07 d-i	14.47 d-k	14.67 k-r	16.00 l-u	7.33 c-j	15.00 d-n	15.27 i-r	16.53 l-t
$N_0W_0I_3$	5.40 q-s	10.47 t-v	11.73 xy	13.60 yz	6.00 q-t	10.47 w	13.60 qr	14.07 y
$N_0W_1I_3$	5.93 o-q	11.13 r-v	11.87 w-y	13.87 w-z	6.33 o-r	11.93 t-w	14.27 n-r	14.60 v-y
$N_0W_2I_3$	6.80 e-l	14.47 d-k	14.20 m-u	15.53 n-v	7.00 h-n	15.07 d-m	14.93 j-r	16.53 l-t

Cont'd

Treatments	Number of tillers hill^{-1} during 2014-2015				Number of tillers hill^{-1} during 2015-2016			
	30 DAT	50 DAT	70 DAT	Harvest	30 DAT	50 DAT	70 DAT	Harvest
$N_0W_3I_3$	6.80 e-l	12.87 i-s	14.53 k-s	15.80 l-u	7.13 f-m	13.80 i-t	15.27 i-r	16.73 k-s
$N_1W_0I_3$	6.93 e-k	14.07 e-m	15.07 i-p	15.73 m-v	7.13 f-m	14.60 e-q	15.67 h-o	16.60 k-s
$N_1W_1I_3$	7.00 d-j	13.07 h-r	14.47 l-t	15.20 p-y	7.33 c-j	13.53 j-u	15.07 j-r	16.00 o-w
$N_1W_2I_3$	8.60 a	16.93 ab	17.80 b	19.40 bc	8.67 a	17.80 ab	18.53 b	20.20 a-c
$N_1W_3I_3$	6.80 e-l	14.27 e-l	15.53 h-n	16.67 h-q	7.20 e-l	14.87 d-p	16.27 e-l	17.33 h-p
$N_2W_0I_3$	7.53 b-d	13.60 g-o	15.00 j-p	16.40 i-r	7.87 b-d	14.40 e-r	15.80 f-n	17.27 h-q
$N_2W_1I_3$	7.53 b-d	14.67 c-i	16.00 d-l	17.33 d-m	7.93 bc	15.53 c-i	16.67 c-j	18.07 e-l
$N_2W_2I_3$	6.47 i-o	13.47 g-p	16.00 d-l	17.07 f-n	6.93 i-o	14.27 f-r	16.67 c-j	17.80 f-m
$N_2W_3I_3$	7.27 c-f	15.13 b-g	16.53 b-j	17.73 d-k	7.53 b-i	15.80 c-h	17.27 b-h	18.53 d-j
$N_3W_0I_3$	5.93 o-q	11.47 q-v	12.80 u-x	14.33 u-z	6.20 p-s	12.47 r-v	13.80 p-r	15.00 t-y
$N_3W_1I_3$	6.20 m-o	12.07 n-u	15.40 h-o	16.80 h-p	6.60 l-q	12.67 q-u	16.13 e-m	17.80 f-m
$N_3W_2I_3$	6.73 e-m	13.93 f-n	14.87 k-q	16.27 i-s	6.93 i-o	14.73 e-p	15.27 i-r	16.93 j-r
$N_3W_3I_3$	6.20 m-o	13.07 h-r	15.80 e-m	17.27 e-m	6.60 l-q	14.07 g-r	16.60 c-j	18.13 e-l
$N_0W_0I_4$	5.33 rs	10.53 t-v	12.07 wx	13.67 x-z	5.67 s-u	10.73 vw	13.60 qr	13.93 y
$N_0W_1I_4$	6.27 l-o	12.67 j-s	14.47 l-t	15.87 l-u	6.67 k-p	13.47 j-u	15.20 i-r	16.53 l-t
$N_0W_2I_4$	6.87 e-k	15.67 a-f	15.73 f-m	17.13 f-n	7.27 d-k	16.27 a-e	16.53 c-k	17.87 f-m
$N_0W_3I_4$	7.13 c-h	13.87 f-o	13.87 o-v	15.27 p-x	7.33 c-j	14.60 e-q	14.53 l-r	15.93 p-w
$N_1W_0I_4$	6.00 n-p	13.47 g-p	13.20 r-x	14.53 t-z	6.53 m-q	14.20 f-r	13.87 o-r	15.27 s-y
$N_1W_1I_4$	6.93 e-k	14.27 e-l	17.60 bc	18.53 b-f	7.20 e-l	15.00 d-n	18.27 bc	19.13 b-g
$N_1W_2I_4$	8.67 a	17.40 a	19.53 a	20.93 a	9.07 a	18.00 a	20.13 a	21.53 a
$N_1W_3I_4$	7.53 b-d	14.93 c-h	17.73 b	18.80 b-e	7.67 b-g	15.60 c-i	18.47 b	19.47 b-e
$N_2W_0I_4$	6.33 k-o	13.80 f-o	15.60 g-n	16.87 g-p	6.67 k-p	14.60 e-q	16.27 e-l	17.60 g-o
$N_2W_1I_4$	7.00 d-j	15.07 b-g	16.87 b-h	17.87 c-i	7.27 d-k	15.87 c-h	17.67 b-e	18.80 b-h
$N_2W_2I_4$	7.07 d-i	15.27 b-g	16.87 b-h	17.80 c-j	7.27 d-k	16.00 b-g	17.53 b-g	18.53 d-j
$N_2W_3I_4$	7.20 c-g	14.47 d-k	16.13 c-k	17.00 f-o	7.40 c-j	15.20 d-l	17.00 b-i	17.73 f-n
$N_3W_0I_4$	7.67 bc	15.07 b-g	15.00 j-p	16.53 i-r	7.87 b-d	15.87 c-h	15.80 f-n	17.20 h-q
$N_3W_1I_4$	7.33 b-e	15.13 b-g	17.53 b-d	18.93 b-d	7.60 b-h	16.13 b-f	18.13 b-d	19.73 b-d
$N_3W_2I_4$	7.27 c-f	16.40 a-d	17.27 b-f	18.80 b-e	7.53 b-i	17.40 a-c	18.20 b-d	19.73 b-d
$N_3W_3I_4$	7.27 c-f	16.53 a-c	16.60 b-i	17.80 c-j	7.73 b-f	17.33 a-c	17.27 b-h	18.67 c-i
SE value	0.481	0.566	0.457	0.485	0.185	0.557	0.528	0.467
Level of significance	*	*	*	*	*	*	*	*
CV (%)	4.39	7.20	5.29	5.17	4.56	6.73	5.80	4.75

*: Significant at 0.05 level of Probability

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

N_0: No urea (control), N_1: Urea super granules (77 kg N ha^{-1}), N_2: Prilled urea at recommended dose (150 kg N ha^{-1}) as 325 kg urea ha^{-1} and N_3= ½ of the recommended dose (75 kg N ha^{-1}) as163 kg urea ha^{-1}

W_0: No weeding (control), W_1: Two hand weeding (20 DAT and 40 DAT), W_2: Pre emergence herbicide (Butachor) and W_3: Post emergence herbicide (Prityloclor)

I_1: Irrigating all time, I_2: Irrigating 3 days after drying, I_3: Irrigating 5 days after drying and I_4: Alternate wetting and drying (AWD) method

4.3 Leaf area index

Due to different levels of nitrogen, weed and irrigation management and also their combined effect showed significant variation in terms of LAI of BRRI dhan29 at 30, 50 and 70 DAT for the two subsequent years (Appendix VI). In general irrespective of treatments and their combined effects, showed an increasing trend (Figure 4.3.1 and Table 4.3.1 to 4.3.4).

4.3.1 Effect of nitrogen management

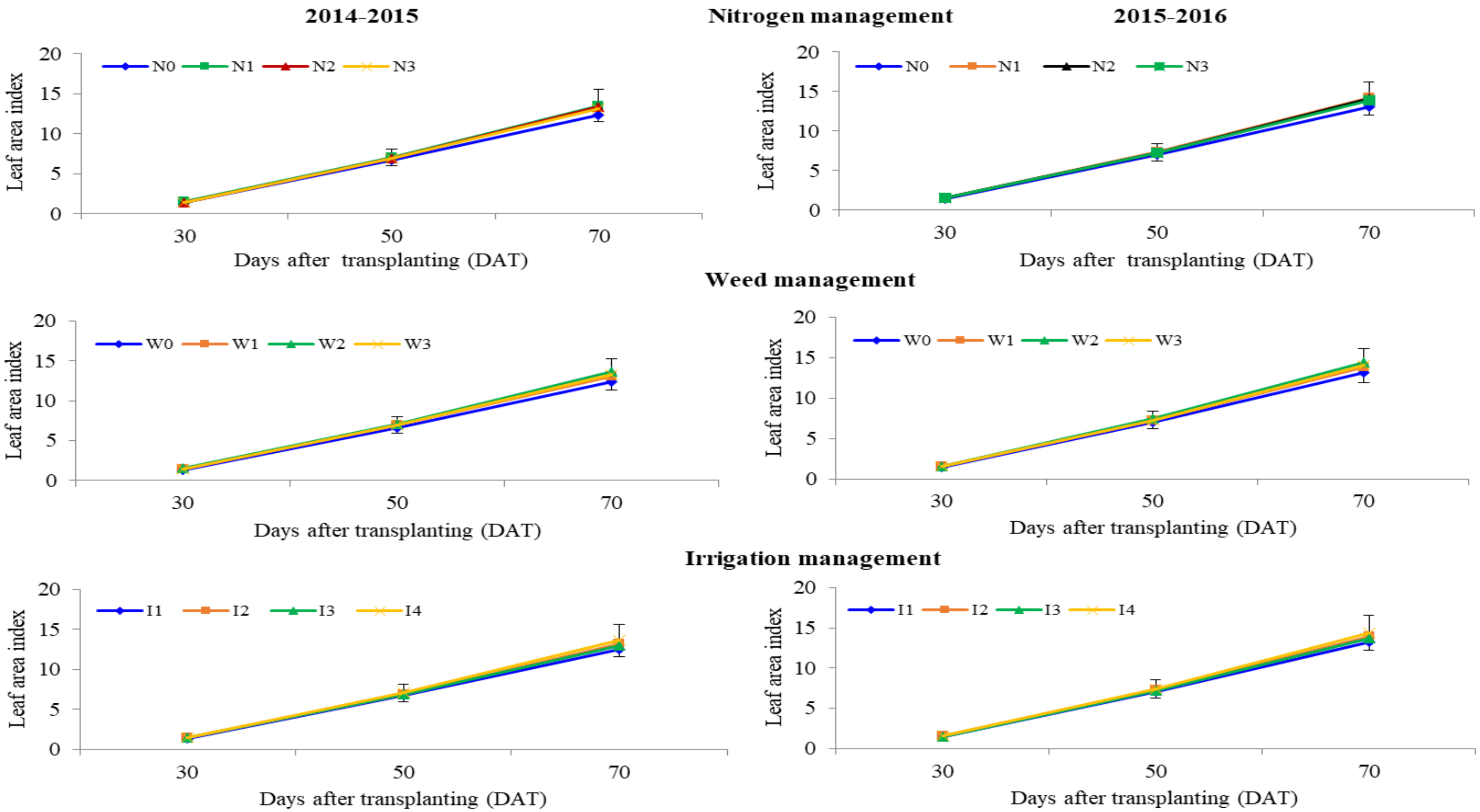
Different nitrogen management showed significant differences in terms of LAI of BRRI dhan29 at 30, 50 and 70 DAT for the two subsequent years (Figure 4.3.1). The highest LAI (1.48, 7.02, 13.54, 1.55, 7.34 and 14.28, respectively) were recorded from N_1 at 30, 50 and 70 DAT, which was statistically similar (1.47, 6.97, 13.33, 1.53, 7.30 and 14.09, respectively) to N_2 and followed (1.44, 6.89, 13.11, 1.51, 7.24 and 13.86, respectively) by N_3, while the lowest (1.37, 6.66, 12.29, 1.43, 6.99 and 13.05, respectively) from N_0.

4.3.2 Effect of weed management

Statistically significant variation was recorded in terms of LAI of BRRI dhan29 at 30, 50 and 70 DAT for different weed management for the two subsequent years (Figure 4.3.1). The highest LAI (1.50, 7.07, 13.59, 1.56, 7.40 and 14.35, respectively) was recorded from W_2, at 30, 50 and 70 DAT, which was followed (1.45, 6.92, 13.26, 1.52, 7.26 and 14.02 ,respectively) by W_3, while the lower (1.36, 6.65, 12.37, 1.43, 6.99 and 13.13, respectively) values of LAI were found from W_0.

4.3.3 Effect of irrigation management

LAI of BRRI dhan29 at 30, 50 and 70 DAT statistically significant influenced due to different irrigation management for the two subsequent years (Figure 4.3.1). The highest LAI (1.49, 7.04, 13.61, 1.56, 7.41 and 14.40, respectively) was found from $I_{4,}$ at 30, 50 and 70 DAT, which was followed (1.44, 6.90, 13.14, 1.51, 7.23 and 13.90, respectively) by I_2 and (1.44, 6.88, 12.99, 1.50, 7.20 and 13.73, respectively) by I_3 and those were statistically similar, whereas the lowest (1.39, 6.72, 12.51, 1.45, 7.03 and 13.26, respectively) was found from I_1.



N_0: No urea (control), N_1: Urea super granules (77 kg N ha^{-1}), N_2: Prilled urea at recommended dose (150 kg N ha^{-1}) as 325 kg urea ha^{-1} and N_3= ½ of the recommended dose (75 kg N ha^{-1}) as163 kg urea ha^{-1}
W_0: No weeding (control), W_1: Two hand weeding (20 DAT and 40 DAT), W_2: Pre emergence herbicide (Butachor) and W_3: Post emergence herbicide (Prityloclor)
I_1: Irrigating all time, I_2: Irrigating 3 days after drying, I_3: Irrigating 5 days after drying and I_4: Alternate wetting and drying (AWD) method

Figure 4.3.1 Effect of different levels of nitrogen, weed management and irrigation on LAI at different DAT of BRRI dhan29.

4.3.4 Combined effect of nitrogen and weed management

LAI of BRRI dhan29 at 30, 50 and 70 DAT varied significantly for the combined effect of different nitrogen and weed management for the two subsequent years (Table 4.2.1). At 30, 50 and 70 DAT, the highest LAI (1.61, 7.42, 14.63, 1.67, 7.74 and 15.37, respectively) was recorded from N_1W_2, whereas the lowest (1.27, 6.34, 11.31, 1.34, 6.64 and 12.05, respectively) from N_0W_0.

4.3.5 Combined effect of nitrogen and irrigation

Combined effect of different irrigation and nitrogen management showed statistically significant differences in terms of LAI of BRRI dhan29 at 30, 50 and 70 DAT days for the two subsequent years (Table 4.2.2). The highest LAI (1.54, 7.18, 14.14, 1.61, 7.59 and 14.95, respectively) was recorded from N_1I_4, at 30, 50 and 70 DAT, whereas the lowest (1.31, 6.47, 11.69, 1.37, 6.80 and 12.48, respectively) was recorded from N_0I_1 ubser the present trails.

4.3.6 Combined effect of irrigation and weed management

Different irrigation and weed management varied significantly in terms of LAI of BRRI dhan29 at 30, 50 and 70 DAT for the two subsequent years due to combined effect (Table 4.2.3). The highest LAI (1.56, 7.26, 14.33, 1.63, 7.60 and 15.23, respectively) was recorded from W_2I_4, at 30, 50 and 70 DAT, whereas the lowest (1.31, 6.45, 11.82, 1.39, 6.76 and 12.58, respectively) from W_0I_1.

4.3.7 Combined effect of nitrogen, weed and irrigation management

Statistically significant differences was observed for the combined effect of different nitrogen, weed management and irrigation in terms of LAI of BRRI dhan29 at 30, 50 and 70 DAT for the two subsequent years (Table 4.2.4). The recorded data revealed that at 30, 50 and 70 DAT, the highest leaf area index (1.67, 7.61, 14.94, 1.74, 7.89 and 15.92, respectively) was recorded from N_1W_2 I_4, while the lowest (1.22, 6.03, 10.89, 1.29, 6.35 and 11.76, respectively) from $N_0W_0I_{1.}$

Table 4.3.1 Combined effect of different levels of nitrogen and weed management on LAI at different DAT of BRRI dhan29.

Treatments	LAI during 2014-2015			LAI during 2015-2016		
	30 DAT	50 DAT	70 DAT	30 DAT	50 DAT	70 DAT
N_0W_0	1.27 g	6.34 f	11.31 j	1.34 f	6.64 i	12.05 i
N_0W_1	1.35 f	6.62 e	12.18 i	1.42 e	7.00 h	12.92 h
N_0W_2	1.45 cd	6.92 c	12.99 e-g	1.51 cd	7.24 c-f	13.77 d-f
N_0W_3	1.39 ef	6.75 de	12.67 gh	1.46 de	7.08 e-h	13.45 fg
N_1W_0	1.39 ef	6.74 de	12.77 f-h	1.46 de	7.06 f-h	13.60 e-g
N_1W_1	1.46 cd	6.95 c	13.26 c-e	1.52 bc	7.27 b-e	13.96 c-e
N_1W_2	1.61 a	7.42 a	14.63 a	1.67 a	7.74 a	15.37 a
N_1W_3	1.46 cd	6.97 bc	13.50 b-d	1.53 bc	7.30 b-d	14.21 b-d
N_2W_0	1.43 de	6.86 cd	12.98 e-g	1.50 cd	7.22 c-g	13.63 e-g
N_2W_1	1.52 b	7.13 b	13.67 b	1.58 b	7.44 b	14.44 b
N_2W_2	1.44 cd	6.90 cd	13.16 d-f	1.51 cd	7.19 d-g	13.90 d-f
N_2W_3	1.48 b-d	7.00 bc	13.51 b-d	1.54 bc	7.35 b-d	14.38 bc
N_3W_0	1.36 f	6.65 e	12.44 hi	1.43 e	7.03 gh	13.25 gh
N_3W_1	1.45 cd	6.92 c	13.07 ef	1.51 cd	7.24 c-f	13.79 d-f
N_3W_2	1.49 bc	7.03 bc	13.58 bc	1.56 bc	7.41 bc	14.38 bc
N_3W_3	1.46 cd	6.97 bc	13.34 b-e	1.54 bc	7.28 b-d	14.03 b-e
SE value	0.016	0.054	0.128	0.018	0.062	0.150
Level of significance	*	*	*	*	*	*
CV (%)	3.11	2.52	3.80	3.64	2.19	3.90

*: Significant at 0.05 level of probability

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

N_0: No urea (control), N_1: Urea super granules (77 kg N ha^{-1}), N_2: Prilled urea at recommended dose (150 kg N ha^{-1}) as 325 kg urea ha^{-1} and N_3= ½ of the recommended dose (75 kg N ha^{-1}) as163 kg urea ha^{-1}

W_0: No weeding (control), W_1: Two hand weeding (20 DAT and 40 DAT), W_2: Pre emergence herbicide (Butachor) and W_3: Post emergence herbicide (Prityloclor)

Table 4.3.2 Combined effect of different levels of nitrogen and irrigation management on LAI at different DAT of BRRI dhan29.

Treatments	LAI during 2014-2015			LAI during 2015-2016		
	30 DAT	50 DAT	70 DAT	30 DAT	50 DAT	70 DAT
N_0I_1	1.31 h	6.47 h	11.69 h	1.37 h	6.80 j	12.48 h
N_1I_1	1.45 cd	6.92 b-e	13.09 de	1.51 c-f	7.23 d-h	13.82 ef
N_2I_1	1.42 d-f	6.84 d-f	12.78 ef	1.49 d-f	7.14 f-h	13.51 fg
N_3I_1	1.36 g	6.64 g	12.50 fg	1.43 g	6.93 ij	13.23 g
N_0I_2	1.40 ef	6.76 e-g	12.57 fg	1.47 e-g	7.09 h	13.28 g
N_1I_2	1.48 bc	7.01 bc	13.66 bc	1.54 b-d	7.32 c-e	14.33 b-d
N_2I_2	1.46 b-d	6.96 b-d	13.30 cd	1.52 b-e	7.27 d-f	14.14 c-e
N_3I_2	1.44 de	6.88 c-f	13.04 de	1.50 c-f	7.25 d-g	13.84 d-f
N_0I_3	1.36 g	6.64 g	12.23 g	1.42 gh	6.95 i	13.04 g
N_1I_3	1.46 b-d	6.97 b-d	13.50 b-d	1.53 b-d	7.31 c-e	14.22 c-e
N_2I_3	1.48 bc	7.02 a-c	13.49 b-d	1.55 bc	7.35 cd	14.22 c-e
N_3I_3	1.44 de	6.87 c-f	12.75 ef	1.50 c-f	7.20 e-h	13.43 fg
N_0I_4	1.39 fg	6.75 fg	12.66 e-g	1.46 fg	7.12 gh	13.39 fg
N_1I_4	1.54 a	7.18 a	14.14 a	1.61 a	7.59 a	14.95 a
N_2I_4	1.50 ab	7.06 ab	13.75 a-c	1.57 ab	7.43 bc	14.50 a-c
N_3I_4	1.53 a	7.17 a	13.90 ab	1.60 a	7.51 ab	14.77 ab
SE value	0.013	0.050	0.143	0.016	0.046	0.156
Level of significance	*	*	*	*	*	*
CV (%)	3.81	2.72	3.40	4.20	2.97	3.77

*: Significant at 0.05 level of Probability

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

N_0: No urea (control), N_1: Urea super granules (77 kg N ha^{-1}), N_2: Prilled urea at recommended dose (150 kg N ha^{-1}) as 325 kg urea ha^{-1} and N_3= ½ of the recommended dose (75 kg N ha^{-1}) as163 kg urea ha^{-1}

I_1: Irrigating all time, I_2: Irrigating 3 days after drying, I_3: Irrigating 5 days after drying and I_4: Alternate wetting and drying (AWD) method

Table 4.3.3 Combined effect of weed and irrigation management on LAI at different DAT of BRRI dhan29.

Treatments	LAI during 2014-2015			LAI during 2015-2016		
	30 DAT	50 DAT	70 DAT	30 DAT	50 DAT	70 DAT
W_0I_1	1.31 h	6.45 j	11.82 g	1.39 h	6.76 h	12.58 g
W_1I_1	1.39 fg	6.74 g-i	12.54 ef	1.45 fg	7.05 fg	13.30 f
W_2I_1	1.44 d-f	6.89 d-g	12.95 de	1.50 d-f	7.19 c-f	13.62 d-f
W_3I_1	1.40 e-g	6.78 f-i	12.75 ef	1.47 e-g	7.10 e-g	13.53 ef
W_0I_2	1.38 g	6.71 hi	12.63 ef	1.45 fg	7.03 fg	13.37 f
W_1I_2	1.45 c-e	6.93 c-f	13.19 cd	1.51 c-e	7.27 b-e	13.91 c-e
W_2I_2	1.51 b	7.10 bc	13.52 bc	1.57 bc	7.43 ab	14.30 bc
W_3I_2	1.43 d-f	6.88 d-h	13.23 cd	1.50 d-f	7.20 c-f	14.01 b-d
W_0I_3	1.37 g	6.69 i	12.39 f	1.43 gh	6.99 g	13.17 f
W_1I_3	1.42 e-g	6.82 e-i	12.71 ef	1.48 e-g	7.15 d-g	13.42 f
W_2I_3	1.48 b-d	7.02 b-d	13.56 bc	1.55 b-d	7.36 bc	14.26 bc
W_3I_3	1.47 b-d	6.99 b-e	13.32 cd	1.54 b-d	7.31 b-d	14.06 b-d
W_0I_4	1.39 fg	6.74 g-i	12.66 ef	1.46 e-g	7.16 d-g	13.41 f
W_1I_4	1.52 ab	7.13 ab	13.73 b	1.59 ab	7.47 ab	14.49 b
W_2I_4	1.56 a	7.26 a	14.33 a	1.63 a	7.60 a	15.23 a
W_3I_4	1.49 bc	7.03 b-d	13.73 b	1.56 bc	7.42 ab	14.48 b
SE value	0.016	0.054	0.128	0.018	0.062	0.150
Level of significance	*	*	*	*	*	*
CV (%)	3.81	2.72	3.40	4.20	2.97	3.77

*: Significant at 0.05 level of Probability

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

W_0: No weeding (control), W_1: Two hand weeding (20 DAT and 40 DAT), W_2: Pre emergence herbicide (Butachor) and W_3: Post emergence herbicide (Prityloclor)

I_1: Irrigating all time, I_2: Irrigating 3 days after drying, I_3: Irrigating 5 days after drying and I_4: Alternate wetting and drying (AWD) method

Table 4.3.4 Combined effect of different levels of nitrogen, weed and irrigation management on LAI at different DAT of BRRI dhan29

Treatments	LAI during 2014-2015			LAI during 2015-2016		
	30 DAT	50 DAT	70 DAT	30 DAT	50 DAT	70 DAT
$N_0W_0I_1$	1.22 t	6.03 v	10.89 z	1.29 u	6.35 x	11.76 y
$N_0W_1I_1$	1.29 st	6.43 u	11.62 x-z	1.35 r-u	6.81 r-w	12.45 u-y
$N_0W_2I_1$	1.42 h-q	6.86 h-r	12.17 t-y	1.47 i-s	7.14 h-v	12.79 r-x
$N_0W_3I_1$	1.32 p-s	6.54 q-u	12.07 u-y	1.38 p-u	6.88 p-w	12.92 p-x
$N_1W_0I_1$	1.37 l-s	6.68 l-u	12.09 u-y	1.45 k-t	6.96 n-w	12.93 p-w
$N_1W_1I_1$	1.45 d-n	6.93 e-p	12.84 m-u	1.51 e-o	7.26 d-q	13.58 j-s
$N_1W_2I_1$	1.57 bc	7.29 a-f	14.40 a-d	1.63 a-f	7.61 a-g	14.98 a-e
$N_1W_3I_1$	1.40 j-r	6.77 j-u	13.05 k-t	1.46 j-s	7.11 i-v	13.78 f-r
$N_2W_0I_1$	1.36 m-s	6.64 m-u	12.18 t-y	1.43 l-t	6.94 o-w	12.80 q-x
$N_2W_1I_1$	1.50 b-j	7.08 b-k	13.34 g-p	1.56 b-l	7.38 b-n	14.11 c-o
$N_2W_2I_1$	1.37 l-s	6.68 l-u	12.41 q-x	1.44 k-t	6.94 o-w	13.11 n-w
$N_2W_3I_1$	1.47 c-m	6.98 d-o	13.18 h-r	1.54 c-n	7.31 b-p	14.00 d-o
$N_3W_0I_1$	1.30 r-t	6.46 s-u	12.11 u-y	1.37 p-u	6.79 s-w	12.83 q-x
$N_3W_1I_1$	1.32 q-t	6.51 r-u	12.36 r-x	1.36 q-u	6.76 u-w	13.06 o-w
$N_3W_2I_1$	1.39 k-s	6.73 k-u	12.82 m-v	1.47 j-s	7.07 j-w	13.62 j-s
$N_3W_3I_1$	1.42 h-q	6.84 i-r	12.70 o-v	1.51 f-o	7.09 i-v	13.42 k-u
$N_0W_0I_2$	1.29 st	6.44 tu	11.64 x-z	1.37 p-u	6.76 vw	12.29 v-y
$N_0W_1I_2$	1.39 k-s	6.73 k-u	12.67 o-v	1.46 j-t	7.12 i-v	13.34 l-u
$N_0W_2I_2$	1.48 c-l	7.00 d-n	12.94 l-u	1.55 b-n	7.28 c-q	13.80 f-r
$N_0W_3I_2$	1.44 g-o	6.89 h-r	13.02 k-t	1.49 g-p	7.21 f-t	13.71 h-s
$N_1W_0I_2$	1.42 h-q	6.84 i-s	13.32 g-p	1.49 h-q	7.14 h-v	13.93 e-p
$N_1W_1I_2$	1.45 e-o	6.91 g-q	13.51 e-o	1.51 f-o	7.21 f-t	14.15 c-n
$N_1W_2I_2$	1.61 ab	7.41 ab	14.39 a-d	1.67 ab	7.74 ab	15.11 a-c
$N_1W_3I_2$	1.44 f-o	6.88 h-r	13.41 f-p	1.51 f-o	7.18 f-v	14.14 c-n
$N_2W_0I_2$	1.45 e-o	6.92 f-q	13.35 g-p	1.51 f-o	7.28 c-q	14.09 c-o
$N_2W_1I_2$	1.55 b-f	7.23 b-h	13.65 d-m	1.60 b-i	7.57 a-h	14.43 c-k
$N_2W_2I_2$	1.40 j-r	6.77 j-u	12.88 m-u	1.46 j-s	7.02 l-w	13.66 j-s
$N_2W_3I_2$	1.44 e-o	6.91 g-q	13.33 g-p	1.51 f-o	7.23 e-r	14.36 c-l
$N_3W_0I_2$	1.35 n-s	6.62 n-u	12.21 s-x	1.43 m-t	6.96 n-w	13.17 n-w
$N_3W_1I_2$	1.43 h-p	6.86 h-r	12.95 l-u	1.50 g-p	7.19 f-v	13.73 h-s
$N_3W_2I_2$	1.54 b-g	7.21 b-i	13.86 c-k	1.60 b-h	7.69 a-c	14.63 b-j
$N_3W_3I_2$	1.42 h-q	6.83 j-s	13.15 i-r	1.48 h-r	7.15 h-v	13.84 f-r
$N_0W_0I_3$	1.29 st	6.43 u	11.35 yz	1.34 tu	6.66 wx	12.22 w-y
$N_0W_1I_3$	1.32q-t	6.51 r-u	11.74 w-y	1.37 p-u	6.85 q-w	12.51 t-y
$N_0W_2I_3$	1.41 i-r	6.79 j-u	13.04 k-t	1.47 i-s	7.15 h-v	13.75 g-r
$N_0W_3I_3$	1.42 h-q	6.84 i-s	12.79 m-v	1.49 h-q	7.12 i-v	13.68 i-s
$N_1W_0I_3$	1.42 h-q	6.82 j-s	13.14 i-r	1.47 i-s	7.17 g-v	14.13 c-n

Cont'd

Treatments	LAI during 2014-2015			LAI during 2015-2016		
	30 DAT	50 DAT	70 DAT	30 DAT	50 DAT	70 DAT
$N_1W_1I_3$	1.39 k-s	6.73 k-u	12.70 o-v	1.45 k-t	7.03 k-w	13.30 m-v
$N_1W_2I_3$	1.60 ab	7.38 a-c	14.78 ab	1.66 a-c	7.74 ab	15.47 ab
$N_1W_3I_3$	1.46 d-n	6.94 d-p	13.38 f-p	1.53 c-n	7.30 c-p	14.00 d-o
$N_2W_0I_3$	1.45 e-o	6.91 g-q	13.09 j-s	1.52 d-o	7.23 e-s	13.63 j-s
$N_2W_1I_3$	1.49 c-k	7.05 b-l	13.66 d-m	1.55 b-n	7.39 b-n	14.45 c-k
$N_2W_2I_3$	1.48 c-l	7.02 c-m	13.32 g-p	1.55 b-n	7.34 b-o	14.07 c-o
$N_2W_3I_3$	1.52 b-i	7.12 b-j	13.89 c-k	1.57 b-k	7.45 b-l	14.73 b-i
$N_3W_0I_3$	1.34 o-s	6.58 p-u	11.96 v-y	1.40 o-u	6.90 p-w	12.69 s-y
$N_3W_1I_3$	1.48 c-l	6.99 d-o	12.74 n-v	1.54 b-n	7.32 b-p	13.43 k-u
$N_3W_2I_3$	1.43 g-o	6.88 h-r	13.09 j-s	1.51 e-o	7.21 f-t	13.76 g-r
$N_3W_3I_3$	1.49 c-k	7.05 b-l	13.21 h-r	1.57 b-k	7.37 b-o	13.85 f-q
$N_0W_0I_4$	1.29 st	6.44 tu	11.34 yz	1.35 s-u	6.78 t-w	11.93 xy
$N_0W_1I_4$	1.41 h-q	6.82 j-t	12.70 o-v	1.48 h-q	7.20 f-u	13.39 k-u
$N_0W_2I_4$	1.48 c-k	7.02 c-l	13.80 c-l	1.55 b-m	7.37 b-o	14.73 b-i
$N_0W_3I_4$	1.38 k-s	6.73 k-u	12.81 m-v	1.47 i-s	7.12 i-v	13.50 k-t
$N_1W_0I_4$	1.35 n-s	6.61 o-u	12.53 p-w	1.42 n-t	6.97 m-w	13.39 k-u
$N_1W_1I_4$	1.55 b-e	7.23 b-h	13.98 b-j	1.63 a-f	7.57 a-h	14.82 b-f
$N_1W_2I_4$	1.67 a	7.61 a	14.94 a	1.74 a	7.89 a	15.92 a
$N_1W_3I_4$	1.56 b-d	7.27 a-g	14.18 a-g	1.64 a-e	7.62 a-f	14.94 b-e
$N_2W_0I_4$	1.47 c-l	6.98 d-o	13.30 g-q	1.54 b-n	7.42 b-l	14.01 d-o
$N_2W_1I_4$	1.53 b-h	7.15 b-j	14.02 b-i	1.62 b-g	7.43 b-l	14.80 b-g
$N_2W_2I_4$	1.51 b-i	7.12 b-j	14.04 b-h	1.58 b-j	7.46 b-k	14.75 b-h
$N_2W_3I_4$	1.48 c-l	7.00 d-n	13.63 d-n	1.54 c-n	7.40 b-m	14.44 c-k
$N_3W_0I_4$	1.45 e-o	6.92 e-p	13.49 e-o	1.52 e-o	7.48 a-j	14.31 c-m
$N_3W_1I_4$	1.58 a-c	7.31 a-d	14.24 a-f	1.64 a-e	7.67 a-d	14.94 b-e
$N_3W_2I_4$	1.57 a-c	7.30 a-e	14.55 a-c	1.65 a-d	7.66 a-e	15.52 ab
$N_3W_3I_4$	1.53 b-h	7.15 b-j	14.30 a-e	1.60 b-h	7.53 a-i	15.03 a-d
SE value	0.032	0.108	0.256	0.037	0.124	0.301
Level of significance	*	*	*	*	*	*
CV (%)	3.81	2.72	3.40	4.20	2.97	3.77

*: Significant at 0.05 level of Probability

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

N_0: No urea (control), N_1: Urea super granules (77 kg N ha^{-1}), N_2: Prilled urea at recommended dose (150 kg N ha^{-1}) as 325 kg urea ha^{-1} and N_3= ½ of the recommended dose (75 kg N ha^{-1}) as163 kg urea ha^{-1}

W_0: No weeding (control), W_1: Two hand weeding (20 DAT and 40 DAT), W_2: Pre emergence herbicide (Butachor) and W_3: Post emergence herbicide (Prityloclor)

I_1: Irrigating all time, I_2: Irrigating 3 days after drying, I_3: Irrigating 5 days after drying and I_4: Alternate wetting and drying (AWD) method

4.4 Total dry nmatter

Due to different nitrogen, weed and irrigation management and also their combined effect showed statistically significant differences in terms of TDM m^2 of BRRI dhan29 at 30, 50 and 70 DAT for the two subsequent years (Appendix VII). In general irrespective of treatments and their combined effects, TDM showed an increasing trend for different date and also different years (Figure 4.4.1 and Table 4.4.1 to 4.4.4).

4.4.1 Effect of nitrogen management

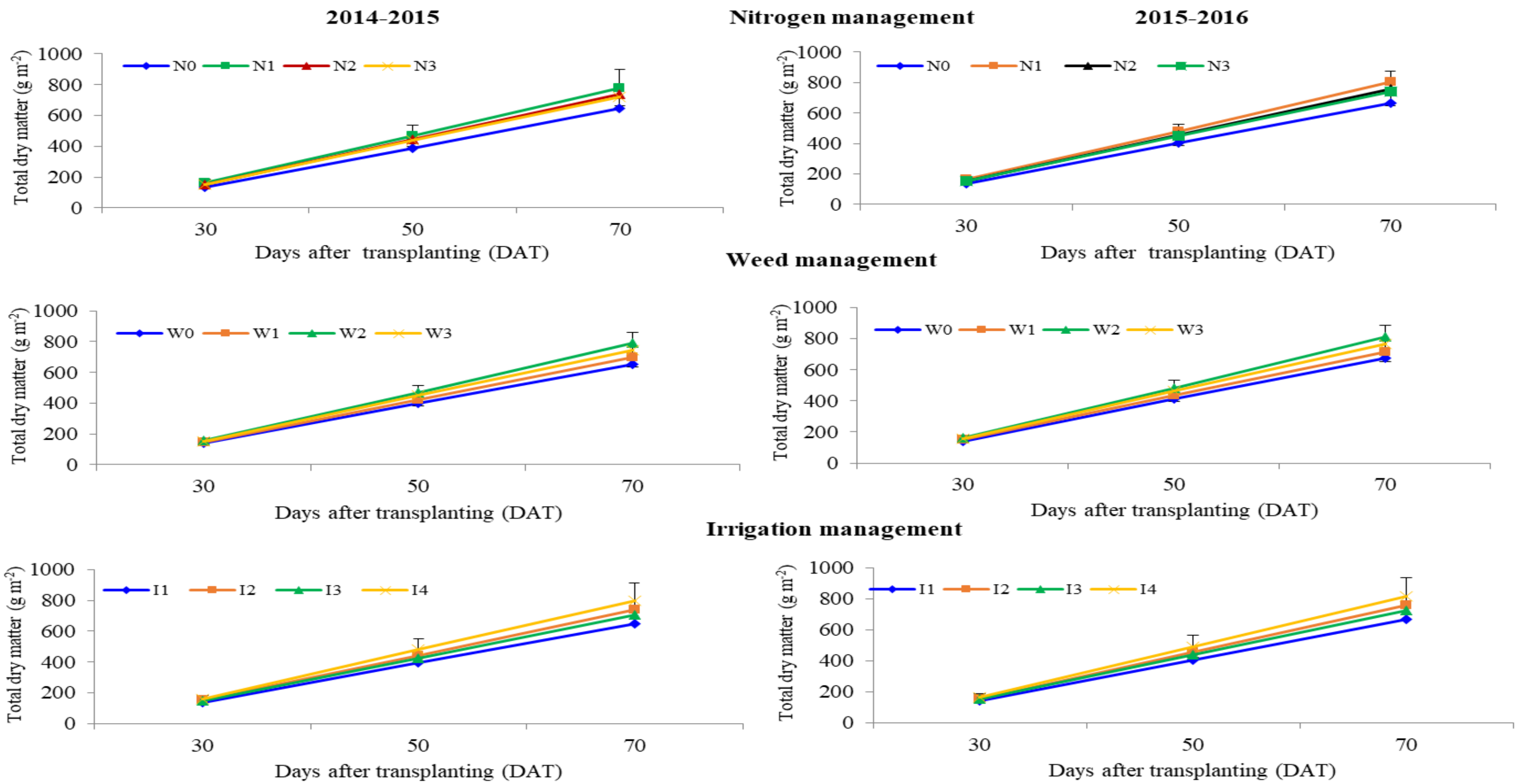
Different nitrogen management showed statistically significant variation in terms of total dry matter of BRRI dhan29 at 30, 50 and 70 DAT for the two subsequent years (Figure 4.4.1). At 30, 50 and 70 DAT, the highest total dry matter (160.00, 468.21, 781.30, 162.60, 481.70 and 802.13 g m^{-2}, respectively) were recorded from N_1, which was followed (153.43, 444.43, 738.41, 156.48, 457.49 and 759.15 g m^{-2}, respectively) to N_2 and (152.20, 438.06, 720.05, 154.87, 450.99 and 740.70 g m^{-2}, respectively) by N_3 and they were statistically similar, while the lowest (134.38, 389.14, 644.84, 136.88, 401.29 and 665.61 g m^{-2}, respectively) were found from N_0.

4.4.2 Effect of weed management

Statistically significant variation was recorded in terms of total dry matter of BRRI dhan29 at 30, 50 and 70 DAT for different weed management for the two subsequent years (Figure 4.4.1). At 30, 50 and 70 DAT, the highest total dry matter (159.81, 469.81, 788.38, 162.57, 483.34 and 809.27 g m^{-2}, respectively) was recorded from W_2 which was followed (153.54, 448.88, 746.91, 156.13, 462.05 and 767.77 g m^{-2},respectively) by W_3, while the lowest (138.84, 399.30, 653.03, 141.55, 411.59 and 673.69 g m^{-2}, respectively) were found from W_0.

4.4.3 Effect of irrigation management

Total dry matter of BRRI dhan29 at 30, 50 and 70 DAT statistically significant differences due to different irrigation management (Figure 4.4.1). Total dry matter was significantly higher compared to control condition in all data recording days for the two subsequent years. At 30, 50 and 70 DAT, the highest total dry matter (159.69, 478.94, 794.60, 162.74, 492.70 and 815.73 g m^{-2}, respectively) were found from I_4 which was followed (152.94, 442.11, 738.83, 155.50, 455.12 and 759.55 g m^{-2}, respectively) by I_2, whereas the lowest (138.47, 393.25, 645.49, 140.72, 405.40 and 666.03 g m^{-2}, respectively) were found from I_1.



N_0: No urea (control), N_1: Urea super granules (77 kg N ha^{-1}), N_2: Prilled urea at recommended dose (150 kg N ha^{-1}) as 325 kg urea ha^{-1} and N_3= ½ of the recommended dose (75 kg N ha^{-1}) as163 kg urea ha^{-1}
W_0: No weeding (control), W_1: Two hand weeding (20 DAT and 40 DAT), W_2: Pre emergence herbicide (Butachor) and W_3: Post emergence herbicide (Prityloclor)
I_1: Irrigating all time, I_2: Irrigating 3 days after drying, I_3: Irrigating 5 days after drying and I_4: Alternate wetting and drying (AWD) method

Figure 4.4.1 Effect of different levels of nitrogen, weed management and irrigation on number of tillers hill^{-1} at different DAT of BRRI dhan29.

4.4.4 Combined effect of nitrogen and weed management

Total dry matter of BRRI dhan29 at 30, 50 and 70 DAT varied significantly for the combined effect of different nitrogen and weed management for the two subsequent years (Table 4.4.1). At 30, 50 and 70 DAT, the highest total dry matter (183.48, 549.47, 914.39, 186.24, 564.40 and 935.53 g m^{-2}, respectively) were recorded from N_1W_2, whereas the lowest (114.87, 341.28, 586.10, 117.55, 352.72 and 607.14 g m^{-2}, respectively) from N_0W_0.

4.4.5 Combined effect of nitrogen and irrigation

Combined effect of different irrigation and nitrogen management varied significantly in terms of total dry matter of BRRI dhan29 at 30, 50 and 70 DAT days for the two subsequent years (Table 4.4.2). At 30, 50 and 70 DAT, the highest total dry matter (172.19, 525.28, 844.33, 174.97, 539.89 and 865.31 g m^{-2}, respectively) were recorded from N_1I_4, whereas the lowest (118.00, 348.22, 570.80, 120.09, 359.75 and 591.79 g m^{-2}, respectively) from N_0I_1.

4.4.6 Combined effect of irrigation and weed management

Different irrigation and weed management varied significantly in terms of total dry matter of BRRI dhan29 at 30, 50 and 70 DAT for the two subsequent years due to combined effect (Table 4.4.3). At 30, 50 and 70 DAT, the highest total dry matter (175.16, 538.29, 879.23, 178.06, 553.15 and 900.67 g m^{-2}, respectively) were recorded from W_2I_4, whereas the lowest (129.05, 359.19, 574.86, 131.23, 370.72 and 595.19 g m^{-2}, respectively) from W_0I_1.

4.4.7 Combined effect of nitrogen, weed and irrigation management

Statistically significant differences was observed for the combined effect of different nitrogen, weed management and irrigation in terms of total dry matter of BRRI dhan29 at 30, 50 and 70 DAT for the two subsequent years (Table 4.4.4). At 30, 50 and 70 DAT, the highest total dry matter (196.97, 585.70, 990.02, 199.40, 601.19 and 1011.07 g m^{-2}, respectively) were recorded from N_1W_2 I_4, while the lowest (112.28, 329.33, 519.46, 114.66, 340.54 and 540.39 g m^{-2}, respectively) from $N_0W_0I_{1.}$

Table 4.4.1 Combined effect of different levels of nitrogen and weed management on TDM gm^{-2} at different of BRRI dhan29.

Treatments	Total dry matter gm^{-2} during (2014-2015)			Total dry matter gm^{-2} during (2015-2016)		
	30 DAT	50 DAT	70 DAT	30 DAT	50 DAT	70 DAT
N_0W_0	114.87 h	341.28 h	586.10 i	117.55 j	352.72 h	607.14 i
N_0W_1	132.13 g	373.01 gh	604.89 hi	134.55 i	384.82 gh	625.40 hi
N_0W_2	145.97 ef	426.28 d-f	718.12 d-f	148.52 f-h	439.07 d-f	738.93 d-f
N_0W_3	144.55 f	415.99 ef	670.24 fg	146.90 h	428.55 ef	690.96 fg
N_1W_0	146.03 ef	423.58 d-f	692.19 ef	148.77 f-h	436.30 d-f	712.88 ef
N_1W_1	152.38 c-f	431.18 c-f	733.26 c-e	155.06 c-g	443.93 c-f	753.72 c-e
N_1W_2	183.48 a	549.47 a	914.39 a	186.24 a	564.40 a	935.53 a
N_1W_3	158.11 bc	468.63 bc	785.35 b	160.34 b-d	482.17 bc	806.38 b
N_2W_0	149.68 d-f	430.49 c-f	690.96 ef	152.35 e-h	443.29 c-f	711.63 ef
N_2W_1	156.59 b-d	456.37 b-d	752.58 b-d	159.74 b-e	469.65 b-d	773.39 b-d
N_2W_2	149.22 d-f	431.41 c-f	739.21 b-e	152.28 e-h	444.24 c-f	759.92 b-e
N_2W_3	158.23 bc	459.45 b-d	770.87 bc	161.57 bc	472.76 b-d	791.66 bc
N_3W_0	144.77 f	401.86 fg	642.86 gh	147.52 gh	414.07 fg	663.13 gh
N_3W_1	150.23 d-f	426.85 d-f	694.36 ef	152.97 d-h	439.54 d-f	714.89 ef
N_3W_2	160.54 b	472.07 b	781.79 bc	163.25 b	485.64 b	802.70 bc
N_3W_3	153.27 b-e	451.46 b-e	761.18 b-d	155.72 b-f	464.70 b-e	782.08 b-d
SE value	2.430	12.10	15.39	2.441	12.35	15.42
Level of significance	*	*	*	*	*	*
CV (%)	4.22	6.09	6.84	4.07	6.03	6.40

*: Significant at 0.05 level of probability

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

N_0: No urea (control), N_1: Urea super granules (77 kg N ha^{-1}), N_2: Prilled urea at recommended dose (150 kg N ha^{-1}) as 325 kg urea ha^{-1} and N_3= ½ of the recommended dose (75 kg N ha^{-1}) as163 kg urea ha^{-1}

W_0: No weeding (control), W_1: Two hand weeding (20 DAT and 40 DAT), W_2: Pre emergence herbicide (Butachor) and W_3: Post emergence herbicide (Prityloclor)

Table 4.4.2 Combined effect of different levels of nitrogen and irrigation management on TDM gm^{-2} at different DAT of BRRI dhan29.

Treatments	Total dry matter gm^{-2} during (2014-2015)			Total dry matter gm^{-2} during (2015-2016)		
	30 DAT	50 DAT	70 DAT	30 DAT	50 DAT	70 DAT
N_0I_1	118.00 i	348.22 i	570.80 i	120.09 h	359.75 i	591.79 i
N_1I_1	150.80 f	425.58 g	723.47 d-f	152.84 e	438.23 g	743.85 d-f
N_2I_1	142.24 g	398.76 h	659.90 gh	144.82 f	410.95 h	680.31 gh
N_3I_1	142.85 g	400.45 h	627.77 h	145.14 f	412.67 h	648.18 h
N_0I_2	140.32 gh	391.58 h	688.63 fg	142.76 fg	403.65 h	709.00 fg
N_1I_2	162.67 bc	492.52 b	792.63 bc	165.05 bc	506.54 b	813.90 bc
N_2I_2	153.50 ef	449.27 e-g	746.02 d	156.36 e	462.44e-g	766.90 d
N_3I_2	155.27 d-f	435.08 fg	728.02 d-f	157.83 de	447.85 fg	748.42 d-f
N_0I_3	135.59 h	387.87 h	622.12 h	138.36 g	399.96 h	642.75 h
N_1I_3	161.52 bc	466.97 c-e	764.76 cd	164.78 bc	480.38 c-e	785.46 cd
N_2I_3	160.03 b-d	455.91 d-f	741.44 de	162.82 b-d	469.09 d-f	762.02 de
N_3I_3	138.49 gh	391.43 h	694.38 e-g	141.52 fg	403.53 h	714.85 e-g
N_0I_4	143.61 g	428.88 g	697.80 e-g	146.31 f	441.79 g	718.89 e-g
N_1I_4	172.19 a	525.28 a	844.33 a	174.97 a	539.89 a	865.31 a
N_2I_4	157.96 c-e	473.79 b-d	806.26 a-c	161.94 cd	487.46 b-d	827.37 a-c
N_3I_4	165.01 b	487.79 bc	830.02 ab	167.74 b	501.64 bc	851.35 ab
SE value	1.828	7.645	14.65	1.792	7.798	14.66
Level of significance	*	*	*	*	*	*
CV (%)	5.61	9.63	7.39	5.54	9.55	7.20

*: Significant at 0.05 level of Probability

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

N_0: No urea (control), N_1: Urea super granules (77 kg N ha^{-1}), N_2: Prilled urea at recommended dose (150 kg N ha^{-1}) as 325 kg urea ha^{-1} and N_3= ½ of the recommended dose (75 kg N ha^{-1}) as163 kg urea ha^{-1}

I_1: Irrigating all time, I_2: Irrigating 3 days after drying, I_3: Irrigating 5 days after drying and I_4: Alternate wetting and drying (AWD) method

Table 4.4.3 Combined effect of weed and irrigation management on TDM gm^{-2} at different DAT of BRRI dhan29.

Treatments	Total dry matter gm^{-2} during (2014-2015)			Total dry matter gm^{-2} diring (2015-2016)		
	30 DAT	50 DAT	70 DAT	30 DAT	50 DAT	70 DAT
W_0I_1	129.05 e	359.19 i	574.86 j	131.23 e	370.72 i	595.19 j
W_1I_1	139.16 d	390.09 hi	620.69 i	141.28 d	402.14 hi	641.12 i
W_2I_1	144.74 d	415.21 e-h	708.20 d-g	147.08 d	427.75 e-h	728.82 d-g
W_3I_1	140.96 d	408.52 f-h	678.20 f-h	143.30 d	420.99 f-h	6 f-h98.99
W_0I_2	144.34 d	418.70 e-h	684.88 f-h	147.01 d	431.33 e-h	705. f-h63
W_1I_2	152.25 c	438.56 c-f	716.53 d-f	154.76 c	451.50 c-f	737.23 d-f
W_2I_2	157.89 bc	450.06 b-e	810.36 b	160.34 bc	463.15 b-e	830.93 b
W_3I_2	157.29 bc	461.13 b-d	743.54 c-e	159.88 bc	474.50 b-d	764.43 c-e
W_0I_3	138.70 d	389.38 hi	653.40 hi	141.63 d	401.43 hi	673.82 hi
W_1I_3	143.44 d	396.25 gh	660.67 g-i	146.59 d	408.35 g-i	680.91 g-i
W_2I_3	161.44 b	475.66 bc	755.72 cd	164.80 b	489.29 bc	776.67 cd
W_3I_3	152.05 c	440.89 c-f	752.90 cd	154.45 c	453.89 c-f	773.67 cd
W_0I_4	143.26 d	429.94 d-g	698.96 e-h	146.30 d	442.89 d-g	720.14 e-h
W_1I_4	156.49 bc	462.51 b-d	787.21 bc	159.68 bc	475.94 b-d	808.13 bc
W_2I_4	175.16 a	538.29 a	879.23 a	178.06 a	553.15 a	900.67 a
W_3I_4	163.86 b	484.99 b	813.01 b	166.91 b	498.80 b	833.99 b
SE value	2.430	12.10	15.39	2.441	12.35	15.42
Level of significance	*	*	*	*	*	*
CV (%)	5.61	9.63	7.39	5.54	9.55	7.20

*: Significant at 0.05 level of Probability

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

W_0: No weeding (control), W_1: Two hand weeding (20 DAT and 40 DAT), W_2: Pre emergence herbicide (Butachor) and W_3: Post emergence herbicide (Prityloclor)

I_1: Irrigating all time, I_2: Irrigating 3 days after drying, I_3: Irrigating 5 days after drying and I_4: Alternate wetting and drying (AWD) method

Table 4.4.4 Combined effect of different levels of nitrogen, weed and irrigation management on TDM gm^{-2} at different DAT of BRRI dhan29.

Treatments	Total dry matter gm^{-2} during (2014-2015)			Total dry matter gm^{-2} during (2015-2016)		
	30 DAT	50 DAT	70 DAT	30 DAT	50 DAT	70 DAT
$N_0W_0I_1$	112.28 x	329.33 y	519.46 t	114.66 z	340.54 v	540.39 u
$N_0W_1I_1$	116.10 wx	336.41 xy	528.30 t	117.84 yz	347.70 uv	549.16 u
$N_0W_2I_1$	119.64 v-x	341.58 u-y	654.49 k-s	121.93 x-z	352.91 t-v	675.12 m-t
$N_0W_3I_1$	124.00 u-x	385.54 o-y	580.95 q-t	125.94 w-z	397.86 m-v	602.50 r-u
$N_1W_0I_1$	130.46 s-w	337.82 w-y	644.30 m-s	1 t-y32.03	348.79 uv	663.77 n-t
$N_1W_1I_1$	143.32 l-t	379.41 o-y	699.86 h-p	145. m-u57	391.09 n-v	719.63 h-q
$N_1W_2I_1$	175.03 bc	531.44 a-e	853.86 b-e	1 bc77.05	546.13 a-e	875.16 b-e
$N_1W_3I_1$	154.39 e-o	453.64 e-q	695.87 h-p	156. d-p72	466.90 e-p	716.82 h-q
$N_2W_0I_1$	135.63 q-u	383.54 o-y	561.36 r-t	137.89 s-w	395.52 n-v	581.89 s-u
$N_2W_1I_1$	147.40 i-r	423.54 g-v	701.85 h-p	149.83 h-s	436.22 g-t	722.52 h-q
$N_2W_2I_1$	137.02 p-u	371.02 q-y	644.13 m-s	139.56 q-w	382.65 p-v	664.18 n-t
$N_2W_3I_1$	148.90 h-r	416.94 h-x	732.27 f-n	152.01 g-s	429.43 h-u	752.66 f-o
$N_3W_0I_1$	137.83 o-u	386.05 n-y	574.32 r-t	140.34 p-w	398.03 m-v	594.73 s-u
$N_3W_1I_1$	149.80 h-r	420.99 h-w	552.74 st	151.89 g-s	433.55 h-u	573.18 tu
$N_3W_2I_1$	147.25 j-r	416.80 h-x	680.31 i-q	149.79 h-s	429.32 h-u	700.83 j-r
$N_3W_3I_1$	136.54 p-u	377.95 p-y	703.71 h-p	138.52 r-w	389.76 o-v	723.97 h-q
$N_0W_0I_2$	116.02 wx	329.19 y	634.86 n-s	118.95 yz	340.30 v	655.41 o-t
$N_0W_1I_2$	148.00 i-r	414.06 i-x	637.59 n-s	150.35 h-s	426.50 i-u	657.99 o-t
$N_0W_2I_2$	144.41 l-s	389.32 m-y	759.87 e-k	146.74 k-t	401.22 m-v	779.86 e-m
$N_0W_3I_2$	152.86 f-p	433.76 f-r	722.22 g-o	155.00 f-r	446.57 f-q	742.74 g-p
$N_1W_0I_2$	159.04 c-l	490.42 c-i	738.25 f-n	161.49 c-m	504.49 c-i	759.71 f-o
$N_1W_1I_2$	162.93 b-k	486.82 c-j	734.61 f-n	165.24 b-j	500.69 c-j	755.73 f-o
$N_1W_2I_2$	170.11 b-e	507.97 a-g	925.84 ab	172.43 b-d	522.19 a-g	946.95 ab
$N_1W_3I_2$	158.59 c-m	484.86 c-j	771.83 e-i	161.04 c-m	498.79 c-j	793.19 e-j
$N_2W_0I_2$	157.44 e-m	471.29 d-n	731.06 f-n	160.15 d-n	484.92 d-m	752.20 f-o
$N_2W_1I_2$	148.12 i-r	430.68 f-t	799.78 c-h	150.95 g-s	443.52 f-s	820.58 c-h
$N_2W_2I_2$	148.78 h-r	431.34 f-s	704.15 h-p	151.45 g-s	444.19 f-r	724.92 h-q
$N_2W_3I_2$	159.65 c-l	463.76 e-o	749.08 e-m	162.90 c-l	477.14 e-o	769.90 e-n
$N_3W_0I_2$	144.86 l-s	383.88 o-y	635.37 n-s	147.47 k-t	395.64 n-v	655.18 o-t
$N_3W_1I_2$	149.93 h-r	422.69 g-v	694.14 h-p	152.51 g-s	435.29 g-t	714.62 h-q
$N_3W_2I_2$	168.25 b-g	471.61 d-m	851.57 b-e	170.76 b-f	484.98 d-m	871.99 b-e
$N_3W_3I_2$	158.06 d-m	462.12 e-p	731.01 f-n	160.60 c-n	475.50 e-o	751.90 f-o
$N_0W_0I_3$	116.42 wx	339.20 v-y	569.08 r-t	118.96 yz	350.55 t-v	589.93 s-u
$N_0W_1I_3$	125.25 u-x	347.26 s-y	572.67 r-t	128.09 v-z	358.59 r-v	592.98 s-u
$N_0W_2I_3$	154.49 e-o	461.97 e-p	663.37 j-r	157.77 d-o	475.43 e-o	684.48 k-s

Cont'd

Treatments	Total dry matter gm^{-2} during (2014-2015)			Total dry matter gm^{-2} during (2015-2016)		
	30 DAT	50 DAT	70 DAT	30 DAT	50 DAT	70 DAT
$N_0W_3I_3$	146.20 k-s	403.06 j-y	683.35 i-q	148.61 j-s	415.27 j-v	703.60 i-r
$N_1W_0I_3$	152.08 g-q	441.91 f-r	735.78 f-n	155.58 d-q	454.94 f-q	756.55 f-o
$N_1W_1I_3$	147.12 j-r	399.11 k-y	661.68 j-r	150.03 h-s	411.19 k-v	681.72 l-s
$N_1W_2I_3$	191.83 a	572.77 ab	887.84 b-d	196.10 a	588.07 ab	908.95 b-d
$N_1W_3I_3$	155.06 e-n	454.08 e-q	773.74 e-i	157.41 d-o	467.34 e-p	794.62 e-j
$N_2W_0I_3$	159.14 c-l	430.35 f-t	701.73 h-p	161.88 c-m	442.91 f-s	721.75 h-q
$N_2W_1I_3$	168.13 b-g	477.07 c-l	711.99 g-p	171.26 b-f	490.57 c-l	732.55 g-q
$N_2W_2I_3$	147.61 i-r	423.17 g-v	763.51 e-j	150.23 h-s	435.84 g-t	784.16 e-l
$N_2W_3I_3$	165.23 b-h	493.04 b-i	788.52 d-i	167.90 b-g	507.01 b-i	809.62 d-i
$N_3W_0I_3$	127.15 t-x	346.06 t-y	607.03 p-t	130.12 u-z	357.31 s-v	627.07 q-u
$N_3W_1I_3$	133.25 r-v	361.55 r-y	696.35 h-p	136.99 s-x	373.04 q-v	716.39 h-q
$N_3W_2I_3$	151.85 g-q	444.72 f-r	708.18 g-p	155.11 e-r	457.83 f-q	729.08 g-q
$N_3W_3I_3$	141.72 m-t	413.39 i-x	765.98 e-j	143.86 n-v	425.96 i-v	786.84 e-l
$N_0W_0I_4$	114.76 wx	367.39 r-y	621.01 o-t	117.63 yz	379.49 q-v	642.83 p-u
$N_0W_1I_4$	139.16 n-u	394.32 l-y	681.01 i-q	141.93 o-w	406.47 l-v	701.49 i-r
$N_0W_2I_4$	165.35 b-h	512.25 a-f	794.76 d-h	167.62 b-g	526.70 a-f	816.27 d-h
$N_0W_3I_4$	155.15 e-n	441.57 f-r	694.44 h-p	158.04 d-o	454.51 f-q	714.98 h-q
$N_1W_0I_4$	142.56 l-t	424.15 g-u	650.44 l-s	145.98 l-u	436.97 g-t	671.48 m-t
$N_1W_1I_4$	156.14 e-n	459.38 e-p	836.88 b-f	159.38 d-n	472.74 e-o	857.78 b-f
$N_1W_2I_4$	196.97 a	585.70 a	990.02 a	199.40 a	601.19 a	1011.07 a
$N_1W_3I_4$	164.39 b-i	481.94 c-k	899.97 a-c	166.19 b-i	495.66 c-k	920.89 a-c
$N_2W_0I_4$	146.51 j-s	436.78 f-r	769.66 e-j	149.47 i-s	449.82 f-q	790.68 e-k
$N_2W_1I_4$	162.69 b-k	494.20 b-i	796.71 c-h	166.90 b-h	508.27 b-i	817.90 c-h
$N_2W_2I_4$	163.48 b-j	500.10 b-h	845.07 b-e	167.88 b-g	514.30 b-h	866.44 b-e
$N_2W_3I_4$	159.15 c-l	464.06 e-o	813.61 c-g	163.49 b-k	477.46 e-n	834.45 c-g
$N_3W_0I_4$	169.23 b-f	491.45 c-i	754.73 e-l	172.13 b-e	505.29 c-i	775.55 e-m
$N_3W_1I_4$	167.95 b-g	502.15 b-h	834.23 b-f	170.51 b-f	516.28 b-h	855.36 b-f
$N_3W_2I_4$	174.82 b-d	555.13 a-c	887.10 b-d	177.34 bc	570.42 a-c	908.88 b-d
$N_3W_3I_4$	176.77 b	552.39 a-d	844.03 b-e	179.92 b	567.56 a-d	865.63 b-e
SE value	4.859	24.19	30.78	4.882	24.69	30.84
Level of significance	*	*	*	*	*	*
CV (%)	5.61	9.63	7.39	5.54	9.55	7.20

*: Significant at 0.05 level of Probability

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

N_0: No urea (control), N_1: Urea super granules (77 kg N ha^{-1}), N_2: Prilled urea at recommended dose (150 kg N ha^{-1}) as 325 kg urea ha^{-1} and N_3= ½ of the recommended dose (75 kg N ha^{-1}) as163 kg urea ha^{-1}

W_0: No weeding (control), W_1: Two hand weeding (20 DAT and 40 DAT), W_2: Pre emergence herbicide (Butachor) and W_3: Post emergence herbicide (Prityloclor)

I_1: Irrigating all time, I_2: Irrigating 3 days after drying, I_3: Irrigating 5 days after drying and I_4: Alternate wetting and drying (AWD) method

4.5 Crop growth Rate (CGR)

Due to different nitrogen, weed and irrigation management and also their combined effect showed statistically significant differences in terms of crop growth rate (CGR) of BRRI dhan29 at 30-50 and 50-70 DAT for the two subsequent years (Appendix VIII). CGR showed differences irrespective of treatments and their combined effects (Table 4.5.1 to 4.5.5).

4.5.1 Effect of nitrogen management

Different nitrogen management showed statistically significant variation in terms of CGR of BRRI dhan29 at 30-50 and 50-70 DAT for the two subsequent years (Table 4.5.1). At 30-50 and 50-70 DAT, the highest CGR (15.41, 15.65, 15.95 and 16.02 g m^{-2} day^{-1}, respectively) were recorded from N_1, which was statistically identical (14.55, 14.70, 15.05 and 15.08 g m^{-2} day^{-1}, respectively) to N_2 and followed (14.29, 14.10, 14.81 and 14.49 g m^{-2} day^{-1}, respectively) by N_3, while the lowest (12.74, 12.78, 13.22 and 13.23 g m^{-2} day^{-1}, respectively) were found from N_0.

4.5.2 Effect of weed management

Statistically significant variation was recorded in terms of CGR of BRRI dhan29 at 30-50 and 50-70 DAT for different weed management for the two subsequent years (Table 4.5.1). At 30-50 and 50-70 DAT, the highest CGR (15.50, 15.93, 16.04 and 16.30 g m^{-2} d^{-1}, respectively) was recorded from W_2 which was followed (14.77, 14.90, 15.30 and 15.29 g m^{-2} day^{-1}, respectively) by W_3, while the lowest (13.02, 12.69, 13.50 and 13.11 g m^{-2} day^{-1}, respectively) were found from W_0.

4.5.3 Effect of irrigation management

CGR of BRRI dhan29 at 30-50 and 70 DAT statistically significant differences due to different irrigation management (Table 4.5.1). At 30-50 and 50-70 DAT, the highest CGR (15.96, 15.78, 16.50 and 16.15, g m^{-2} day^{-1}, respectively) were found from I_4 which was statitically similar (14.46, 14.84, 14.98 and 15.22 g m^{-2} day^{-1}, respectively) to I_2 and follwed (13.83, 14.01, 14.32 and 14.40 g m^{-2} day^{-1}, respectively) by I_3, while the lowest (12.74, 12.61, 13.23 and 13.03, g m^{-2} day^{-1}, respectively) were recorded from I_1.

Table 4.5.1 Effect of different levels of irrigation, nitrogen and weed management on CGR, RGR and (NAR of BRRI dhan29.

Treatments	CGR (g m^{-2}day^{-1})				RGR (mg g^{-1}day^{-1})				NAR (g m^{-2}day^{-1})			
	2014-2015		2015-2016		2014-2015		2015-2016		2014-2015		2015-2016	
	30-50 DAT	50-70 DAT	30-50 DAT	50-70 DAT	30-50 DAT	50-70 DAT	30-50 DAT	50-70 DAT	30-50 DAT	50-70 DAT	30-50 DAT	50-70 DAT
Nitrogen management												
N_0	12.74 c	12.78 c	13.22 c	13.23 c	23.06 ab	11.01	23.33 ab	11.04	6.29 c	2.29 b	6.22 c	2.25 b
N_1	15.41 a	15.65 a	15.95 a	16.02 a	23.18 a	11.18	23.45 a	11.14	7.12 a	2.59 a	7.05 a	2.52 a
N_2	14.55 ab	14.70 ab	15.05 ab	15.08 ab	23.01 ab	11.02	23.21 ab	11.00	6.79 b	2.47 ab	6.72 b	2.41 ab
N_3	14.29 b	14.10 b	14.81 b	14.49 b	22.82 b	10.83	23.08 b	10.81	6.75 b	2.39 b	6.67 b	2.33 b
SE value	0.155	0.382	0.161	0.382	0.109	0.271	0.116	0.264	0.070	0.061	0.068	0.059
Level of significance	*	*	*	*	*	NS	*	NS	*	*	*	*
CV (%)	10.83	14.30	10.86	13.95	5.81	19.71	5.99	19.29	11.63	15.36	11.87	14.63
Weed management												
W_0	13.02 c	12.69 c	13.50 c	13.11 c	22.67 b	10.78	22.92 b	10.80	6.43 b	2.27 c	6.35 b	2.22 c
W_1	13.70 c	13.72 bc	14.20 c	14.12 bc	22.85 ab	10.90	23.09 ab	10.90	6.47 b	2.34 bc	6.40 b	2.28 bc
W_2	15.50 a	15.93 a	16.04 a	16.30 a	23.31 a	11.33	23.55 a	11.28	7.10 a	2.63 a	7.03 a	2.56 a
W_3	14.77 b	14.90 b	15.30 b	15.29 b	23.24 a	11.03	23.50 a	11.01	6.96 a	2.51 ab	6.88 a	2.45 ab
SE value	0.251	0.467	0.257	0.469	0.181		0.182	0.361	0.119	0.079	0.116	0.076
Level of significance	*	*	*	*	*	NS	*	NS	*	*	*	*
CV (%)	7.54	18.48	7.58	18.01	3.28	14.83	3.46	16.65	7.15	17.42	7.02	17.29
Irrigation management												
I_1	12.74 c	12.61 c	13.23 c	13.03 c	22.61 b	10.72	22.91 b	10.75	6.22 c	2.22 c	6.18 c	2.18 c
I_2	14.46 ab	14.84 ab	14.98 ab	15.22 ab	22.98 b	11.07	23.24 b	11.03	6.83 b	2.52 ab	6.76 b	2.45 ab
I_3	13.83 b	14.01 b	14.32 b	14.40 b	22.71 b	11.08	22.92 b	11.07	6.55 bc	2.40 bc	6.48 bc	2.35 bc
I_4	15.96 a	15.78 a	16.50 a	16.15 a	23.77 a	11.16	23.98 a	11.14	7.35 a	2.60 a	7.23 a	2.53 a
SE value	0.223	0.295	0.231	0.296	0.193	0.313	0.201	0.306	0.113	0.054	0.114	0.050
Level of significance	*	*	*	*	*	NS	*	NS	*	*	*	*
CV (%)	12.20	22.63	12.08	22.10	5.45	23.18	5.42	22.72	12.26	22.44	12.01	22.22

*: Significant at 0.05 level of Probability; NS: Non significant

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

N_0: No urea (control), N_1: Urea super granules (77 kg N ha^{-1}), N_2: Prilled urea at recommended dose (150 kg N ha^{-1}) as 325 kg urea ha^{-1} and N_3= ½ of the recommended dose (75 kg N ha^{-1}) as163 kg urea ha^{-1}

W_0: No weeding (control), W_1: Two hand weeding (20 DAT and 40 DAT), W_2: Pre emergence herbicide (Butachor) and W_3: Post emergence herbicide (Prityloclor)

I_1: Irrigating all time, I_2: Irrigating 3 days after drying, I_3: Irrigating 5 days after drying and I_4: Alternate wetting and drying (AWD) method

4.5.4 Combined effect of nitrogen and weed management

CGR of BRRI dhan29 at 30-50 and 50-70 DAT varied significantly for the combined effect of different nitrogen and weed management for the two subsequent years (Table 4.5.2). At 30-50 and 50-70 DAT, the highest CGR (18.30, 18.25, 18.91 and 18.56 g m^{-2} day^{-1}, respectively) were recorded from N_1W_2, whereas the lowest (11.32, 12.24, 11.76 and 12.72 g m^{-2} day^{-1}, respectively) from N_0W_0.

4.5.5 Combined effect of nitrogen and irrigation

Combined effect of different irrigation and nitrogen management varied significantly in terms of CGR of BRRI dhan29 at 30-50 and 50-70 DAT for the two subsequent years (Table 4.5.3). At 30-50 and 50-70 DAT, the highest CGR (17.65, 17.83, 18.25 and 18.18 g m^{-2} day^{-1}, respectively) were recorded from N_1I_4, whereas the lowest (11.51, 11.13, 11.98 and 11.60 g m^{-2} day^{-1}, respectively) from N_0I_1.

4.5.6 Combined effect of irrigation and weed management

Different irrigation and weed management varied significantly in terms of CGR of BRRI dhan29 at 30-50 and 50-70 DAT for the two subsequent years due to combined effect (Table 4.5.4). At 30-50 and 50-70 DAT, the highest CGR (18.16, 18.01, 18.75 and 18.39 g m^{-2} day^{-1}, respectively) were recorded from W_2I_4, whereas the lowest (11.51, 10.78, 11.97 and 11.22 g m^{-2} day^{-1}, respectively) from W_0I_1.

4.5.7 Combined effect of nitrogen, weed and irrigation management

Statistically significant differences was observed for the combined effect of different nitrogen, weed management and irrigation in terms of CGR of BRRI dhan29 at 30-50 and 50-70 DAT for the two subsequent years (Table 4.5.5). At 30-50 and 50-70 DAT, the highest CGR (19.44, 20.89, 20.09 and 21.26 g m^{-2} day^{-1}, respectively) were recorded from N_1W_2 I_4, while the lowest (10.37, 6.59, 10.84 and 6.98 g m^{-2} day^{-1}, respectively) from $N_0W_0I_{1.}$

Table 4.5.2 Combined effect of different levels of nitrogen and weed management on CGR, Relative RGR and NAR of BRRI dhan29.

Treatments	CGR (g m^{-2}day^{-1})				RGR (mg g^{-1}day^{-1})				NAR (g m^{-2}day^{-1})			
	2014-2015		2015-2016		2014-2015		2015-2016		2014-2015		2015-2016	
	30-50 DAT	50-70 DAT	30-50 DAT	50-70 DAT	30-50 DAT	50-70 DAT	30-50 DAT	50-70 DAT	30-50 DAT	50-70 DAT	30-50 DAT	50-70 DAT
N_0W_0	11.32 g	12.24 cd	11.76 f	12.72 c-e	22.06 c	10.21	22.30 c	10.22	5.92 e	2.10 b	5.87 d	2.06 b
N_0W_1	12.04 fg	11.59 d	12.51 ef	12.03 e	22.54 bc	10.52	22.83 bc	10.58	5.99 de	2.34 ab	5.91 d	2.31 ab
N_0W_2	14.02 b-e	14.59 b-d	14.53 b-d	14.99 b-e	23.14 a-c	11.54	23.41 a-c	11.51	6.63 b-e	2.51 ab	6.57 b-d	2.45 ab
N_0W_3	13.57 de	12.71 b-d	14.08 cd	13.12 b-e	22.96 a-c	10.31	23.26 a-c	10.34	6.61 b-e	2.22 b	6.53 b-d	2.18 b
N_1W_0	13.88 c-e	13.43 b-d	14.38 cd	13.83 b-e	22.90 a-c	10.91	23.14 a-c	10.90	6.76 b-d	2.35 ab	6.68 bc	2.29 ab
N_1W_1	13.94 b-e	15.10 bc	14.44 b-d	15.49 b-d	22.44 bc	11.63	22.70 bc	11.60	6.53 b-e	2.55 ab	6.47 b-d	2.49 ab
N_1W_2	18.30 a	18.25 a	18.91 a	18.56 a	23.80 a	11.75	24.07 a	11.71	7.93 a	2.83 a	7.87 a	2.75 a
N_1W_3	15.53 bc	15.84 ab	16.09 b	16.21 ab	23.57 ab	11.11	23.89 ab	11.07	7.27 ab	2.63 ab	7.19 b	2.56 ab
N_2W_0	14.04 b-e	13.02 b-d	14.55 b-d	13.42 b-e	22.87 a-c	11.67	23.12 a-c	11.73	6.69 b-e	2.23 b	6.59 b-d	2.19 b
N_2W_1	14.99 b-d	14.81 bc	15.50 bc	15.19 b-d	23.13 a-c	10.94	23.32 a-c	10.91	6.82 bc	2.44 ab	6.76 bc	2.38 ab
N_2W_2	14.11 b-e	15.39 ab	14.60 b-d	15.78 a-c	22.94 a-c	11.08	23.14 a-c	10.99	6.66 b-e	2.62 ab	6.60 b-d	2.55 ab
N_2W_3	15.06 b-d	15.57 ab	15.56 bc	15.94 ab	23.09 a-c	11.17	23.26 a-c	11.13	7.00 bc	2.59 ab	6.91 bc	2.51 ab
N_3W_0	12.85 ef	12.05 cd	13.33 de	12.45 de	23.59 ab	10.31	23.81 ab	10.34	6.35 c-e	2.15 b	6.24 cd	2.09 b
N_3W_1	13.83 de	13.38 b-d	14.33 cd	13.77 b-e	22.57 bc	10.52	22.81 bc	10.52	6.52 b-e	2.26 b	6.47 b-d	2.22 b
N_3W_2	15.58 b	15.49 ab	16.12 b	15.85 ab	23.33 ab	10.94	23.58 ab	10.90	7.19 b	2.56 ab	7.08 b	2.48 ab
N_3W_3	14.91 b-d	15.49 ab	15.45 bc	15.87 ab	23.32 ab	11.53	23.61 ab	11.49	6.96 bc	2.61 ab	6.88 bc	2.55 ab
SE value	0.502	0.935	0.515	0.938	0.362	0.737	0.364	0.721	0.238	0.158	0.231	0.153
Level of significance	*	*	*	*	*	NS	*	NS	*	*	*	*
CV (%)	7.54	18.48	7.58	18.01	3.28	14.83	3.46	16.65	7.15	17.42	7.02	17.29

*: Significant at 0.05 level of Probability; NS: Non Significnat

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

N_0: No urea (control), N_1: Urea super granules (77 kg N ha^{-1}), N_2: Prilled urea at recommended dose (150 kg N ha^{-1}) as 325 kg urea ha^{-1} and N_3= ½ of the recommended dose (75 kg N ha^{-1}) as163 kg urea ha^{-1}

W_0: No weeding (control), W_1: Two hand weeding (20 DAT and 40 DAT), W_2: Pre emergence herbicide (Butachor) and W_3: Post emergence herbicide (Prityloclor)

Table 4.5.3 Combined effect of different levels of nitrogen and irrigation management on CGR, RGR and NAR of BRRI dhan29.

Treatments	CGR (g m^{-2}day^{-1})				RGR (mg g^{-1}day^{-1})				NAR (g m^{-2}day^{-1})			
	2014-2015		2015-2016		2014-2015		2015-2016		2014-2015		2015-2016	
	30-50 DAT	50-70 DAT	30-50 DAT	50-70 DAT	30-50 DAT	50-70 DAT	30-50 DAT	50-70 DAT	30-50 DAT	50-70 DAT	30-50 DAT	50-70 DAT
N_0I_1	11.51 i	11.13 d	11.98 j	11.60 d	22.26 e	9.70 e	22.54 f	9.75 e	5.92 h	2.01 f	5.87 i	1.98 e
N_1I_1	13.74 fg	14.89 bc	14.27 gh	15.28bc	22.27 e	11.79 a-c	22.62 f	11.76 a-c	6.45 e-g	2.54 a-c	6.41 d-g	2.48 a-c
N_2I_1	12.83 gh	13.06 cd	13.31 hi	13.47 cd	22.34 e	10.71 a-e	22.60 f	10.74 a-e	6.12 gh	2.25 c-f	6.08 g-i	2.21 c-e
N_3I_1	12.88 gh	11.37 d	13.38 hi	11.78 d	22.33 e	10.66 b-e	22.64 f	10.75 a-e	6.39 fg	2.08 ef	6.35 e-h	2.05 de
N_0I_2	12.56 h	14.85 bc	13.04 i	15.27 bc	23.50 a-c	12.27 ab	23.83 a-c	12.25 ab	6.09 gh	2.61 a-c	6.02 g-i	2.56 a-c
N_1I_2	16.49 b	15.01 bc	17.07 b	15.37 bc	22.44 e	10.22 c-e	22.64 f	10.20 c-e	7.67 ab	2.47 a-e	7.61 a	2.41 a-d
N_2I_2	14.79 de	14.84 bc	15.30 d-f	15.22 bc	23.28 b-d	11.04 a-e	23.51 b-e	11.02 a-e	6.94 cd	2.50 a-d	6.88 bc	2.43 a-d
N_3I_2	13.99 ef	14.65 bc	14.50 fg	15.03 bc	22.32 e	11.12 a-e	22.60 f	11.10 a-e	6.64 d-f	2.49 a-e	6.55 c-f	2.42 a-d
N_0I_3	12.61 h	11.71 d	13.08 i	12.14 d	22.78 de	10.35 c-e	23.01 d-f	10.40 c-e	6.24 f-h	2.11 d-f	6.19 f-i	2.07 de
N_1I_3	15.27 cd	14.89 bc	15.78 c-e	15.25 bc	22.92 c-e	10.83 a-e	23.11 c-f	10.80 a-e	7.11 c	2.49 a-e	7.03 b	2.42 a-d
N_2I_3	14.79 de	14.28 bc	15.31 d-f	14.65 bc	22.68 de	10.61 b-e	22.92 ef	10.59 b-e	6.84 c-e	2.38 b-f	6.78 b-e	2.32 b-e
N_3I_3	12.65 h	15.15 bc	13.10 i	15.57 bc	24.04 a	12.54 a	24.43 a	12.51 a	6.01 gh	2.62 a-c	5.94 hi	2.57 a-c
N_0I_4	14.26 ef	13.45 cd	14.77 e-g	13.85 cd	23.70 ab	10.76 a-e	23.93 ab	10.76 a-e	6.91 cd	2.36 b-f	6.80 b-d	2.31 b-e
N_1I_4	17.65 a	17.83 a	18.25 a	18.18 a	23.48 a-c	11.87 a-c	23.73 a-d	11.81 a-c	7.97 a	2.87 a	7.82 a	2.77 a
N_2I_4	15.79 bc	16.62 ab	16.28 b-d	17.00 ab	23.73 ab	11.70 a-d	23.81 a-c	11.65 a-d	7.27 bc	2.74 ab	7.13 b	2.66 ab
N_3I_4	16.14 bc	15.24 bc	16.70 bc	15.57 bc	24.18 a	9.94 de	24.34 a	9.90 de	7.26 bc	2.45 b-e	7.18 b	2.37 b-e
SE value	0.310	0.764	0.323	0.764	0.218	0.541	0.232	0.529	0.139	0.123	0.135	0.119
Level of significance	*	*	*	*	*	*	*	*	*	*	*	*
CV (%)	12.20	22.63	12.08	22.10	5.45	23.18	5.42	22.72	12.26	22.44	12.01	22.22

*: Significant at 0.05 level of Probability

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

N_0: No urea (control), N_1: Urea super granules (77 kg N ha^{-1}), N_2: Prilled urea at recommended dose (150 kg N ha^{-1}) as 325 kg urea ha^{-1} and N_3= ½ of the recommended dose (75 kg N ha^{-1}) as163 kg urea ha^{-1}

I_1: Irrigating all time, I_2: Irrigating 3 days after drying, I_3: Irrigating 5 days after drying and I_4: Alternate wetting and drying (AWD) method

Table 4.5.4 Combined effect of weed and irrigation management on CGR, RGR and NAR of BRRI dhan29.

Treatments	CGR (g m^{-2}day^{-1})				RGR (mg g^{-1}day^{-1})				NAR (g m^{-2}day^{-1})			
	2014-2015		2015-2016		2014-2015		2015-2016		2014-2015		2015-2016	
	30-50 DAT	50-70 DAT	30-50 DAT	50-70 DAT	30-50 DAT	50-70 DAT	30-50 DAT	50-70 DAT	30-50 DAT	50-70 DAT	30-50 DAT	50-70 DAT
W_0I_1	11.51 g	10.78 f	11.97 g	11.22 e	22.00 e	9.99 b	22.18 d	10.05 b	5.89 f	2.00 c	5.83 f	1.97 c
W_1I_1	12.55 fg	11.53 ef	13.04 fg	11.95 de	22.39 c-e	10.23 b	22.73 cd	10.30 ab	6.13 ef	2.02 c	6.10 d-f	1.99 c
W_2I_1	13.52 ef	14.65 b-d	14.03 ef	15.05 b-d	22.77 b-e	11.77 ab	23.06 b-d	11.75 ab	6.40 d-f	2.52 a-c	6.36 d-f	2.47 a-c
W_3I_1	13.38 ef	13.48 c-f	13.88 ef	13.90 c-e	23.09 b-e	10.87 ab	23.39 bc	10.89 ab	6.47 c-f	2.34 bc	6.41 c-f	2.29 bc
W_0I_2	13.72 d-f	13.31 c-f	14.22 d-f	13.71 c-e	23.00 b-e	10.85 ab	23.25 b-d	10.86 ab	6.69 b-e	2.36 bc	6.61 b-e	2.31 bc
W_1I_2	14.32 c-e	13.90 c-e	14.84 c-e	14.29 cd	22.93 b-e	10.66 ab	23.20 b-d	10.65 ab	6.74 b-e	2.35 bc	6.68 b-e	2.30 bc
W_2I_2	14.61 b-e	17.05 ab	15.14 b-e	17.38 ab	22.66 b-e	10.64 ab	22.95 b-d	10.58 ab	6.68 b-e	2.70 ab	6.61 b-e	2.61 ab
W_3I_2	15.19 b-d	14.12 b-e	15.73 b-d	14.50 b-d	23.31 a-d	10.36 ab	23.58 a-c	10.34 ab	7.23 bc	2.39 bc	7.16 bc	2.33 bc
W_0I_3	12.53 fg	13.20 d-f	12.99 fg	13.62 c-e	22.36 c-e	11.34 ab	22.57 cd	11.35 ab	6.16 ef	2.35 bc	6.11 d-f	2.30 bc
W_1I_3	12.64 fg	13.22 d-f	13.09 fg	13.63 c-e	22.19 de	11.22 ab	22.51 cd	11.23 ab	6.05 ef	2.31 bc	5.99 ef	2.26 bc
W_2I_3	15.71 bc	14.00 c-e	16.22 bc	14.37 b-d	23.41 a-d	10.10 b	23.58 a-c	10.08 b	7.27 b	2.32 bc	7.16 bc	2.27 bc
W_3I_3	14.44 c-e	15.60 a-d	14.97 b-e	15.99 a-c	23.06 b-e	11.67 ab	23.36 b-d	11.63 ab	6.73 b-e	2.62 ab	6.66 b-d	2.56 ab
W_0I_4	14.33 c-e	13.45 c-f	14.83 c-e	13.86 c-e	23.86 ab	10.68 ab	24.05 ab	10.68 ab	6.98 b-d	2.36 bc	6.82 b-d	2.30 bc
W_1I_4	15.30 b-d	16.23 a-d	15.81 b-d	16.61 a-c	23.37 a-d	11.74 ab	23.55 a-c	11.68 ab	6.95 b-d	2.66 ab	6.85 b-d	2.59 ab
W_2I_4	18.16 a	18.01 a	18.75 a	18.39 a	24.38 a	12.79 a	24.61 a	12.71 a	8.08 a	2.97 a	7.98 a	2.88 a
W_3I_4	16.06 b	16.40 a-c	16.59 b	16.76 a-c	23.48 a-c	11.22 ab	23.69 a-c	11.17 ab	7.41 ab	2.69 ab	7.27 b	2.61 ab
SE value	0.502	0.935	0.515	0.938	0.362	0.737	0.364	0.721	0.238	0.158	0.231	0.153
Level of significance	*	*	*	*	*	*	*	*	*	*	*	*
CV (%)	12.20	22.63	12.08	22.10	5.45	23.18	5.42	22.72	12.26	22.44	12.01	22.22

*: Significant at 0.05 level of Probability

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

W_0: No weeding (control), W_1: Two hand weeding (20 DAT and 40 DAT), W_2: Pre emergence herbicide (Butachor) and W_3: Post emergence herbicide (Prityloclor)

I_1: Irrigating all time, I_2: Irrigating 3 days after drying, I_3: Irrigating 5 days after drying and I_4: Alternate wetting and drying (AWD) method

Table 4.5.5 Combined effect of different levels of nitrogen, weed and irrigation management on CGR, RGR and NAR of BRRI dhan29.

Treatments	CGR (g m^{-2}day^{-1})				RGR (mg g^{-1}day^{-1})				NAR (g m^{-2}day^{-1})			
	2014-2015		2015-2016		2014-2015		2015-2016		2014-2015		2015-2016	
	30-50DAT	50-70DAT	30-50DAT	50-70DAT	30-50DAT	50-70DAT	30-50DAT	50-70DAT	30-50DAT	50-70DAT	30-50DAT	50-70DAT
$N_0W_0I_1$	10.37 v	6.59 k	10.84 u	6.98 k	20.46 i	5.94 h	20.90 i	6.09 g	5.11 p	1.19 j	5.10 q	1.20 g
$N_0W_1I_1$	11.02 r-v	9.59 h-k	11.49 q-u	10.07 h-k	23.24 a-h	9.81 a-h	23.63 a-h	9.94 a-g	5.72 i-p	1.81 f-j	5.65 k-q	1.79 d-g
$N_0W_2I_1$	11.10 q-v	15.65 a-i	11.55 q-u	16.11 a-i	22.78 a-i	14.14 a-c	23.08 a-i	14.10 ab	5.37 n-p	2.81 a-h	5.38 o-q	2.76 a-e
$N_0W_3I_1$	13.08 h-v	9.77 g-k	13.60 h-u	10.23 g-k	24.63 a-c	8.81 d-h	24.97 a-c	8.93 c-g	6.62 c-p	1.80 f-j	6.56 c-q	1.77 d-g
$N_1W_0I_1$	10.85 t-v	15.32 a-j	11.29 s-u	15.75 a-j	23.37 a-h	14.24 ab	23.64 a-h	14.19 ab	5.95 h-p	2.78 a-h	5.87 h-q	2.70 a-e
$N_1W_1I_1$	11.80 o-v	16.02 a-i	12.28 o-u	16.43 a-i	21.07 hi	13.37 a-f	21.39 hi	13.31 a-e	5.56 l-p	2.76 a-h	5.53 m-q	2.69 a-f
$N_1W_2I_1$	17.82 a-d	16.12 a-h	18.45 a-d	16.45 a-i	24.12 a-e	10.30 a-h	24.46 a-f	10.24 a-g	7.89 a-f	2.55 a-i	7.85 a-f	2.49 a-f
$N_1W_3I_1$	14.96 d-p	12.11 d-k	15.51 d-p	12.50 d-k	23.42 a-h	9.27 b-h	23.73 a-h	9.29 b-g	7.25 a-l	2.08 b-j	7.17 a-m	2.04 b-g
$N_2W_0I_1$	12.40 l-v	8.89 jk	12.88 l-u	9.32 jk	22.57 a-i	8.14 f-h	22.88 a-i	8.26 e-g	6.15 g-p	1.60 ij	6.09 g-q	1.60 fg
$N_2W_1I_1$	13.81 e-v	13.92 b-j	14.32 f-u	14.31 b-j	22.86 a-i	10.86 a-h	23.14 a-i	10.85 a-g	6.34 f-p	2.32 a-i	6.31 d-q	2.28 a-f
$N_2W_2I_1$	11.70 o-v	13.66 b-j	12.15 p-u	14.08 b-j	21.63 e-i	11.98 a-g	21.90 f-i	11.98 a-f	5.76 i-p	2.44 a-i	5.73 i-q	2.40 a-f
$N_2W_3I_1$	13.40 f-v	15.77 a-i	13.87 f-u	16.16 a-i	22.30 c-i	11.87 a-g	22.49 c-i	11.85 a-f	6.25 f-p	2.65 a-i	6.18 g-q	2.58 a-f
$N_3W_0I_1$	12.41 l-v	9.41 i-k	12.88 l-u	9.83 i-k	22.34 c-i	8.65 e-h	22.61 c-i	8.74 d-g	6.35 e-p	1.73 h-j	6.28 e-q	1.71 e-g
$N_3W_1I_1$	13.56 f-v	9.51 h-k	14.08 f-u	9.99 i-k	22.40 c-i	9.89 a-h	22.74 b-i	10.02 a-g	6.89 a-o	1.91 e-j	6.91 a-o	1.88 c-g
$N_3W_2I_1$	13.48 f-v	13.18 c-j	13.98 f-u	13.58 c-j	22.55 b-i	10.68 a-h	22.82 a-i	10.68 a-g	6.57 d-p	2.30 a-i	6.48 d-q	2.24 a-g
$N_3W_3I_1$	12.07 n-v	16.29 a-g	12.56 n-u	16.71 a-h	22.02 d-i	13.53 a-e	22.38 c-i	13.48 a-d	5.76 i-p	2.84 a-h	5.74 i-q	2.78 a-e
$N_0W_0I_2$	10.66 uv	15.28 a-j	11.07 tu	15.76 a-j	22.63 a-i	14.04 a-d	22.81 a-i	14.02 a-c	5.49 m-p	2.86 a-g	5.41 n-q	2.81 a-d
$N_0W_1I_2$	13.30 g-v	11.18 e-k	13.81 g-u	11.57 e-k	22.32 c-i	9.42 a-h	22.62 c-i	9.46 a-g	6.48e-p	1.97c-j	6.38 d-q	1.94 c-g
$N_0W_2I_2$	12.25 m-v	18.53 a-d	12.72 m-u	18.93 a-d	21.50 f-i	11.44 a-g	21.80 g-i	11.33 a-f	5.69 j-p	3.16 ab	5.66 j-q	3.06 ab
$N_0W_3I_2$	14.04 e-u	14.42 a-j	14.58 e-t	14.81 a-j	22.58 a-i	11.06 a-h	22.91 a-i	11.04 a-g	6.68 c-p	2.46 a-i	6.64 c-q	2.41 a-f
$N_1W_0I_2$	16.57 a-h	12.39 c-k	17.15 a-h	12.76 c-k	24.44 a-d	8.88 c-h	24.72 a-e	8.89 c-g	7.93 a-f	2.10 b-j	7.86 a-e	2.07 b-g
$N_1W_1I_2$	16.19 a-j	12.39 c-k	16.77 a-j	12.75 c-k	23.77 a-f	8.93 c-h	24.07 a-g	8.93 c-g	7.66 a-g	2.08 b-j	7.60 a-g	2.04 b-g
$N_1W_2I_2$	16.89 a-f	20.22 ab	17.49 a-f	21.24 a	23.73 a-g	13.07 a-g	24.04 a-g	12.96 a-f	7.34 a-j	3.28 a	7.30 a-k	3.18 a
$N_1W_3I_2$	16.31 a-j	14.35 a-j	16.89 a-i	14.72 a-j	24.24 a-d	10.02 a-h	24.52 a-e	10.00 a-g	7.74 a-g	2.41 a-i	7.67 a-g	2.35 a-f
$N_2W_0I_2$	15.69 b-m	12.99 c-k	16.24 b-m	13.36 c-k	23.79 a-f	9.56 a-h	24.04 a-g	9.56 a-g	7.40 a-i	2.19 a-j	7.31 a-j	2.14 a-g
$N_2W_1I_2$	14.13 e-u	18.46 a-d	14.63 e-t	18.85 a-d	23.12 a-h	13.51 a-e	23.35 a-i	13.43 a-d	6.33 f-p	3.02 a-e	6.30 d-q	2.93 a-c
$N_2W_2I_2$	14.13 e-u	13.64 b-j	14.64 e-t	14.04 b-j	23.06 a-h	10.71 a-h	23.31 a-i	10.70 a-g	6.84 a-o	2.37 a-i	6.81 a-p	2.32 a-f
$N_2W_3I_2$	15.21 d-o	14.27 b-j	15.71 d-p	14.64 a-j	23.15 a-h	10.39 a-h	23.33 a-i	10.37 a-g	7.18 a-m	2.41 a-i	7.10 a-m	2.32 a-f
$N_3W_0I_2$	11.95 n-v	12.57 c-j	12.41 n-u	12.98 c-k	21.14 g-i	10.94 a-h	21.41 hi	10.95 a-g	5.94 h-p	2.27 a-j	5.86 h-q	2.20 a-g
$N_3W_1I_2$	13.64 f-v	13.57 c-j	14.14 f-u	13.97 b-j	22.50 c-i	10.78 a-h	22.76 a-i	10.77 a-g	6.50 d-p	2.34 a-i	6.43 d-q	2.28 a-f
$N_3W_2I_2$	15.17 d-o	19.00 a-c	15.71 d-p	19.35 a-c	22.36 c-i	12.81 a-g	22.65 c-i	12.72 a-f	6.82 a-o	3.07 a-d	6.68 b-q	2.95 a-c
$N_3W_3I_2$	15.20 d-o	13.44 c-j	15.75 d-p	13.82 c-j	23.29 a-h	9.96 a-h	23.56 a-h	9.96 a-g	7.30 a-k	2.30 a-i	7.22 a-l	2.25 a-g
$N_0W_0I_3$	11.14 q-v	11.49 e-k	11.58 q-u	11.97 e-k	23.22 a-h	11.24 a-g	23.47 a-i	11.30 a-f	5.75 i-p	2.19 a-j	5.77 h-q	2.16 a-g
$N_0W_1I_3$	11.10 q-v	11.27 e-k	11.53 q-u	11.72 e-k	22.14 c-i	10.84 a-h	22.35 d-i	10.90 a-g	5.64 k-p	2.09 b-j	5.58 l-q	2.05 b-g
$N_0W_2I_3$	15.37 c-n	10.07 f-k	15.88 c-o	10.45 f-k	23.75 a-f	7.91 gh	23.91 a-h	7.96 fg	7.41 a-i	1.74 g-j	7.29 a-k	1.71 e-g

Cont'd

Treatments	CGR (g $m^{-2}day^{-1}$)				RGR (mg $g^{-1}day^{-1}$)				NAR (g $m^{-2}day^{-1}$)			
	2014-2015		2015-2016		2014-2015		2015-2016		2014-2015		2015-2016	
	30-50DAT	50-70DAT	30-50DAT	50-70DAT	30-50DAT	50-70DAT	30-50DAT	50-70DAT	30-50DAT	50-70DAT	30-50DAT	50-70DAT
$N_0W_3I_3$	12.84 i-v	14.01 b-j	13.33 i-u	14.42 b-j	22.02 d-i	11.43 a-g	22.32 e-i	11.42 a-f	6.16 g-p	2.42 a-i	6.13 g-q	2.36 a-f
$N_1W_0I_3$	14.49 d-s	14.69 a-j	14.97 d-r	15.08 a-j	23.07 a-h	11.14 a-h	23.20 a-i	11.11 a-g	6.98 a-o	2.51 a-i	6.90 a-o	2.42 a-f
$N_1W_1I_3$	12.60 k-v	13.13 c-j	13.06 k-u	13.53 c-j	21.61 e-i	11.03 a-h	21.83 g-i	11.03 a-g	6.13 g-p	2.31 a-i	6.09 g-q	2.27 a-f
$N_1W_2I_3$	19.05 ab	15.75 a-i	19.60 ab	16.04 a-i	23.74 a-f	9.51 a-h	23.83 a-h	9.45 a-g	8.31 a-c	2.44 a-i	8.19 a-c	2.37 a-f
$N_1W_3I_3$	14.95 d-p	15.98 a-i	15.50 d-p	16.36 a-i	23.27 a-h	11.65 a-g	23.57 a-h	11.60 a-f	7.02 a-n	2.69 a-i	6.92 a-o	2.63 a-f
$N_2W_0I_3$	13.56 f-v	13.57 c-j	14.05 f-u	13.94 b-j	21.56 e-i	10.65 a-h	21.81 g-i	10.64 a-g	6.41 e-p	2.31 a-i	6.34 d-q	2.28 a-f
$N_2W_1I_3$	15.45 c-n	11.75 e-k	15.97c-n	12.10 e-k	22.64 a-i	8.70 e-h	22.85 a-i	8.72 d-g	7.12 a-m	1.94 d-j	7.05 a-n	1.90 c-g
$N_2W_2I_3$	13.78 f-v	17.02 a-e	14.28f-u	17.42 a-e	22.81 a-i	12.89 a-g	23.06 a-i	12.83 a-f	6.38 e-p	2.86 a-g	6.32 d-q	2.78 a-e
$N_2W_3I_3$	16.39 a-i	14.77 a-j	16.96a-i	15.13 a-j	23.72 a-g	10.20 a-h	23.98 a-h	10.16 a-g	7.46 a-h	2.41 a-i	7.40 a-h	2.34 a-f
$N_3W_0I_3$	10.95 s-v	13.05 c-k	11.36 r-u	13.49 c-j	21.60 e-i	12.34 a-g	21.79 g-i	12.35 a-f	5.50 m-p	2.39 a-i	5.44 n-q	2.34 a-f
$N_3W_1I_3$	11.42 p-v	16.74 a-f	11.80 q-u	17.17 a-e	21.60 e-i	14.33 ab	21.69 g-i	14.26 ab	5.31 op	2.89 a-f	5.25 pq	2.82 a-d
$N_3W_2I_3$	14.64 d-q	13.17 c-j	15.14 d-q	13.56 c-j	23.33 a-h	10.09 a-h	23.50 a-h	10.09 a-g	6.96 a-o	2.25 a-j	6.86 a-p	2.21 a-g
$N_3W_3I_3$	13.58 f-v	17.63 a-e	14.10 f-u	18.04 a-e	23.24 a-h	13.40 a-f	23.57 a-h	13.34 a-e	6.26 f-p	2.97 a-e	6.21 f-q	2.90 a-c
$N_0W_0I_4$	12.63 k-v	12.68 c-k	13.09 k-u	13.17 c-k	23.64 a-h	11.53 a-g	25.32 ab	11.57 a-f	6.51 d-p	2.42 a-i	6.42 d-q	2.39 a-f
$N_0W_1I_4$	12.76 j-v	14.33 a-j	13.23 j-u	14.75 a-j	22.48 c-i	12.03 a-g	22.71 c-i	12.01 a-f	6.13 g-p	2.51 a-i	6.04 g-q	2.45 a-f
$N_0W_2I_4$	17.34 a-e	14.13 b-j	17.95 a-e	14.48 b-j	24.55 a-d	9.54 a-h	24.86 a-e	9.52 a-g	8.04 a-e	2.32 a-i	7.93 a-d	2.25 a-g
$N_0W_3I_4$	14.32 d-t	12.64 c-k	14.82 e-s	13.02 c-k	22.61 a-i	9.95 a-h	22.84 a-i	9.95 a-g	6.97 a-o	2.21 a-j	6.80 a-p	2.16 a-g
$N_1W_0I_4$	14.08 e-u	11.31 e-k	14.55 e-t	11.73 e-k	23.61 a-h	9.37 a-h	23.73 a-h	9.42 a-g	7.02 a-n	2.02 c-j	6.88 a-p	1.97 b-g
$N_1W_1I_4$	15.16 d-o	18.87 a-c	15.67 d-p	19.25 a-c	23.32 a-h	13.19 a-f	23.50 a-h	13.10 a-f	6.77 b-p	3.05 a-d	6.67 b-q	2.96 a-c
$N_1W_2I_4$	19.44 a	20.89 a	20.09 a	21.26 a	25.15 a	14.56 a	25.36 a	14.47 a	8.19 a-d	3.07 a-c	8.16 a-c	2.96 a-c
$N_1W_3I_4$	15.88 b-l	20.90 a	16.47 b-l	20.49 ab	23.36 a-h	13.49 a-e	23.74 a-h	13.38 a-f	7.07 a-m	2.33 a-i	7.00 a-o	2.27 a-f
$N_2W_0I_4$	14.51 d-r	16.64 a-f	15.02 d-q	17.04 a-f	23.55 a-h	12.49 a-g	23.76 a-h	12.43 a-g	6.81 b-o	2.80 a-h	6.64 c-q	2.72 a-e
$N_2W_1I_4$	16.58 a-h	15.13 a-j	17.07 a-h	15.48 a-j	23.90 a-f	10.70 a-h	23.95 a-h	10.65 a-f	7.51 a-h	2.46 a-i	7.39 a-h	2.40 a-f
$N_2W_2I_4$	16.83 a-g	17.25 a-e	17.32 a-g	17.61 a-e	24.26 a-d	11.41 a-g	24.29 a-g	11.34 a-f	7.67 a-g	2.79 a-h	7.54 a-g	2.72 a-e
$N_2W_3I_4$	15.25 d-o	17.48 a-e	15.70 d-p	17.85 a-e	23.21 a-h	12.22 a-g	23.25 a-i	12.15 a-f	7.09 a-m	2.90 a-f	6.94 a-o	2.80 a-e
$N_3W_0I_4$	16.11 a-k	13.16 c-j	16.66 a-k	13.51 c-j	23.15 a-h	9.32 a-h	23.38 a-i	9.31 b-g	7.60 a-h	2.21 a-j	7.35 a-i	2.12 a-g
$N_3W_1I_4$	16.71 a-g	16.60 a-f	17.29 a-g	16.95 a-f	23.77 a-f	11.03 a-h	24.05 a-g	10.97 a-g	7.38 a-j	2.64 a-i	7.31 a-j	2.57 a-f
$N_3W_2I_4$	19.02 ab	16.60 a-f	19.65 ab	16.92 a-g	25.08 ab	10.18 a-h	23.93 a-h	10.12 a-g	8.41 ab	2.61 a-i	8.29 ab	2.51 a-f
$N_3W_3I_4$	18.78 a-c	14.58 a-j	19.38 a-c	14.90 a-j	24.73 a-c	9.23 b-h	24.93 a-d	9.19 b-g	8.51 a	3.32 a	8.34 a	3.21 a
SE value	1.004	1.869	1.029	1.876	0.725	1.473	0.729	1.442	0.477	0.316	0.462	0.305
Level of significance	*	*	*	*	*	*	*	*	*	*	*	*
CV (%)	12.20	22.63	12.08	22.10	5.45	23.18	5.42	22.72	12.26	22.44	12.01	22.22

*: Significant at 0.05 level of Probability

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

N_0: No urea (control), N_1: Urea super granules (77 kg N ha^{-1}), N_2: Prilled urea at recommended dose (150 kg N ha^{-1}) as 325 kg urea ha^{-1} and N_3= ½ of the recommended dose (75 kg N ha^{-1}) as163 kg urea ha^{-1}

W_0: No weeding (control), W_1: Two hand weeding (20 DAT and 40 DAT), W_2: Pre emergence herbicide (Butachor) and W_3: Post emergence herbicide (Prityloclor)

I_1: Irrigating all time, I_2: Irrigating 3 days after drying, I_3: Irrigating 5 days after drying and I_4: Alternate wetting and drying (AWD) method

4.6 Relative growth rate (RGR)

Due to different nitrogen, weed and irrigation management and also their combined effect showed statistically significant differences in terms of crop growth rate (RGR) of BRRI dhan29 at 30-50 and 50-70 DAT for the two subsequent years (Appendix VIII). RGR showed differences irrespective of treatments and their combined effects (Table 4.5.1 to 4.5.5).

4.6.1 Effect of nitrogen management

Different nitrogen management showed statistically significant variation in terms of RGR of BRRI dhan29 at 30-50 and 50-70 DAT for the two subsequent years (Table 4.5.1). Data revealed that at 30-50 and 50-70 DAT, the highest RGR (23.18, 11.18. 23.45 and 11.14 mg g^{-1} day^{-1}, respectively) were recorded from N_1, while the lowest (22.82, 10.83, 23.08 and 10.81 mg g^{-1} day^{-1}, respectively) were found from N_3.

4.6.2 Effect of weed management

Statistically significant variation was recorded in terms of RGR of BRRI dhan29 at 30-50 and 50-70 DAT for different weed management for the two subsequent years (Table 4.5.1). At 30-50 and 50-70 DAT, the highest RGR (23.31, 11.33, 23.55 and 11.28 mg g^{-1} day^{-1}, respectively) was recorded from W_2, while the lowest (22.67, 10.78, 22.92 and 10.80 mg g^{-1} day^{-1}, respectively) were found from W_0.

4.6.3 Effect of irrigation management

RGR of BRRI dhan29 at 30-50 and 70 DAT statistically significant differences due to different irrigation management (Table 4.5.1). At 30-50 and 50-70 DAT, the highest RGR (23.77, 11.16, 23.98 and 11.14 mg g^{-1} day^{-1}, respectively) were recorded from I_4 whereas the lowest (22.61, 10.72, 22.91 and 10.75 mg g^{-1} day^{-1}, respectively) were observed from I_1. Ghosh *et al.* (2015) found that BRRI dhan27 gave the highest CGR (41.36 g m^{-2} day^{-1}) under irrigated condition. Under rainfed condition also the same variety showed the maximum CGR (39.21 g m^{-2} day^{-1}).

4.6.4 Combined effect of nitrogen and weed management

RGR of BRRI dhan29 at 30-50 and 50-70 DAT varied significantly for the combined effect of different nitrogen and weed management for the two subsequent years (Table 4.5.2). At 30-50 and 50-70 DAT, the highest RGR (23.80, 11.75, 24.07 and 11.73 mg g^{-1} day^{-1}, respectively) were recorded from N_1W_2, whereas the lowest (22.06, 10.21, 24.07 and 10.22 mg g^{-1} day^{-1}, respectively) from N_0W_0.

4.6.5 Combined effect of nitrogen and irrigation

RGR of BRRI dhan29 at 30-50 and 50-70 DAT varied significantly with the combined effect of different irrigation and nitrogen management for the two subsequent years (Table 4.5.3). At 30-50 and 50-70 DAT, the highest RGR (24.04, 12.54, 24.43 and 12.51 mg g^{-1} day^{-1}, respectively) were recorded from N_3I_3, whereas the lowest (22.26, 970, 22.54 and 9.57 mg g^{-1} day^{-1}, respectively) from N_0I_1.

4.6.6 Combined effect of irrigation and weed management

RGR of BRRI dhan29 at 30-50 and 50-70 DAT varied significantly with the combined effect of different irrigation and weed management for the two subsequent years (Table 4.5.4). At 30-50 and 50-70 DAT, the highest RGR (24.38, 12.79, 24.61 and 12.71 mg g^{-1} day^{-1}, respectively) were recorded from W_2I_4, whereas the lowest (22.00, 9.99, 22.18 and 10.05 mg g^{-1} day^{-1}, respectively) from W_0I_1.

4.6.7 Combined effect of nitrogen, weed and irrigation management

Statistically significant differences was observed for the combined effect of different nitrogen, weed management and irrigation in terms of RGR of BRRI dhan29 at 30-50 and 50-70 DAT for the two subsequent years (Table 4.5.5). At 30-50 and 50-70 DAT, the highest RGR (25.15, 14.56, 25.36 and 14.47 mg g^{-1} day^{-1}, respectively) were recorded from N_1W_2 I_4, while the lowest (20.46, 5.94, 20.90 and 6.09 mg g^{-1} day^{-1}, respectively) from $N_0W_0I_{1.}$

4.7 Net assimilation rate (NAR)

Due to different nitrogen, weed and irrigation management and also their combined effect showed statistically significant differences in terms of crop growth rate (NAR) of BRRI dhan29 at 30-50 and 50-70 DAT for the two subsequent years (Appendix VIII). NAR showed differences irrespective of treatments and their combined effects (Table 4.5.1 to 4.5.5).

4.7.1 Effect of nitrogen management

Different nitrogen management showed statistically significant variation in terms of NAR of BRRI dhan29 at 30-50 and 50-70 DAT for the two subsequent years (Table 4.5.1). At 30-50 and 50-70 DAT, the highest NAR (7.12, 2.59, 7.05 and 2.52g m^{-2} day^{-1}, respectively) were recorded from N_1, which was followed (6.79, 2.47, 6.72 and 2.41 g m^{-2} day^{-1}, respectively) by N_3, while the lowest (6.29, 2.29, 6.22 and 2.25 g m^{-2} day^{-1}, respectively) were found from N_0.

4.7.2 Effect of weed management

Statistically significant variation was recorded in terms of NAR of BRRI dhan29 at 30-50 and 50-70 DAT for different weed management for the two subsequent years (Table 4.5.1). At 30-50 and 50-70 DAT, the highest NAR (7.10, 2.63, 7.03 and 2.56 g m^{-2} day^{-1}, respectively) was recorded from W_2 which was statistically similar (6.96, 2.51, 6.88 and 2.45 g m^{-2} day^{-1}, respectively) to W_3 and followed (6.47, 2.34, 6.40 and 2.28 g m^{-2} day^{-1}, respectively) by W_1, while the lowest (6.29, 2.29, 6.22 and 2.25 g m^{-2} day^{-1}, respectively) were found from W_0.

4.7.3 Effect of irrigation management

NAR of BRRI dhan29 at 30-50 and 70 DAT statistically significant differences due to different irrigation management (Table 4.5.1). At 30-50 and 50-70 DAT, the highest NAR (7.35, 2.60, 7.23 and 2.53 g m^{-2} day^{-1}, respectively) were found from I_4 which was follwed (6.83, 2.52, 6.76 and 2.45 g m^{-2} day^{-1}, respectively) by I_1, whereas the lowest (6.22, 2.22, 6.18 and 2.18 g m^{-2} day^{-1}, respectively) were found from I_1. Ghosh *et al.* (2015) showed that at 24-31 DAS, the highest and NAR (0.0202 g m^{-2} day^{-1}) were found in Nerika1 under irrigated treatment.

4.7.4 Combined effect of nitrogen and weed management

NAR of BRRI dhan29 at 30-50 and 50-70 DAT varied significantly for the combined effect of different nitrogen and weed management for the two subsequent years (Table 4.5.2). At 30-50 and 50-70 DAT, the highest NAR (7.93, 2.83, 7.87 and 2.75 g m^{-2} day^{-1}, respectively) were recorded from N_1W_2, whereas the lowest (5.92, 2.10, 5.87 and 2.06 g m^{-2} day^{-1}, respectively) from N_0W_0.

4.7.5 Combined effect of nitrogen and irrigation

NAR of BRRI dhan29 at 30-50 and 50-70 DAT varied significantly for the combined effect of different nitrogen and irrigation management for the two subsequent years (Table 4.5.3). At 30-50 and 50-70 DAT, the highest NAR (7.97, 2.87, 7.82 and 2.77 g m^{-2} day^{-1}, respectively) were recorded from N_1I_4, whereas the lowest (5.92, 2.01, 5.87 and 1.98 g m^{-2} day^{-1}, respectively) was observed from N_0I_1.

4.7.6 Combined effect of irrigation and weed management

NAR of BRRI dhan29 at 30-50 and 50-70 DAT varied significantly for the combined effect of different irrigation and weed management for the two subsequent years (Table 4.5.4). At 30-50 and 50-70 DAT, the highest NAR (8.08, 2.97, 7.98 and 2.88 g m^{-2} day^{-1}, respectively) were recorded from W_2I_4, whereas the lowest (5.89, 2.00, 5.83 and 1.97 g m^{-2} day^{-1}, respectively) from W_0I_1.

4.7.7 Combined effect of nitrogen, weed and irrigation management

Statistically significant differences was observed for the combined effect of different nitrogen, weed management and irrigation in terms of NAR of BRRI dhan29 at 30-50 and 50-70 DAT for the two subsequent years (Table 4.5.5). At 30-50 and 50-70 DAT, the highest NAR (8.51, 3.32, 8.34 and 3.21 g m^{-2} day^{-1}, respectively) were recorded from $N_3W_3I_4$, while the lowest (5.11, 1.19, 5.10 and 1.20 g m^{-2} day^{-1}, respectively) from $N_0W_0I_1$.

4.8 Effective tillers hill^{-1}

Statistically significant variation was observed in terms of number of effective tillers hill^{-1} of BRRI dhan29 due to different nitrogen, weed and irrigation management and also their combined effect (Appendix IX). Data revealed that the highest number of effective tillers hill^{-1} was produced in the 2nd year of the experimental period compared to 1st year (Table 4.6.1 to 4.6.5).

4.8.1 Effect of nitrogen management

Statistically significant variation was observed in terms of number of effective tillers hill^{-1} of BRRI dhan29 for different nitrogen management for the two subsequent years (Table 4.6.1). The highest number of effective tillers hill^{-1} (15.46) was recorded from N_1, which was closely followed (14.96) by N_2, while the lowest number (12.38) was found from N_0, which was followed (14.19) by N_3. Mollah *et al.* (2015) recorded the maximum number of effective tillers hill^{-1} in balanced fertilizer lower dose irrespective of growing period in BRRI dhan29.

4.8.2 Effect of weed management

Number of effective tillers hill^{-1} of BRRI dhan29 showed statistically significant differences for different weed management for the two subsequent years (Table 4.6.1). The highest number of effective tillers hill^{-1} (15.60) was recorded from W_2, which was closely followed (14.51) by W_3 and (14.34) by W_1 and they were statistically similar, while the lowest number (12.56) were found from W_0.

4.8.3 Effect of irrigation management

Number of effective tillers hill^{-1} of BRRI dhan29 showed statistically significant differences due to different irrigation management (Table 4.6.1). Number of effective tillers hill^{-1} was significantly higher compared to control condition for the two subsequent years. The highest number of effective tillers hill^{-1} (15.59) was found from I_4 which was closely followed (14.38) by I_2, whereas the lowest number (12.95) was recorded from I_1 which was followed (14.08) by I_3. Nasir *et al.* (2014) recorded maximum number of effective tillers hill^{-1} (21.5) from AWD irrigation management.

Table 4.6.1 Effect of different levels of nitrogen, weed management and irrigation on number of effective, non-effective tillers hill^{-1} and panicle length of BRRI dhan29

Treatments	Effective tillers hill^{-1} (No.)		Non-effective tillers hill^{-1} (No.)		Panicle length (cm)	
	2014-2015	2015-2016	2014-2015	2015-2016	2014-2015	2015-2016
Nitrogen management						
N_0	12.38 d	13.18 d	2.44 a	2.32 a	20.00 d	20.25 d
N_1	15.46 a	16.29 a	1.63 d	1.58 d	24.35 a	24.57 a
N_2	14.96 b	15.81 b	1.85 c	1.75 c	23.28 b	23.51 b
N_3	14.19 c	15.08 c	2.08 b	2.00 b	22.74 c	23.01 c
SE value	0.143	0.133	0.023	0.023	0.087	0.091
Level of significance	*	*	*	*	*	*
CV (%)	3.67	2.78	8.67	8.76	2.59	2.91
Weed management						
W_0	12.56 c	13.34 c	2.22 a	2.11 a	20.52 d	20.76 d
W_1	14.34 b	15.23 b	2.01 b	1.92 b	22.33 c	22.54 c
W_2	15.60 a	16.47 a	1.78 c	1.70 c	24.11 a	24.38 a
W_3	14.51 b	15.32 b	1.97 b	1.90 b	23.41 b	23.66 b
SE value	0.122	0.117	0.029	0.027	0.121	0.122
Level of significance	*	*	*	*	*	*
CV (%)	6.95	6.09	7.91	8.44	2.68	2.76
Irrigation management						
I_1	12.95 d	13.78 d	2.23 a	2.13 a	20.87 d	21.04 d
I_2	14.38 b	15.24 b	1.98 c	1.90 c	23.17 b	23.48 b
I_3	14.08 c	14.96 c	2.10 b	2.01 b	22.21 c	22.47 c
I_4	15.59 a	16.38 a	1.68 d	1.60 d	24.12 a	24.35 a
SE value	0.076	0.061	0.025	0.024	0.084	0.096
Level of significance	*	*	*	*	*	*
CV (%)	5.94	5.35	10.02	9.69	3.73	3.70

*: Significant at 0.05 level of probability

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

N_0: No urea (control), N_1: Urea super granules (77 kg N ha^{-1}), N_2: Prilled urea at recommended dose (150 kg N ha^{-1}) as 325 kg urea ha^{-1} and N_3= ½ of the recommended dose (75 kg N ha^{-1}) as163 kg urea ha^{-1}

W_0: No weeding (control), W_1: Two hand weeding (20 DAT and 40 DAT), W_2: Pre emergence herbicide (Butachor) and W_3: Post emergence herbicide (Prityloclor)

I_1: Irrigating all time, I_2: Irrigating 3 days after drying, I_3: Irrigating 5 days after drying and I_4: Alternate wetting and drying (AWD) method

4.8.4 Combined effect of nitrogen and weed management

The Number of effective tillers $hill^{-1}$ of BRRI dhan29 varied significantly with the combined effect of different nitrogen and weed management for the two subsequent years (Table 4.6.2). The highest number of effective tillers $hill^{-1}$ (18.03) was recorded from N_1W_2, whereas the lowest number (10.38) from N_0W_0.

4.8.5 Combined effect of nitrogen and irrigation management

The Number of effective tillers $hill^{-1}$ of BRRI dhan29 varied significantly with the combined effect of different nitrogen and irrigation management for the two subsequent years (Table 4.6.3). The highest number of effective tillers $hill^{-1}$ (17.00) was recorded from N_1I_4, whereas the lowest number (10.98) from N_0I_1.

4.8.6 Combined effect of weed management and irrigation management

Different irrigation and weed management varied significantly due to combined effect in terms of number of effective tillers $hill^{-1}$ of BRRI dhan29 for the two subsequent years (Table 4.6.4). The highest number of effective tillers $hill^{-1}$ (17.02) was recorded from W_2I_4, whereas the lowest number (10.95) from W_0I_1.

4.8.7 Combined effect of nitrogen, weed and irrigation mangement

Statistically significant variation was recorded due to the combined effect of different nitrogen, weed management and irrigation in terms of number of effective tillers $hill^{-1}$ of BRRI dhan29 for the two subsequent years (Table 4.6.5). The highest number of effective tillers $hill^{-1}$ (19.80) was recorded from N_1W_2 I_4, while the lowest number (8.27) from N_0W_0 I_1.

4.9 Non-effective tillers $hill^{-1}$

Statistically significant variation was observed in terms of number of non-effective tillers $hill^{-1}$ of BRRI dhan29 due to different nitrogen, weed and irrigation management and also their combined effect (Appendix IX). In general irrespective of treatments and their combined effects, comparatively the lowest number of non-effective tillers $hill^{-1}$ was produced in the 2^{nd} year of the experimental period compared to 1^{st} year (Table 4.6.1 to 4.6.5).

Table 4.6.2 Combined effect of different levels of nitrogen and weed management on number of effective, non-effective tillers hill^{-1} and panicle length of BRRI dhan29.

Treatments	Effective tillers hill^{-1} (No.)		Non-effective tillers hill^{-1} (No.)		Panicle length (cm)	
	2014-2015	2015-2016	2014-2015	2015-2016	2014-2015	2015-2016
N_0W_0	10.38 j	10.87 k	2.62 a	2.47 a	18.44 j	18.71 j
N_0W_1	12.15 i	13.05 j	2.42 b	2.30 b	19.36 i	19.56 i
N_0W_2	14.03 ef	15.00 e-g	2.32 b	2.20 b	21.46 fg	21.72 fg
N_0W_3	12.97 gh	13.82 hi	2.40 b	2.30 b	20.76 gh	21.01 gh
N_1W_0	13.55 fg	14.37 gh	1.75 ef	1.70 fg	21.72 f	21.92 f
N_1W_1	15.08 bc	15.93 cd	1.55 gh	1.48 hi	23.98 cd	24.17 cd
N_1W_2	18.03 a	18.87 a	1.63 f-h	1.55 gh	26.61 a	26.89 a
N_1W_3	15.18 bc	15.98 cd	1.60 f-h	1.57 gh	25.08 b	25.30 b
N_2W_0	13.97 ef	14.88 fg	2.13 c	2.00 cd	21.25 f-h	21.46 f-h
N_2W_1	15.82 b	16.72 b	1.97 cd	1.87 de	23.54 d	23.76 d
N_2W_2	14.87 cd	15.68 c-e	1.47 h	1.38 i	23.97 cd	24.21 cd
N_2W_3	15.20 bc	15.97 cd	1.82 de	1.77 ef	24.38 bc	24.60 bc
N_3W_0	12.33 hi	13.25 ij	2.40 b	2.28 b	20.69 h	20.95 h
N_3W_1	14.30 de	15.22 ef	2.12 c	2.05 c	22.46 e	22.69 e
N_3W_2	15.45 bc	16.32 bc	1.70 e-g	1.67 fg	24.40 bc	24.68 bc
N_3W_3	14.68 c-e	15.53 d-f	2.08 c	1.98 cd	23.40 d	23.71 d
SE value	0.244	0.233	0.058	0.053	0.244	0.244
Level of significance	*	*	*	*	*	*
CV (%)	6.95	6.09	7.91	8.44	2.68	2.76

*: Significant at 0.05 level of probability

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

N_0: No urea (control), N_1: Urea super granules (77 kg N ha^{-1}), N_2: Prilled urea at recommended dose (150 kg N ha^{-1}) as 325 kg urea ha^{-1} and N_3= ½ of the recommended dose (75 kg N ha^{-1}) as163 kg urea ha^{-1}

W_0: No weeding (control), W_1: Two hand weeding (20 DAT and 40 DAT), W_2: Pre emergence herbicide (Butachor) and W_3: Post emergence herbicide (Prityloclor)

Table 4.6.3 Combined effect of different levels of nitrogen and irrigation on number of effective, non-effective tillers hill^{-1} and panicle length BRRI dhan29.

Treatments	Effective tillers hill^{-1} (No.)		Non-effective tillers hill^{-1} (No.)		Panicle length (cm)	
	2014-2015	2015-2016	2014-2015	2015-2016	2014-2015	2015-2016
N_0I_1	10.98 j	11.67 j	2.63 a	2.53 a	18.45 h	18.57 h
N_1I_1	14.47 d-f	15.32 d-f	2.00 d-f	1.92 e-g	22.80 d	22.92 d
N_2I_1	13.92 fg	14.75 fg	2.07 de	1.95 ef	21.29 e	21.46 e
N_3I_1	12.45 hi	13.38 hi	2.22 c	2.13 cd	20.94 ef	21.20 ef
N_0I_2	13.08 gh	13.97 gh	2.40 b	2.28 b	20.53 f	20.83 f
N_1I_2	15.23 cd	16.17 cd	1.73 h	1.67 hi	25.10 a	25.39 a
N_2I_2	14.90 de	15.70 de	1.83 gh	1.78 gh	23.60 c	23.90 c
N_3I_2	14.28 ef	15.12 ef	1.93 e-g	1.87 e-g	23.43 c	23.78 c
N_0I_3	12.12 i	13.03 i	2.58 a	2.45 a	19.64 g	20.00 g
N_1I_3	15.15 c-e	15.98 cd	1.60 i	1.55 i	24.29 b	24.50 b
N_2I_3	15.15 c-e	16.03 cd	1.98 ef	1.88 e-g	23.70 c	23.92 c
N_3I_3	13.92 fg	14.80 fg	2.25 c	2.17 bc	21.21 e	21.47 e
N_0I_4	13.35 g	14.07 gh	2.13 cd	2.00 de	21.39 e	21.60 e
N_1I_4	17.00 a	17.68 a	1.20 j	1.17 k	25.36 a	25.59 a
N_2I_4	15.88 bc	16.77 bc	1.50 i	1.40 j	24.55 b	24.76 b
N_3I_4	16.12 b	17.02 ab	1.90 fg	1.82 fg	25.20 a	25.47 a
SE value	0.286	0.266	0.046	0.047	0.175	0.182
Level of significance	*	*	*	*	*	*
CV (%)	5.94	5.35	10.02	9.69	3.73	3.70

*: Significant at 0.05 level of Probability

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

N_0: No urea (control), N_1: Urea super granules (77 kg N ha^{-1}), N_2: Prilled urea at recommended dose (150 kg N ha^{-1}) as 325 kg urea ha^{-1} and N_3= ½ of the recommended dose (75 kg N ha^{-1}) as163 kg urea ha^{-1}

I_1: Irrigating all time, I_2: Irrigating 3 days after drying, I_3: Irrigating 5 days after drying and I_4: Alternate wetting and drying (AWD) method

Table 4.6.4 Combined effect of weed management and irrigation on number of effect, non-effective tillers hill^{-1} and panicle length of BRRI dhan29.

Treatments	Effective tillers hill^{-1} (No.)		Non-effective tillers hill^{-1} (No.)		Panicle length (cm)	
	2014-2015	2015-2016	2014-2015	2015-2016	2014-2015	2015-2016
W_0I_1	10.95 j	11.72 l	2.62 a	2.48 a	18.92 i	19.10 i
W_1I_1	12.98 g-i	13.87 jk	2.32 b	2.23 b	20.79 gh	20.93 gh
W_2I_1	14.37 ef	15.23 fg	1.87 de	1.78 de	22.33 de	22.51 de
W_3I_1	13.52 gh	14.30 ij	2.12 c	2.03 c	21.44 fg	21.60 fg
W_0I_2	12.88 hi	13.73 jk	2.27 bc	2.15 bc	21.29 fg	21.57 fg
W_1I_2	14.57 de	15.48 ef	1.93 d	1.87 d	22.82 d	23.10 d
W_2I_2	15.75 bc	16.65 bc	1.78 d-f	1.72 d-f	24.33 c	24.66 c
W_3I_2	14.30 ef	15.08 f-h	1.92 d	1.87 d	24.22 c	24.57 c
W_0I_3	12.68 i	13.50 k	2.33 b	2.23 b	20.43 h	20.72 h
W_1I_3	13.70 fg	14.60 g-i	2.10 c	2.02 c	21.74 ef	21.95 ef
W_2I_3	15.25 cd	16.13 c-e	1.82 d-f	1.73 def	23.81 c	24.11 c
W_3I_3	14.70 de	15.62 d-f	2.17 bc	2.07 c	22.86 d	23.10 d
W_0I_4	13.72 fg	14.42 h-j	1.68 ef	1.58 f	21.44 fg	21.65 fg
W_1I_4	16.10 b	16.97 b	1.70 ef	1.58 f	23.99 c	24.19 c
W_2I_4	17.02 a	17.85 a	1.65 f	1.57 f	25.96 a	26.22 a
W_3I_4	15.52 bc	16.30 b-d	1.70 ef	1.65 ef	25.10 b	25.35 b
SE value	0.244	0.233	0.058	0.053	0.244	0.244
Level of significance	*	*	*	*	*	*
CV (%)	5.94	5.35	10.02	9.69	3.73	3.70

*: Significant at 0.05 level of Probability

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

W_0: No weeding (control), W_1: Two hand weeding (20 DAT and 40 DAT), W_2: Pre emergence herbicide (Butachor) and W_3: Post emergence herbicide (Prityloclor)

I_1: Irrigating all time, I_2: Irrigating 3 days after drying, I_3: Irrigating 5 days after drying and I_4: Alternate wetting and drying (AWD) method

Table 4.6.5 Combined effect of different levels of nitrogen, weed management and irrigation on number of effective, non-effective tillers hill^{-1} and panicle length of BRRI dhan29.

Treatments	Effective tillers hill^{-1} (No.)		Non-effective tillers hill^{-1} (No.)		Panicle length (cm)	
	2014-2015	2015-2016	2014-2015	2015-2016	2014-2015	2015-2016
$N_0W_0I_1$	8.27 z	8.47 z	2.87 ab	2.73 ab	17.61 x	17.69 x
$N_0W_1I_1$	10.60 yz	11.53 yz	2.73 a-c	2.67 a-c	18.12 wx	18.23 wx
$N_0W_2I_1$	13.33 o-v	14.27 o-t	2.53 b-e	2.40 b-e	18.85 u-x	18.94 v-x
$N_0W_3I_1$	11.73 v-z	12.40 w-z	2.40 c-g	2.33 c-f	19.21 t-x	19.39 u-w
$N_1W_0I_1$	12.80 r-x	13.60 r-w	2.20 e-i	2.07 e-j	19.18 t-x	19.33 u-w
$N_1W_1I_1$	14.53 i-q	15.40 i-q	2.00 g-k	1.93 g-l	22.15 k-p	22.26 l-p
$N_1W_2I_1$	16.93 b-e	17.80 b-e	1.87 i-m	1.80 i-n	26.27 a-c	26.41 a-d
$N_1W_3I_1$	13.60 m-t	14.47 n-t	1.93 h-l	1.87 h-m	23.62 h-l	23.69 i-l
$N_2W_0I_1$	12.20 t-z	13.07 t-y	2.47 c-f	2.33 c-f	19.67 s-w	19.83 s-w
$N_2W_1I_1$	15.20 f-m	16.07 f-n	2.27 d-h	2.13 d-i	21.42 n-r	21.59 n-r
$N_2W_2I_1$	13.47 n-u	14.27 o-t	1.47 n-r	1.40 o-t	21.82 n-q	22.10 l-p
$N_2W_3I_1$	14.80 h-p	15.60 h-p	2.07 g-j	1.93 g-l	22.23 k-p	22.33 k-p
$N_3W_0I_1$	10.53 yz	11.73 x-z	2.93 a	2.80 a	19.24 t-w	19.54 t-w
$N_3W_1I_1$	11.60 w-z	12.47 v-z	2.27 d-i	2.20 d-h	21.46 n-r	21.65 n-r
$N_3W_2I_1$	13.73 l-t	14.60 m-t	1.60 l-p	1.53 m-r	22.37 k-p	22.61 k-o
$N_3W_3I_1$	13.93 k-s	14.73 k-s	2.07 g-j	2.00 f-k	20.70 p-t	20.99 o-t
$N_0W_0I_2$	11.00 yz	11.67 x-z	2.60 a-d	2.47 b-d	19.00 u-x	19.31 u-w
$N_0W_1I_2$	12.93 q-x	13.93 q-v	2.27 d-i	2.13 d-i	20.47 q-u	20.78 p-u
$N_0W_2I_2$	14.67 h-p	15.67 h-o	2.20 e-i	2.07 e-j	21.19 o-s	21.51 n-r
$N_0W_3I_2$	13.73 l-t	14.60 m-t	2.53 b-e	2.47 b-d	21.48 n-r	21.73 n-r
$N_1W_0I_2$	13.93 k-s	14.80 k-r	2.00 g-k	1.93 g-l	23.05 i-n	23.40 j-m
$N_1W_1I_2$	14.67 h-p	15.67 h-o	1.60 l-p	1.53 m-r	25.44 b-f	25.68 b-f
$N_1W_2I_2$	17.87 b	18.73 b	1.67 k-o	1.60 l-q	26.29 a-c	26.56 a-c
$N_1W_3I_2$	14.47 i-r	15.47 i-q	1.67 k-o	1.60 l-q	25.62 a-f	25.93 a-f
$N_2W_0I_2$	14.33 i-r	15.27 i-q	2.13 f-i	2.00 f-k	21.99 l-q	22.21 l-p
$N_2W_1I_2$	16.53 b-f	17.33 b-g	1.93 h-l	1.93 g-l	23.08 i-n	23.41 j-m
$N_2W_2I_2$	14.00 j-r	14.80 k-r	1.53 m-q	1.47 n-s	24.36 f-j	24.63 f-j
$N_2W_3I_2$	14.73 h-p	15.40 i-q	1.73 j-n	1.73 j-o	25.00 c-h	25.35 c-h
$N_3W_0I_2$	12.27 s-y	13.20 s-x	2.33 d-h	2.20 d-h	21.12 p-s	21.36 n-s
$N_3W_1I_2$	14.13 i-r	15.00 j-r	1.93 h-l	1.87 h-m	22.31 k-p	22.52 k-o
$N_3W_2I_2$	16.47 b-g	17.40 b-f	1.73 j-n	1.73 j-o	25.50 a-f	25.95 a-f
$N_3W_3I_2$	14.27 i-r	14.87 k-r	1.73 j-n	1.67 k-p	24.81 c-h	25.28 c-i
$N_0W_0I_3$	10.73 yz	11.33 yz	2.87 ab	2.73 ab	18.29 wx	18.79 v-x
$N_0W_1I_3$	11.33 x-z	12.20 w-z	2.53 b-e	2.40 b-e	18.87 u-x	19.13 v-x
$N_0W_2I_3$	13.20 p-w	14.27 o-t	2.33 d-h	2.27 d-g	21.32 o-r	21.68 n-r
$N_0W_3I_3$	13.20 p-w	14.33 o-t	2.60 a-d	2.40 b-e	20.10 r-v	20.43 q-v

Cont'd

Treatments	Effective tillers $hill^{-1}$ (No.)		Non-effective tillers $hill^{-1}$ (No.)		Panicle length (cm)	
	2014-2015	2015-2016	2014-2015	2015-2016	2014-2015	2015-2016
$N_1W_0I_3$	14.20 i-r	15.07 i-r	1.53 m-q	1.53 m-r	22.86 j-o	22.97 k-n
$N_1W_1I_3$	13.80 l-t	14.67 l-s	1.40 n-r	1.33 p-t	22.80 j-o	22.96 k-n
$N_1W_2I_3$	17.53 b	18.47 bc	1.87 i-m	1.73 j-o	26.75 ab	27.09 ab
$N_1W_3I_3$	15.07 f-n	15.73 h-o	1.60 l-p	1.60 l-q	24.73 c-h	24.97 c-j
$N_2W_0I_3$	13.93 k-s	14.93 j-r	2.47 c-f	2.33 c-f	21.99 l-q	22.18 l-p
$N_2W_1I_3$	15.27 f-m	16.13 f-m	2.07 g-j	1.93 g-l	24.57 d-i	24.73 e-j
$N_2W_2I_3$	15.73 c-i	16.53 d-j	1.33 o-r	1.27 q-t	23.53 h-m	23.73 h-l
$N_2W_3I_3$	15.67 d-j	16.53 d-j	2.07 g-j	2.00 f-k	24.73 c-h	25.02 c-j
$N_3W_0I_3$	11.87 u-z	12.67 u-z	2.47 c-f	2.33 c-f	18.61 v-x	18.95 v-x
$N_3W_1I_3$	14.40 i-r	15.40 i-q	2.40 c-g	2.40 b-e	20.70 p-t	20.99 o-t
$N_3W_2I_3$	14.53 i-q	15.27 i-q	1.73 j-n	1.67 k-p	23.64 h-k	23.93 h-k
$N_3W_3I_3$	14.87 g-p	15.87 f-o	2.40 c-g	2.27 d-g	21.88 m-q	22.00 m-q
$N_0W_0I_4$	11.53 x-z	12.00 x-z	2.13 f-i	1.93 g-l	18.87 u-x	19.03 v-x
$N_0W_1I_4$	13.73 l-t	14.53 m-t	2.13 f-i	2.00 f-j	19.98 r-v	20.11 r-v
$N_0W_2I_4$	14.93 f-o	15.80 g-o	2.20 e-i	2.07 e-j	24.47 e-i	24.76 d-j
$N_0W_3I_4$	13.20 p-w	13.93 q-v	2.07 g-j	2.00 f-k	22.26 k-p	22.48 k-o
$N_1W_0I_4$	13.27 o-v	14.00 p-u	1.27 p-r	1.27 q-t	21.79 n-q	21.99 m-q
$N_1W_1I_4$	17.33 bc	18.00 b-d	1.20 qr	1.13 st	25.51 a-f	25.77 b-f
$N_1W_2I_4$	19.80 a	20.47 a	1.13 r	1.07 t	27.12 a	27.51 a
$N_1W_3I_4$	17.60 b	18.27 bc	1.20 qr	1.20 r-t	26.36 a-c	26.61 a-c
$N_2W_0I_4$	15.40 e-l	16.27 e-l	1.47 n-r	1.33 p-t	21.34 o-r	21.61 n-r
$N_2W_1I_4$	16.27 b-h	17.33 b-g	1.60 l-p	1.47 n-s	25.10 b-h	25.31 c-i
$N_2W_2I_4$	16.27 b-h	17.13 c-h	1.53 m-q	1.40 o-t	26.17 a-d	26.39 a-e
$N_2W_3I_4$	15.60 d-k	16.33 e-k	1.40 n-r	1.40 o-t	25.58 a-f	25.72 b-f
$N_3W_0I_4$	14.67 h-p	15.40 i-q	1.87 i-m	1.80 i-n	23.78 g-k	23.96 g-k
$N_3W_1I_4$	17.07 b-d	18.00 b-d	1.87 i-m	1.73 j-o	25.38 b-g	25.58 b-g
$N_3W_2I_4$	17.07 b-d	18.00 b-d	1.73 j-n	1.73 j-o	26.08 a-e	26.22 a-f
$N_3W_3I_4$	15.67 d-j	16.67 d-i	2.13 f-i	2.00 f-k	26.20 a-d	26.59 a-c
SE value	0.489	0.466	0.116	0.107	0.487	0.488
Level of significance	*	*	*	*	*	*
CV (%)	5.94	5.35	10.02	9.69	3.73	3.70

*: Significant at 0.05 level of probability

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

N_0: No urea (control), N_1: Urea super granules (77 kg N ha^{-1}), N_2: Prilled urea at recommended dose (150 kg N ha^{-1}) as 325 kg urea ha^{-1} and N_3= ½ of the recommended dose (75 kg N ha^{-1}) as163 kg urea ha^{-1}

W_0: No weeding (control), W_1: Two hand weeding (20 DAT and 40 DAT), W_2: Pre emergence herbicide (Butachor) and W_3: Post emergence herbicide (Prityloclor)

I_1: Irrigating all time, I_2: Irrigating 3 days after drying, I_3: Irrigating 5 days after drying and I_4: Alternate wetting and drying (AWD) method

4.9.1 Effect of nitrogen management

Statistically significant variation was observed in terms of number of non-effective tillers hill^{-1} of BRRI dhan29 for different nitrogen management for the two subsequent years (Table 4.6.1). The lowest number of non-effective tillers hill^{-1} in each year (1.63 and 1.58) were recorded from N_1, which was closely followed (1.85 and 1.75) by N_2, while the highest number (2.44 and 2.32) were found from N_0,which was followed (2.08 and 2.00) by N_3.

4.9.2 Effect of weed management

Number of non-effective tillers hill^{-1} of BRRI dhan29 showed statistically significant differences for different weed management for the two subsequent years (Table 4.6.1). The lowest number of non-effective tillers hill^{-1} in each year (1.78 and 1.70) were recorded from W_2, which was closely followed (1.97 and 1.90) by W_3 and (2.01and 1.92) by W_1 and they were statistically similar, whereas the highest number (2.22 and 2.11) were found from W_0.

4.9.3 Effect of irrigation management

Number of non-effective tillers hill^{-1} of BRRI dhan29 showed statistically significant differences due to different irrigation management (Table 4.6.1). Number of non-effective tillers hill^{-1} was significantly lower compared to control condition for the two subsequent years. The lowest number of non-effective tillers hill^{-1} in each year (1.68 and 1.60) were found from I_4 which was closely followed (1.98 and 1.90) by I_2, whereas the highest number (2.23 and 2.13) were recorded from I_1 which was followed (2.10 and 2.01) by I_3. Khairi *et al.* (2015a) reported that AWD treatment produced minimum number of non-effective tillers hill^{-1} in rice.

4.9.4 Combined effect of nitrogen and weed management

Number of non-effective tillers hill^{-1} of BRRI dhan29 varied significantly for the combined effect of different nitrogen and weed management for the two subsequent years (Table 4.6.2). The lowest number of non-effective tillers hill^{-1} (1.47 and 1.38) were recorded from N_2W_2, whereas the highest number (2.62 and 2.47) from N_0W_0.

4.9.5 Combined effect of nitrogen and irrigation management

Combined effect of different nitrogen and irrigation management varied significantly in terms of number of non-effective tillers hill^{-1} of BRRI dhan29 for the two subsequent years (Table 4.6.3). The lowest number of non-effective tillers hill^{-1} (1.20 and 1.17) was recorded from N_1I_4, whereas the highest number (2.63 and 2.53) from N_0I_1. Hatamifar *et al.* (2013) reported that alternating irrigation, in addition to decrease the production costs and preserving the water resources, may increase the N consumption efficiency and produced the lowest number of non-effective tillers.

4.9.6 Combined effect of weed management and irrigation menegement

Number of non-effective tillers hill^{-1} of BRRI dhan29 varied significantly with the combined effect of different irrigation and weed management for the two subsequent years (Table 4.6.4). The lowest number of non-effective tillers hill^{-1} (1.65 and 1.57) was recorded from W_2I_4, whereas the highest number (2.62 and 2.48) from W_0I_1.

4.9.7 Combined effect of nitrogen, weed and irrigation mangement

Statistically significant variation was recorded due to the combined effect of different irrigation, nitrogen and weed management in terms of number of non-effective tillers hill^{-1} of BRRI dhan29 for the two subsequent years (Table 4.6.5). The lowest number of non-effective tillers hill^{-1} (1.13 and 1.07) was recorded from N_1W_2 I_4, while the highest number (2.87 and 2.73) from $N_3W_0I_1$.

4.10 Panicle length

Panicle length of BRRI dhan29 showed statistically significant differences due to different nitrogen, weed and irrigation mangement and also their combined effect (Appendix IX). In general irrespective of treatments and their combined effects, the longest panicle was produced in the 2nd year of the experimental period compared to 1st year (Table 4.6.1 to 4.6.5).

4.10.1 Effect of nitrogen management

Statistically significant variation was observed in terms of panicle length of BRRI dhan29 for different nitrogen management for the two subsequent years

(Table 4.6.1). The longest panicle (24.35 and 24.57 cm) were recorded from N_1 which was closely followed (23.28 and 23.51 cm) by N_2, while the shortest panicle (20.00 and 20.35 cm) were found from N_0 which was followed (22.74 and 23.01 cm) by N_3. Ferdous *et al.* (2014) reported that application of N as PU and USG resulted in a significant increase in panicle length of BRRI dhan29.

4.10.2 Effect of weed management

Panicle length of BRRI dhan29 showed statistically significant differences for different weed management for the two subsequent years (Table 4.6.1). The longest panicle (24.11 and 24.38 cm) was recorded from W_2, which was closely followed (23.41 and 23.66 cm) by W_3, while the shortest panicle (20.52 and 20.76 cm) was found from W_0 which was followed (22.33 and 22.54 cm) by W_1.

4.10.3 Effect of irrigation management

Panicle length of BRRI dhan29 showed statistically significant differences due to different irrigation management (Table 4.6.1). Panicle length was significantly higher compared to control condition for the two subsequent years. The longest panicle (24.12 and 24.35 cm) was found from I_4 which was closely followed (23.17 and 23.48 cm) by I_2, while the shortest panicle (20.87 and 21.04 cm) was recorded from I_1 which was closely followed (22.21 and 22.47 cm) by I_3. Khairi *et al.* (2015a) reported that AWD treatment produced longest panicle.

4.10.4 Combined effect of nitrogen and weed management

Panicle length of BRRI dhan29 varied significantly for the combined effect of different nitrogen and weed management for the two subsequent years (Table 4.6.2). The longest panicle (26.61 and 26.89 cm) was recorded from N_1W_2, whereas the shortest panicle (18.44 and 18.71 cm) from N_0W_0.

4.10.5 Combined effect of nitrogen and irrigation management

Panicle length of BRRI dhan29 varied significantly with the combined effect of different nitrogen and irrigation management for the two subsequent years (Table 4.6.3). The longest panicle (25.36 and 25.59 cm) was recorded from N_1I_4, whereas the shortest panicle (18.45 and 18.57 cm) from N_0I_1.

4.10.6 Combined effect of weed and irrigation management

Panicle length of BRRI dhan29 varied significantly for the combined effect of different irrigation and weed management for the two subsequent years (Table 4.6.4). The longest panicle (26.96 and 26.22 cm) was recorded from W_2I_4, whereas the shortest panicle (18.92 and 19.10 cm) from W_0I_1.

4.10.7 Combined effect of nitrogen, weed and irrigation management

Statistically significant variation was recorded due to the combined effect of different nitrogen, weed and irrigation management in terms of panicle length of BRRI dhan29 for the two subsequent years (Table 4.6.5). The longest panicle (27.12 and 27.51 cm) was recorded from $N_1W_2I_4$, while the shortest panicle (17.61 and 17.69 cm) from N_0W_0 I_1.

4.11 Filled grains panicle^{-1}

Number of filled grains panicle^{-1} of BRRI dhan29 varied significantly due to different nitrogen, weed and irrigation management and also their combined effect (Appendix X). The highest number of filled grains panicle^{-1} was produced in the 2nd year of the experimental period compared to 1st year irrespective of treatments and their combined effects (Table 4.7.1 to 4.7.5).

4.11.1 Effect of nitrogen management

Statistically significant variation was observed in terms of number of filled grains panicle^{-1} of BRRI dhan29 for different nitrogen management for the two subsequent years (Table 4.7.1). The highest number of filled grains panicle^{-1} (76.57 and 78.04) was recorded from N_1, which was closely followed (74.62 and 76.20) by N_2, while the lowest number (65.90 and 67.71) were found from N_0 which was followed (71.86 and 73.68) by N_3.

4.11.2 Effect of weed management

Number of filled grains panicle^{-1}of BRRI dhan29 showed statistically significant differences for different weed management for the two subsequent years (Table 4.7.1). The highest number of filled grains panicle^{-1} (77.39 and 79.12) was recorded from W_2, which was closely followed (73.41, 75.10) by W_3 and (72.30, 73,97) W_1 and they were statistically similar, while the lowest number (65.86 and 67.44) were found from W_0.

Table 4.7.1 Effect of different levels of nitrogen, weed management and irrigation on filled, unfilled, total grans panicle^{-1} and weight of 1000-grains of BRRI dhan29.

Treatments	Filled grains panicle^{-1} (No.)		Unfilled grains panicle^{-1} (No.)		Total grains panicle^{-1} (No.)		Weight of 1000-grains (g)	
	2014-2015	2015-2016	2014-2015	2015-2016	2014-2015	2015-2016	2014-2015	2015-2016
Nitrogen management								
N_0	65.90 d	67.71 d	7.32 a	6.96 a	73.21 c	74.67 c	21.13 d	21.40 d
N_1	76.57 a	78.04 a	4.91 d	4.72 d	81.49 a	82.77 a	26.18 a	26.41 a
N_2	74.62 b	76.20 b	5.54 c	5.26 c	80.16 a	81.46 ab	25.02 b	25.31 b
N_3	71.86 c	73.68 c	6.22 b	5.99 b	78.08 b	79.67 b	24.35 c	24.61 c
SE value	0.606	0.590	0.071	0.070	0.618	0.616	0.127	0.123
Level of significance	*	*	*	*	*	*	*	*
CV (%)	3.56	3.75	8.70	8.61	3.25	3.62	4.00	4.05
Weed management								
W_0	65.86 c	67.44 c	6.69 a	6.34 a	72.55 c	73.78 c	21.80 d	22.11 d
W_1	72.30 b	73.97 b	6.04 b	5.78 b	78.34 b	79.75 b	23.84 c	24.10 c
W_2	77.39 a	79.12 a	5.33 c	5.10 c	82.72 a	84.23 a	25.91 a	26.14 a
W_3	73.41 b	75.10 b	5.93 b	5.71 b	79.33 b	80.81 b	25.14 b	25.38 b
SE value	0.544	0.549	0.086	0.080	0.562	0.565	0.175	0.159
Level of significance	*	*	*	*	*	*	*	*
CV (%)	5.81	5.53	8.22	8.47	5.48	5.35	3.63	3.49
Irrigation management								
I_1	66.78 c	68.53 c	6.70 a	6.41 a	73.48 c	74.94 c	22.08 d	22.30 d
I_2	72.76 b	74.30 b	5.92 c	5.70 c	78.68 b	80.00 b	24.88 b	25.14 b
I_3	71.49 b	73.18 b	6.32 b	6.04 b	77.81 b	79.21 b	23.66 c	23.96 c
I_4	77.92 a	79.62 a	5.05 d	4.79 d	82.97 a	84.41 a	26.08 a	26.33 a
SE value	0.371	0.400	0.075	0.071	0.367	0.416	0.140	0.143
Level of significance	*	*	*		*	*	*	*
CV (%)	5.22	5.14	9.89	9.67	4.98	4.91	5.03	4.50

*: Significant at 0.05 level of probability

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

N_0: No urea (control), N_1: Urea super granules (77 kg N ha^{-1}), N_2: Prilled urea at recommended dose (150 kg N ha^{-1}) as 325 kg urea ha^{-1} and N_3= ½ of the recommended dose (75 kg N ha^{-1}) as163 kg urea ha^{-1}

W_0: No weeding (control), W_1: Two hand weeding (20 DAT and 40 DAT), W_2: Pre emergence herbicide (Butachor) and W_3: Post emergence herbicide (Prityloclor)

I_1: Irrigating all time, I_2: Irrigating 3 days after drying, I_3: Irrigating 5 days after drying and I_4: Alternate wetting and drying (AWD) method

4.11.3 Effect of irrigation management

Number of filled grains panicle^{-1} of BRRI dhan29 showed statistically significant differences due to different irrigation management (Table 4.7.1). Number of filled grains panicle^{-1} was significantly higher compared to control condition for the two subsequent years. The highest number of filled grains panicle^{-1} (77.92 and 79.62) was found from I_4 which was closely followed (72.76 and 74.30) by I_2 and (71.49 and 73.18) I_3 and they were statistically similar, whereas the lowest number (66.78 and 68.53) was recorded from I_1. Khairi *et al.* (2015a) reported that AWD treatment gave the highest number of filled grains panicle^{-1}.

4.11.4 Combined effect of nitrogen and weed management

Number of filled grains panicle^{-1} of BRRI dhan29 varied significantly for the combined effect of different nitrogen and weed management for the two subsequent years (Table 4.7.2). The highest number of filled grains panicle^{-1} (88.95 and 90.62) was recorded from N_1W_2, whereas the lowest number (60.85 and 62.40) from N_0W_0.

4.11.5 Combined effect of nitrogen and irrigation management

Number of filled grains panicle^{-1} of BRRI dhan29 varied significantly for the combined effect of different nitrogen and irrigation management for the two subsequent years (Table 4.7.3). The highest number of filled grains panicle^{-1} (82.58 and 84.77) was recorded from N_1I_4, whereas the lowest number (61.35 and 63.47) from N_0I_1. Jemberu (2011) reported that number of grains panicle^{-1} were significantly affected with deficit irrigation and N fertilizer rates.

4.11.6 Combined effect of weed and irrigation management

Number of filled grains panicle^{-1} of BRRI dhan29 varied significantly for the combined effect of different irrigation and weed management for the two subsequent years (Table 4.7.4). The highest number of filled grains panicle^{-1} (84.72 and 86.63) was recorded from W_2I_4, whereas the lowest number (60.82 and 62.25) from W_0I_1. Pramanik (2014) reported that cultivation of Boro rice with AWD method and application of Pyrazosulfuran-ethyl herbicide appear as the best combination for obtaining higher grains panicle.

Table 4.7.2 Combined effect of different levels of nitrogen and weed management on filled, unfilled, total grans panicle^{-1} and weight of 1000-grains of BRRI dhan29.

Treatments	Filled grains panicle^{-1} (No.)		Unfilled grains panicle^{-1} (No.)		Total grains panicle^{-1} (No.)		Weight of 1000-grains (g)	
	2014-2015	2015-2016	2014-2015	2015-2016	2014-2015	2015-2016	2014-2015	2015-2016
N_0W_0	60.85 i	62.40 h	7.90 a	7.42 a	68.75 i	69.82 h	19.25 i	19.54 i
N_0W_1	64.72 gh	66.38 g	7.25 b	6.92 b	71.97 hi	73.30 g	20.37 h	20.63 h
N_0W_2	71.22 e	73.03 ef	6.93 b	6.62 b	78.15 d-f	79.65 de	22.92 fg	23.20 f
N_0W_3	66.80 gh	69.02 g	7.18 b	6.90 b	73.98 gh	75.92 fg	21.99 g	22.24 g
N_1W_0	67.82 fg	68.95 g	5.27 ef	5.10 fg	73.08 h	74.05 g	23.23 ef	23.54 ef
N_1W_1	73.70 c-e	75.27 d-f	4.65 gh	4.45 hi	78.35 d-f	79.72 de	25.55 cd	25.83 cd
N_1W_2	88.95 a	90.62 a	4.92 f-h	4.65 gh	93.87 a	95.27 a	28.86 a	28.98 a
N_1W_3	75.83 bc	77.33 b-d	4.82 f-h	4.70 gh	80.65 c-e	82.03 cd	27.10 b	27.28 b
N_2W_0	70.75 ef	72.38 f	6.40 c	6.00 cd	77.15 e-g	78.38 ef	22.82 fg	23.13 fg
N_2W_1	78.90 b	80.53 b	5.92 cd	5.60 de	84.82 b	86.13 b	25.42 cd	25.70 cd
N_2W_2	72.45 de	73.98 ef	4.40 h	4.15 i	76.85 fg	78.13 ef	25.56 cd	25.82 cd
N_2W_3	76.37 bc	77.90 b-d	5.45 de	5.30 ef	81.82 bc	83.20 b-d	26.30 bc	26.61 bc
N_3W_0	64.02 h	66.03 g	7.20 b	6.85 b	71.22 hi	72.88 gh	21.91 g	22.24 g
N_3W_1	71.87 de	73.72 ef	6.35 c	6.15 c	78.22 d-f	79.87 de	24.00 e	24.26 e
N_3W_2	76.93 bc	78.85 bc	5.08 e-g	5.00 fg	82.02 bc	83.85 bc	26.32 bc	26.55 bc
N_3W_3	74.63 cd	76.13 c-e	6.25 c	5.95 cd	80.88 cd	82.08 cd	25.17 d	25.39 d
SE value	1.088	1.097	0.171	0.160	1.124	1.129	0.351	0.318
Level of significance	*	*	*	*	*	*	*	*
CV (%)	5.81	5.53	8.22	8.47	5.48	5.35	3.63	3.49

*: Significant at 0.05 level of probability

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

N_0: No urea (control), N_1: Urea super granules (77 kg N ha^{-1}), N_2: Prilled urea at recommended dose (150 kg N ha^{-1}) as 325 kg urea ha^{-1} and N_3= ½ of the recommended dose (75 kg N ha^{-1}) as163 kg urea ha^{-1}

W_0: No weeding (control), W_1: Two hand weeding (20 DAT and 40 DAT), W_2: Pre emergence herbicide (Butachor) and W_3: Post emergence herbicide (Prityloclor)

Table 4.7.3 Combined effect of different levels of nitrogen and irrigation management on filled, unfilled, total grans panicle^{-1} and weight of 1000-grains of BRRI dhan29.

Treatments	Filled grains panicle^{-1} (No.)		Unfilled grains panicle^{-1} (No.)		Total grains panicle^{-1} (No.)		Weight of 1000-grains (g)	
	2014-2015	2015-2016	2014-2015	2015-2016	2014-2015	2015-2016	2014-2015	2015-2016
N_0I_1	61.35 i	63.47 j	7.95 a	7.63 a	69.30 i	71.10 h	19.41 k	19.63 j
N_1I_1	72.07 ef	73.77 e-g	6.02 e-g	5.75 e-g	78.08 d-f	79.52 de	24.26 g	24.43 f
N_2I_1	69.13 fg	70.50 gh	6.22 d-f	5.85 ef	75.35 fg	76.35 e-g	22.50 h	22.74 g
N_3I_1	64.57 hi	66.40 ij	6.63 cd	6.40 cd	71.20 hi	72.80 gh	22.16 hi	22.41 gh
N_0I_2	67.60 gh	69.65 hi	7.18 b	6.85 b	74.78 f-h	76.50 e-g	21.56 i	21.84 h
N_1I_2	77.53 b-d	78.95 b-d	5.22 ij	5.00 hi	82.75 bc	83.95 bc	27.41 ab	27.61 ab
N_2I_2	74.47 de	75.85 d-f	5.50 hi	5.35 gh	79.97 c-e	81.20 cd	25.41 ef	25.69 de
N_3I_2	71.43 e-g	72.77 f-h	5.80 f-h	5.60 e-g	77.23 d-f	78.37 de	25.12 f	25.40 e
N_0I_3	64.93 hi	66.62 ij	7.75 a	7.35 a	72.68 g-i	73.97 f-h	20.75 j	21.07 i
N_1I_3	75.92 cd	77.23 c-e	4.82 jk	4.65 i	80.73 b-d	81.88 b-d	26.03 de	26.30 cd
N_2I_3	76.25 cd	78.05 cd	5.95 e-h	5.65 e-g	82.20 bc	83.70 bc	25.57 ef	25.92 de
N_3I_3	68.87 fg	70.80 gh	6.75 c	6.50 bc	75.62 fg	77.30 ef	22.29 hi	22.57 gh
N_0I_4	69.70 fg	71.10 gh	6.38 c-e	6.02 de	76.08 e-g	77.12 ef	22.81 h	23.07 g
N_1I_4	82.58 a	84.77 a	3.60 l	3.50 k	88.28 a	90.22 a	27.84 a	28.07 a
N_2I_4	78.62 bc	80.40 bc	4.50 k	4.20 j	83.12 bc	84.60 bc	26.62 cd	26.90 bc
N_3I_4	80.78 ab	82.22 ab	5.70 gh	5.45 fg	84.38 b	85.72 b	27.04 bc	27.29 b
SE value	1.212	1.179	0.142	0.140	1.237	1.231	0.254	0.246
Level of significance	*	*	*	*	*	*	*	*
CV (%)	5.22	5.14	9.89	9.67	4.98	4.91	5.03	4.50

*: Significant at 0.05 level of probability

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

N_0: No urea (control), N_1: Urea super granules (77 kg N ha^{-1}), N_2: Prilled urea at recommended dose (150 kg N ha^{-1}) as 325 kg urea ha^{-1} and N_3= ½ of the recommended dose (75 kg N ha^{-1}) as163 kg urea ha^{-1}

I_1: Irrigating all time, I_2: Irrigating 3 days after drying, I_3: Irrigating 5 days after drying and I_4: Alternate wetting and drying (AWD) method

Table 4.7.4 Combined effect of weed and irrigation management on filled, unfilled, total grans panicle^{-1} and weight of 1000-grains of BRRI dhan29.

Treatments	Filled grains panicle^{-1} (No.)		Unfilled grains panicle^{-1} (No.)		Total grains panicle^{-1} (No.)		Weight of 1000-grains (g)	
	2014-2015	2015-2016	2014-2015	2015-2016	2014-2015	2015-2016	2014-2015	2015-2016
W_0I_1	60.82 h	62.25 i	7.92 a	7.47 a	68.73 g	69.72 i	19.85 h	20.14 i
W_1I_1	67.75 fg	69.57 gh	6.97 b	6.72 b	74.72 f	76.28 gh	22.13 fg	22.34 gh
W_2I_1	70.62 ef	72.37 e-g	5.58 de	5.35 de	76.20 d-f	77.72 e-g	23.68 de	23.88 ef
W_3I_1	67.93 fg	69.95 gh	6.35 c	6.10 c	74.28 f	76.05 gh	22.67 e-g	22.86 gh
W_0I_2	67.53 fg	69.18 gh	6.80 bc	6.45 bc	74.33 f	75.63 gh	22.72 e-g	23.09 fg
W_1I_2	73.10 de	74.73 de	5.80 d	5.60 d	78.90 cd	80.33 c-e	24.47 d	24.73 de
W_2I_2	77.43 bc	79.10 bc	5.37 d-f	5.15 d-f	82.80 b	84.25 b	26.13 c	26.32 c
W_3I_2	72.97 de	74.20 d-f	5.73 d	5.60 d	78.70 c-e	79.80 d-f	26.19 bc	26.41 c
W_0I_3	65.63 g	67.37 h	7.00 b	6.70 b	72.63 f	74.07 h	21.69 g	22.01 h
W_1I_3	69.13 f	70.62 gh	6.30 c	6.05 c	75.43 ef	76.67 f-h	22.83 ef	23.19 fg
W_2I_3	76.78 bc	78.38 bc	5.45 d-f	5.20 d-f	82.23 b	83.58 bc	25.57 c	25.82 c
W_3I_3	74.42 cd	76.33 cd	6.52 bc	6.20 c	80.93 bc	82.53 b-d	24.54 d	24.83 d
W_0I_4	69.45 f	70.97 fg	5.05 ef	4.75 f	74.50 f	75.72 gh	22.95 ef	23.21 fg
W_1I_4	79.20 b	80.98 b	5.10 ef	4.75 f	84.30 b	85.73 b	25.91 c	26.16 c
W_2I_4	84.72 a	86.63 a	4.93 f	4.72 f	89.65 a	91.35 a	28.28 a	28.53 a
W_3I_4	78.32 b	79.90 b	5.10 ef	4.95 ef	83.42 b	84.85 b	27.17 b	27.43 b
SE value	1.088	1.097	0.171	0.160	1.124	1.129	0.351	0.318
Level of significance	*	*	*	*	*	*	*	*
CV (%)	5.22	5.14	9.89	9.67	4.98	4.91	5.03	4.50

*: Significant at 0.05 level of Probability

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

W_0: No weeding (control), W_1: Two hand weeding (20 DAT and 40 DAT), W_2: Pre emergence herbicide (Butachor) and W_3: Post emergence herbicide (Prityloclor)

I_1: Irrigating all time, I_2: Irrigating 3 days after drying, I_3: Irrigating 5 days after drying and I_4: Alternate wetting and drying (AWD) method

4.11.7 Combined effect of nitrogen, weed and irrigation management

Statistically significant variation was recorded due to the combined effect of different nitrogen, weed and irrigation management in terms of number of filled grains panicle^{-1} of BRRI dhan29 for the two subsequent years (Table 4.7.5). The highest number of filled grains panicle^{-1} in each year (91.60 and 93.33) was recorded from N_1W_2 I_4, while the lowest number (58.27 and 59.47) from N_0W_0 I_1.

4.12 Unfilled grains panicle^{-1}

Number of unfilled grains panicle^{-1} of BRRI dhan29 showed statistically significant differences due to different nitrogen, weed and irrigation management and also their combined effect (Appendix X). In general irrespective of treatments and their combined effects, the comparatively the lowest number of unfilled grains panicle^{-1} was produced in the 2nd year of the experimental period compared to 1st year (Table 4.7.1 to 4.7.5).

4.12.1 Effect of nitrogen management

Statistically significant variation was observed in terms of number of unfilled grains panicle^{-1} of BRRI dhan29 for different nitrogen management for the two subsequent years (Table 4.7.1). The lowest number of unfilled grains panicle^{-1} in each year (4.91 and 4.72) was recorded from N_1, which was closely followed (5.54 and 5.26) by N_2, while the highest number (7.32 and 6.96) were found from N_0 which was followed (6.22 and 5.99) by N_3. Ferdous *et al.* (2014) reported that application of N as PU and USG resulted in a significantly decrease number of unfilled grains panicle^{-1} of BRRI dhan29.

4.12.2 Effect of weed management

Number of unfilled grains panicle^{-1}of BRRI dhan29 showed statistically significant differences for different weed management for the two subsequent years (Table 4.7.1). The lowest number of unfilled grains panicle^{-1} in each year (5.33 and 5.10) was recorded from W_2, which was closely followed (5.93 and 5.71) by W_3 and (6.04 and 5.78) by W_1 and they were statistically similar, while the highest number (6.69 and 6.34) were found from W_0.

Table 4.7.5 Combined effect of different levels of nitrogen, weed management and irrigation on filled, unfilled, total grans panicle^{-1} and weight of 1000-grains of BRRI dhan29.

Treatments	Filled grains panicle^{-1} (No.)		Unfilled grains panicle^{-1} (No.)		Total grains panicle^{-1} (No.)		Weight of 1000-grains (g)	
	2014-2015	2015-2016	2014-2015	2015-2016	2014-2015	2015-2016	2014-2015	2015-2016
$N_0W_0I_1$	58.27 z	59.47 z	8.80 a	8.27 ab	67.07 tu	67.73 w	18.78 v	18.93 w
$N_0W_1I_1$	63.00 t-z	65.13 u-z	8.20 a-c	8.07 a-c	71.20 o-u	73.20 p-w	19.59 s-v	19.79 u-w
$N_0W_2I_1$	64.33 s-z	65.93 t-z	7.60 b-e	7.20 c-e	71.93 m-u	73.13 p-w	19.38 t-v	19.59 vw
$N_0W_3I_1$	59.80 yz	63.33 v-z	7.20 c-g	7.00 d-f	67.00 tu	70.33 s-w	19.87 r-v	20.21 t-w
$N_1W_0I_1$	62.20 v-z	63.40 v-z	6.67 d-j	6.20 e-j	68.87 r-u	69.60 t-w	19.69 s-v	20.07 t-w
$N_1W_1I_1$	70.20 m-t	72.07 m-u	6.00 h-l	5.80 g-l	76.20 j-r	77.87 l-s	23.09 i-p	23.39 j-p
$N_1W_2I_1$	86.07 a-e	87.93 a-e	5.60 j-n	5.40 i-n	91.67 a-c	93.33 a-d	28.83 a	28.98 a
$N_1W_3I_1$	69.80 n-u	71.67 n-u	5.80 i-m	5.60 h-m	75.60 k-s	77.27 m-u	25.41 c-i	25.27 e-k
$N_2W_0I_1$	62.73 u-z	63.93 v-z	7.40 c-f	7.00 d-f	70.13 q-u	70.93 s-w	20.69 q-v	20.95 r-w
$N_2W_1I_1$	76.00 h-o	77.27 h-o	6.87 d-i	6.40 d-i	82.87 e-k	83.67 f-m	22.92 j-q	23.03 l-r
$N_2W_2I_1$	64.27 s-z	65.80 t-z	4.40 o-s	4.20 o-t	68.67 r-u	70.00 s-w	22.70 k-q	23.04 l-r
$N_2W_3I_1$	73.53 k-r	75.00 k-s	6.20 g-k	5.80 g-l	79.73 g-m	80.80 g-p	23.69 h-n	23.96 i-o
$N_3W_0I_1$	60.07 x-z	62.20 x-z	8.80 a	8.40 a	68.87 r-u	70.60 s-w	20.21 r-v	20.60 s-w
$N_3W_1I_1$	61.80 v-z	63.80 v-z	6.80 d-i	6.60 d-h	68.60 r-u	70.40 s-w	22.94 j-q	23.13 k-q
$N_3W_2I_1$	67.80 p-x	69.80 o-w	4.73 m-r	4.60 m-r	72.53 m-u	74.40 o-w	23.79 h-n	23.91 i-o
$N_3W_3I_1$	68.60 o-w	69.80 o-w	6.20 g-k	6.00 f-k	74.80 l-t	75.80 m-v	21.70 m-t	21.99 n-t
$N_0W_0I_2$	60.73 x-z	63.33 v-z	7.80 a-d	7.40 b-d	68.53 r-u	70.73 s-w	19.31 uv	19.72 u-w
$N_0W_1I_2$	66.87 r-z	68.47 r-y	6.80 d-i	6.40 d-i	73.67 l-u	74.87 o-w	21.76 m-s	21.99 n-t
$N_0W_2I_2$	71.40 l-s	73.80 l-s	6.60 e-j	6.20 e-j	78.00 i-p	80.00 i-q	22.19 l-r	22.52 m-s
$N_0W_3I_2$	71.40 l-s	73.00 l-t	7.53 b-f	7.40 b-d	78.93 g-o	80.40 g-p	23.00 i-q	23.13 k-q
$N_1W_0I_2$	73.27 k-r	74.00 l-s	6.00 h-l	5.80 g-l	79.27 g-n	79.80 i-q	25.34 d-j	25.73 c-i
$N_1W_1I_2$	74.73 i-q	77.00 h-p	4.80 m-q	4.60 m-r	79.53 g-m	81.60 g-o	27.62 a-d	27.89 a-c
$N_1W_2I_2$	88.07 a-c	89.13 a-d	5.07 k-p	4.80 l-q	93.13 ab	93.93 a-d	28.82 a	28.81 a
$N_1W_3I_2$	74.07 j-r	75.67 i-s	5.00 l-p	4.80 l-q	79.07 g-n	80.47 g-p	27.85 ab	28.03 ab
$N_2W_0I_2$	74.07 j-r	75.73 i-s	6.40 f-j	6.00 f-k	80.47 g-l	81.73 g-o	24.04 h-m	24.39 g-m
$N_2W_1I_2$	80.47 d-k	81.67 e-k	5.80 i-m	5.80 g-l	86.27 b-h	87.47 c-i	24.68 f-k	24.97 f-l
$N_2W_2I_2$	69.00 o-v	70.47 o-v	4.60 n-r	4.40 n-s	73.60 l-u	74.87 o-w	25.96 b-h	26.12 b-h
$N_2W_3I_2$	74.33 i-r	75.53 j-s	5.20 k-o	5.20 j-o	79.53 g-m	80.73 g-p	26.96 a-g	27.28 a-e
$N_3W_0I_2$	62.07 v-z	63.67 v-z	7.00 d-h	6.60 d-h	69.07 r-u	70.27 s-w	22.17 l-r	22.53 m-s
$N_3W_1I_2$	70.33 m-t	71.80 n-u	5.80 i-m	5.60 h-m	76.13 j-r	77.40 m-t	23.81 h-n	24.07 h-n
$N_3W_2I_2$	81.27 c-j	83.00 c-j	5.20 k-o	5.20 j-o	86.47 b-h	88.20 c-g	27.57 a-e	27.81 a-c
$N_3W_3I_2$	72.07 l-r	72.60 m-u	5.20 k-o	5.00 k-p	77.27 j-q	77.60 l-s	26.94 a-g	27.19 a-e
$N_0W_0I_3$	60.07 x-z	61.27 yz	8.60 ab	8.20 ab	68.67 r-u	69.47 u-w	19.43 s-v	19.78 u-w
$N_0W_1I_3$	61.20 w-z	62.53 w-z	7.60 b-e	7.20 c-e	68.80 r-u	69.73 t-w	19.13 uv	19.50 vw
$N_0W_2I_3$	70.27 m-t	72.07 m-u	7.00 d-h	6.80 d-g	77.27 j-q	78.87k-r	23.17 n-u	23.50 j-p

Cont'd

Treatments	Filled grains panicle^{-1} (No.)		Unfilled grains panicle^{-1} (No.)		Total grains panicle^{-1} (No.)		Weight of 1000-grains (g)	
	2014-2015	2015-2016	2014-2015	2015-2016	2014-2015	2015-2016	2014-2015	2015-2016
$N_0W_3I_3$	68.20 p-x	70.60 o-v	7.80 a-d	7.20 c-e	76.00 k-r	77.80 l-s	21.25 o-u	21.49 p-v
$N_1W_0I_3$	71.60 l-s	72.73 l-u	4.60 n-r	4.60 m-r	76.20 j-r	77.33 m-t	24.59 g-l	24.84 g-l
$N_1W_1I_3$	67.27 q-y	68.20 s-y	4.20 o-s	4.00 p-t	71.47 n-u	72.20 q-w	24.06 h-m	24.38 g-m
$N_1W_2I_3$	90.07 ab	92.07 ab	5.60 j-n	5.20 j-o	95.67 a	97.27 a	28.86 a	28.98 a
$N_1W_3I_3$	74.73 i-q	75.93 i-r	4.87 l-q	4.80 l-q	79.60 g-m	80.73 g-p	26.60 a-g	26.99 a-f
$N_2W_0I_3$	71.87 l-r	73.93 l-s	7.40 c-f	7.00 d-f	79.27 g-n	80.93 g-p	23.55 i-o	23.89 i-o
$N_2W_1I_3$	77.73 f-m	79.53 g-m	6.20 g-k	5.80 g-l	83.93 d-j	85.33 e-l	26.67 a-g	27.06 a-f
$N_2W_2I_3$	74.87 i-q	76.53 h-q	4.00 p-s	3.80 q-t	78.87 h-o	80.33 h-p	25.01 f-k	25.30 e-k
$N_2W_3I_3$	80.53 d-k	82.20 d-k	6.20 g-k	6.00 f-k	86.73 b-g	88.20 c-g	27.03 a-f	27.43 a-d
$N_3W_0I_3$	59.00 yz	61.53 yz	7.40 c-f	7.00 d-f	66.40 u	68.53 vw	19.20 uv	19.55 vw
$N_3W_1I_3$	70.33 m-t	72.20 m-u	7.20 c-g	7.20 c-e	77.53 j-q	79.40 j-q	21.47 n-u	21.83 o-u
$N_3W_2I_3$	71.93 l-r	72.87 l-t	5.20 k-o	5.00 k-p	77.13 j-q	77.87 l-s	25.22 e-j	25.48 d-j
$N_3W_3I_3$	74.20 j-r	76.60 h-q	7.20 c-g	6.80 d-g	81.40 f-l	83.40 f-m	23.26 i-p	23.41 j-p
$N_0W_0I_4$	64.33 s-z	65.53 t-z	6.40 f-j	5.80 g-l	70.73 p-u	71.33 r-w	19.46 s-v	19.74 u-w
$N_0W_1I_4$	67.80 p-x	69.40 p-x	6.40 f-j	6.00 f-k	74.20 l-u	75.40 n-w	21.01 p-v	21.22 q-v
$N_0W_2I_4$	78.87 e-l	80.33 f-l	6.53 e-j	6.27 e-j	85.40 c-i	86.60 d-k	26.92 a-g	27.18 a-e
$N_0W_3I_4$	67.80 p-x	69.13 q-x	6.20 g-k	6.00 f-k	74.00 l-u	75.13 o-w	23.86 h-n	24.12 h-n
$N_1W_0I_4$	64.20 s-z	65.67 t-z	3.80 q-s	3.80 q-t	68.00 s-u	69.47 u-w	23.29 i-p	23.52 j-p
$N_1W_1I_4$	82.60 c-h	83.80 c-h	3.60 rs	3.40 st	86.20 b-h	87.20 d-j	27.42 a-e	27.66 a-c
$N_1W_2I_4$	91.60 a	93.33 a	3.40 s	3.20 t	95.00 a	96.53 ab	28.93 a	29.15 a
$N_1W_3I_4$	84.73 a-f	86.07 b-g	3.60 rs	3.60 r-t	88.33 a-f	89.67 b-f	28.53 a	28.84 a
$N_2W_0I_4$	74.33 i-r	75.93 i-r	4.40 o-s	4.00 p-t	78.73 h-o	79.93 i-q	22.98 j-q	23.28 k-q
$N_2W_1I_4$	81.40 c-j	83.67 c-h	4.80 m-q	4.40 n-s	86.20 b-h	88.07 c-h	27.42 a-e	27.73 a-c
$N_2W_2I_4$	81.67 c-i	83.13 c-i	4.60 n-r	4.20 o-t	86.27 b-h	87.33 d-i	28.55 a	28.82 a
$N_2W_3I_4$	77.07 g-n	78.87 g-n	4.20 o-s	4.20 o-t	81.27 f-l	83.07 f-n	27.52 a-e	27.77 a-c
$N_3W_0I_4$	74.93 i-p	76.73 h-q	5.60 j-n	5.40 i-n	80.53 g-l	82.13 f-o	26.07 b-h	26.30 b-g
$N_3W_1I_4$	85.00 a-f	87.07 a-f	5.60 j-n	5.20 j-o	90.60 a-d	92.27 a-e	27.78 a-c	28.03 ab
$N_3W_2I_4$	86.73 a-d	89.73 a-c	5.20 k-o	5.20 j-o	91.93 a-c	94.93 a-c	28.71 a	28.98 a
$N_3W_3I_4$	83.67 b-g	85.53 b-g	6.40 f-j	6.00 f-k	90.07 a-e	91.53 a-e	28.79 a	28.98 a
SE value	2.176	2.194	0.343	0.320	2.247	2.259	0.701	0.635
Level of significance	*	*	*	*	*	*	*	*
CV (%)	5.22	5.14	9.89	9.67	4.98	4.91	5.03	4.50

*: Significant at 0.05 level of probability

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

N_0: No urea (control), N_1: Urea super granules (77 kg N ha^{-1}), N_2: Prilled urea at recommended dose (150 kg N ha^{-1}) as 325 kg urea ha^{-1} and N_3= ½ of the recommended dose (75 kg N ha^{-1}) as163 kg urea ha^{-1}

W_0: No weeding (control), W_1: Two hand weeding (20 DAT and 40 DAT), W_2: Pre emergence herbicide (Butachor) and W_3: Post emergence herbicide (Prityloclor)

I_1: Irrigating all time, I_2: Irrigating 3 days after drying, I_3: Irrigating 5 days after drying and I_4: Alternate wetting and drying (AWD) method

4.12.3 Effect of irrigation management

Number of unfilled grains panicle^{-1} of BRRI dhan29 showed statistically significant differences due to different irrigation management (Table 4.7.1). Number of unfilled grains panicle^{-1} was significantly higher compared to control condition for the two subsequent years. The lowest number of unfilled grains panicle^{-1} in each year (5.05 and 4.79) was found from I_4 which was closely followed (5.92 and 5.70) by I_2, whereas the highest number (6.70 and 6.41) were recorded from I_1 which was followed (6.32 and 6.04) by I_3.

4.12.4 Combined effect of nitrogen and weed management

Number of unfilled grains panicle^{-1} of BRRI dhan29 varied significantly for the combined effect of different nitrogen and weed management for the two subsequent years (Table 4.7.2). The lowest number of unfilled grains panicle^{-1} (4.92 and 4.65) was recorded from N_1W_2, whereas the highest number (7.90 and 7.42) from N_0W_0. Seema *et al.* (2014) reported that 100 kg N ha^{-1} is sufficient for aerobic rice in which weeds can be managed by integration of chemical and cultural practices that produced minimum number of unfilled grains.

4.12.5 Combined effect of nitrogen and irrigation management

Combined effect of different nitrogen and irrigation management varied significantly in terms of number of unfilled grains panicle^{-1} of BRRI dhan29 for the two subsequent years (Table 4.7.3). The lowest number of unfilled grains panicle^{-1} (3.60 3.50) were recorded from N_1I_4, whereas the highest number (7.95 and 7.63) from N_0I_1.

4.12.6 Combined effect of weed and irrigation management

Unfilled grains panicle^{-1} varied due to combined of different irrigation and weed management to effect of BRRI dhan29 for the two subsequent years (Table 4.7.4). The lowest number of unfilled grains panicle^{-1} (4.93 and 4.72) was recorded from W_2 I_4, whereas the highest number (7.92 and 7.47) from W_0I_1.

4.12.7 Combined effect of nitrogen, weed and irrigation management

Statistically significant variation was recorded due to the combined effect of different nitrogen, weed and irrigation management in terms of number of unfilled grains panicle^{-1} of BRRI dhan29 for the two subsequent years (Table 4.7.5). The lowest number of unfilled grains panicle^{-1} (3.40 and 3.20) was recorded from $N_1W_2 I_4$, while the highest number (7.00 and 6.80) from $N_0W_0 I_1$.

4.13 Total grains panicle^{-1}

Number of total grains panicle^{-1} of BRRI dhan29 varied significantly due to different nitrogen, weed and irrigation management and also their combined effect (Appendix X). In general irrespective of treatments and their combined effects, the highest number of total grains panicle^{-1} was produced in the 2nd year of the experimental period compared to 1st year (Table 4.7.1 to 4.7.5).

4.13.1 Effect of nitrogen management

Statistically significant variation was observed in terms of number of total grains panicle^{-1} of BRRI dhan29 for different nitrogen management for the two subsequent years (Table 4.7.1). The higher number of total grains panicle^{-1} (81.49 and 82.77) was recorded from N_1 which was statistically identical (80.16 at the year 2014-15) and statistically similar (81.46 at the year 2015-16) to N_2, while the lowest number (73.21 and 74.67) was found from N_0. Kumar *et al.* (2015) reported that 150 kg ha^{-1} N application produced highest values of number of grains panicle^{-1} (1340).

4.13.2 Effect of weed management

Number of total grains panicle^{-1}of BRRI dhan29 showed statistically significant differences for different weed management for the two subsequent years (Table 4.7.1). The highest number of total grains panicle^{-1} (82.72 and 84.23) was recorded from W_2, which was closely followed (79.33 and 80.81) by W_3 and (78.34 and 79.75) by W_1 and they was statistically similar, while the lowest number (72.55 and 73.78) was found from W_0.

4.13.3 Effect of irrigation management

Number of total grains panicle^{-1} of BRRI dhan29 showed statistically significant differences due to different irrigation management (Table 4.7.1). Number of filled grains panicle^{-1} was significantly higher compared to control condition for the two subsequent years. The highest number of total grains panicle^{-1} of both years (82.97 and 84.41) was found from I_4 which was closely followed (80.00 and 79.34) by I_2 and (79.21 and 78.51) by I_3 and they were statistically similar, while the lowest number (74.94 and 74.21) were recorded from I_1.

4.13.4 Combined effect of nitrogen and weed management

Number of total grains panicle^{-1} of BRRI dhan29 varied significantly for the combined effect of different nitrogen and weed management for the two subsequent years (Table 4.7.2). The highest number of total grains panicle^{-1} (93.87 and 95.27) was recorded from N_1W_2, whereas the lowest number (68.75 and 69.82) from N_0W_0. Das *et al.* (2007) reported higher number of total grains panicle^{-1} of BRRI dhan29 under drum seeded condition and better weed control achieved by the application of 120 kg N ha^{-1} and Rifit 500 EC @ 1L ha^{-1}.

4.13.5 Combined effect of nitrogen and irrigation management

Number of total grains panicle^{-1} of BRRI dhan29 varied significantly for the combined effect of different nitrogen and irrigation management for the two subsequent years (Table 4.7.3). The highest number of total grains panicle^{-1} (88.28 and 90.22) was recorded from N_1I_4, whereas the lowest number (69.30 and 71.10) from N_0I_1.

4.13.6 Combined effect of weed and irrigation management

Number of total grains panicle^{-1} of BRRI dhan29 varied significantly for the combined effect of different irrigation and weed management for the two subsequent years (Table 4.7.4). The highest number of total grains panicle^{-1} (89.65 and 91.35) was recorded from W_2I_4, whereas the lowest number (68.73 and 69.72) from W_0I_1.

4.13.7 Combined effect of nitrogen, weed and irrigation management

Statistically significant variation was recorded due to the combined effect of different nitrogen, weed and irrigation management in terms of number of total grains panicle^{-1} of BRRI dhan29 for the two subsequent years (Table 4.7.5). The highest number of total grains panicle^{-1} (95.00) was statistically identical at the year 2014-2015 and (96.53) was statistically similar at the year 2015-2016 recorded from N_1W_2 I_4, while the lowest number (67.07 and 67.73) from N_0W_0 I_1. Latheef *et al.* (2013) reported that yield attributes varied between irrigation scheduled at 7 days interval during vegetative stage and 4 days interval during reproductive stage and irrigation once in 2 days.

4.14 Weight of 1000-grains

Weight of 1000-grains of BRRI dhan29 showed statistically significant differences due to different nitrogen, weed and irrigation management and also their combined effect (Appendix X). In general irrespective of treatments and their combined effects, the highest weight of 1000-grains was produced in the 2nd year of the experimental period compared to 1st year (Table 4.7.1 to 4.7.5).

4.14.1 Effect of nitrogen management

Statistically significant variation was observed in terms of weight of 1000-grains of BRRI dhan29 for different nitrogen management for the two subsequent years (Table 4.7.1). The maximum weight of 1000-grains in both years (26.18 and 26.41 g) were recorded from N_1 which was closely followed (25.02 25.31 g) to N_2, while the minimum weight (21.13 and 21.40 g) was found from N_0 which was followed (24.35 and 24.61 g) by N_3. Kumar *et al.* (2015) reported that 150 kg ha^{-1} N application produced highest values of 1000-grain weight (26.08 g).

4.14.2 Effect of weed management

Weight of 1000-grains of BRRI dhan29 showed statistically significant differences for different weed management for the two subsequent years (Table 4.7.1). The maximum weight of 1000-grains in both years (25.91 and 26.14 g) was recorded from W_2, which was closely followed (25.14 and 25.38 g) by W_3, while the minimum weight (21.80 and 22.11 g) was found from W_0 which was followed (23.84 and 24.10 g) by W_1.

4.14.3 Effect of irrigation management

Weight of 1000-grains of BRRI dhan29 showed statistically significant differences due to different irrigation management (Table 4.7.1). Weight of 1000-grains was significantly higher compared to control condition for the two subsequent years. The maximum weight of 1000-grains in both years (26.08 and 26.33 g) was found from I_4 which was closely followed (24.88 and 25.14 g) by I_2, while the minimum weight (22.08 and 22.30 g) was recorded from I_1 which was followed (23.66 and 23.96 g) by I_3. Khairi *et al.* (2015a) reported that AWD treatment affected weight of 1000-grains.

4.14.4 Combined effect of nitrogen and weed management

Weight of 1000-grains of BRRI dhan29 varied significantly for the combined effect of different nitrogen and weed management for the two subsequent years (Table 4.7.2). The maximum weight of 1000-grains in both years (28.86 and 28.98 g) was recorded from N_1W_2, whereas the minimum weight (19.25 and 19.54 g) from N_0W_0.

4.14.5 Combined effect of nitrogen and irrigation management

Combined effect of different irrigation and nitrogen management varied significantly in terms of weight of 1000-grains of BRRI dhan29 for the two subsequent years (Table 4.7.3). The maximum weight of 1000-grains in both years (27.84 and 28.07 g) was recorded from N_1I_4, whereas the minimum weight (19.41 and 19.63 g) from N_0I_1.

4.14.6 Combined effect of weed and irrigation management

Different weed and irrigation management varied significantly due to combined effect in terms of weight of 1000-grains of BRRI dhan29 for the two subsequent years (Table 4.7.4). The maximum weight of 1000-grains in both years (28.28 and 28.53 g) was recorded from W_2I_4, whereas the minimum weight (19.85 and 20.14 g) from W_0I_1.

4.14.7 Combined effect of nitrogen, weed management and irrigation,

Statistically significant variation was recorded due to the combined effect of different nitrogen, weed and irrigation management and in terms of weight of

1000-grains of BRRI dhan29 for the two subsequent years (Table 4.7.5). The maximum weight of 1000-grains (28.93 and 29.15g) was recorded from $N_1W_2I_4$, while the minimum weight (18.78 and 18.93 g) from N_0W_0 I_1. Latheef *et al.* (2013) reported that weight of 1000-grains was not much varied between irrigation scheduled at 7 days interval during vegetative stage and 4 days interval during reproductive stage and irrigation once in 2 days.

4.15 Grain yield

Grain yield of BRRI dhan29 showed statistically significant differences due to different nitrogen, weed and irrigation management and also their combined effect (Appendix XI). In general irrespective of treatments and their combined effects, the highest grain yield was recorded in the 2nd year of the experimental period compared to 1st year (Table 4.8.1 to 4.8.5).

4.15.1 Effect of nitrogen management

Statistically significant variation was observed in terms of grain yield of BRRI dhan29 for different nitrogen management for the two subsequent years and also pooled of these years (Table 4.8.1). At pooled, the highest grain yield (6.01 t ha^{-1}) was recorded from N_1 which was closely followed (5.58 t ha^{-1}) to N_2, while the lowest (4.35 t ha^{-1}) was found from N_0 which was followed (5.37 t ha^{-1}) by N_3. Kumar *et al.* (2015) reported that grain yield increased upto 150% recommended dose of N ha^{-1}.

4.15.2 Effect of weed management

Grain yield of BRRI dhan29 showed statistically significant differences for different weed management for the two subsequent years and also pooled of these years (Table 4.8.1). At pooled, the highest grain yield (5.92 t ha^{-1}) was recorded from W_2, which was closely followed (5.65 t ha^{-1}) by W_3, while the lowest (4.49 t ha^{-1}) was found from W_0 which was followed (5.26 t ha^{-1}) by W_1.

Table 4.8.1 Effect of different levels of nitrogen, weed and irrigation management on grain, straw, biological yield and harvest index of BRRI dhan29.

Treatments	Grain yield (t ha^{-1})			Straw yield (t ha^{-1})		Biological yield (t ha^{-1})		Harvest index (%)	
	2014-2015	2015-2016	Pooled	2014-2015	2015-2016	2014-2015	2015-2016	2014-2015	2015-2016
Nitrogen management									
N_0	4.31 d	4.40 d	4.35 d	5.99 c	6.09 c	10.31 d	10.49 d	41.82 c	41.90 c
N_1	5.97 a	6.06 a	6.01 a	7.08 a	7.16 a	13.04 a	13.22 a	45.61 a	45.70 a
N_2	5.53 b	5.63 b	5.58 b	6.88 b	6.98 b	12.42 b	12.61 b	44.41 b	44.49 b
N_3	5.31 c	5.44 c	5.37 c	6.75 b	6.83 b	12.06 c	12.26 c	43.81 b	44.13 b
SE value	0.033	0.037	0.034	0.047	0.052	0.060	0.067	0.212	0.231
Level of significance	*	*	*	*	*	*	*	*	*
CV (%)	3.34	4.20	3.61	6.23	7.10	3.89	4.11	4.07	4.94
Weed management									
W_0	4.44 d	4.54 d	4.49 d	6.24 c	6.33 c	10.68 d	10.87 d	41.48 c	41.70 c
W_1	5.22 c	5.31 c	5.26 c	6.57 b	6.66 b	11.79 c	11.97 c	44.10 b	44.17 b
W_2	5.87 a	5.97 a	5.92 a	7.03 a	7.10 a	12.90 a	13.07 a	45.39 a	45.55 a
W_3	5.59 b	5.70 b	5.65 b	6.87 a	6.97 a	12.46 b	12.67 b	44.68 ab	44.79 ab
SE value	0.039	0.043	0.040	0.062	0.060	0.078	0.076	0.274	0.283
Level of significance	*	*	*	*	*	*	*	*	*
CV (%)	4.32	4.70	4.44	4.88	5.37	3.50	3.84	3.35	3.63
Irrigation management									
I_1	4.65 d	4.74 d	4.70 d	6.17 d	6.27 d	10.82 d	11.01 d	42.79 c	42.86 b
I_2	5.48 b	5.61 b	5.54 b	6.84 b	6.93 b	12.32 b	12.53 b	44.28 ab	44.55 a
I_3	5.15 c	5.25 c	5.20 c	6.57 c	6.65 c	11.72 c	11.90 c	43.73 b	43.95 ab
I_4	5.84 a	5.92 a	5.88 a	7.13 a	7.22 a	12.97 a	13.14 a	44.84 a	44.86 a
SE value	0.025	0.033	0.028	0.060	0.069	0.067	0.072	0.258	0.314
Level of significance	*	*	*	*	*	*	*	*	*
CV (%)	5.07	5.55	5.20	6.44	6.11	4.51	4.34	4.32	4.46

*: Significant at 0.05 level of probability

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

N_0: No urea (control), N_1: Urea super granules (77 kg N ha^{-1}), N_2: Prilled urea at recommended dose (150 kg N ha^{-1}) as 325 kg urea ha^{-1} and N_3= ½ of the recommended dose (75 kg N ha^{-1}) as163 kg urea ha^{-1}

W_0: No weeding (control), W_1: Two hand weeding (20 DAT and 40 DAT), W_2: Pre emergence herbicide (Butachor) and W_3: Post emergence herbicide (Prityloclor)

I_1: Irrigating all time, I_2: Irrigating 3 days after drying, I_3: Irrigating 5 days after drying and I_4: Alternate wetting and drying (AWD) method

4.15.3 Effect of irrigation management

Grain yield of BRRI dhan29 showed statistically significant differences due to different irrigation management (Table 4.8.1). Grain yield was significantly higher in irrigated treatments compared to control condition for the two subsequent years and also pooled of these years. At pooled, the highest grain yield (5.88 t ha^{-1}) was found from I_4 which was closely followed (5.54 t ha^{-1}) by I_2, while the lowest (4.70 t ha^{-1}) was recorded from I_1 which was followed (5.20 t ha^{-1}) by I_3. Karim *et al.* (2014) reported that grain yield was 7.62% higher in sprinkler and 4.72% higher in AWD irrigation method over flood irrigation method.

4.15.4 Combined effect of nitrogen and weed management

Grain yield of BRRI dhan29 varied significantly for the combined effect of different nitrogen and weed management for the two subsequent years and also pooled of these years (Table 4.8.2). At pooled, the highest grain yield (6.80 t ha^{-1}) was recorded from N_1W_2, whereas the lowest (3.85 t ha^{-1}) was found from N_0W_0.

4.15.5 Combined effect of nitrogen and irrigation management

The grain yield of two consequtive years varied significantly by combined application different nitrogen and irrigation management of BRRI dhan29 and also pooled of these years (Table 4.8.3). At pooled, the highest grain yield (6.36 t ha^{-1}) was recorded from N_1I_4, whereas the lowest (3.80 t ha^{-1}) was observed from N_0I_1.

4.15.6 Combined effect of weed and irrigation management

The grain yield of two consequtive years varied significantly by combined application different irrigation and weed management of BRRI dhan29 and also pooled of these years (Table 4.8.4).At pooled, the highest grain yield (6.52 t ha^{-1}) was recorded from W_2I_4, whereas the lowest (3.85 t ha^{-1}) was observed from W_0I_1.

Table 4.8.2 Combined effect of different levels of nitrogen and weed management on grain, straw, biological yield and harvest index of BRRI dhan29.

Treatments	Grain yield (t ha^{-1})			Straw yield (t ha^{-1})		Biological yield (t ha^{-1})		Harvest index (%)	
	2014-2015	2015-2016	Pooled	2014-2015	2015-2016	2014-2015	2015-2016	2014-2015	2015-2016
N_0W_0	3.81 j	3.89 j	3.85 j	5.25 i	5.34 h	9.06 j	9.23 j	41.90 ef	42.06 f
N_0W_1	4.10 i	4.18 i	4.14 i	5.84 h	5.93 g	9.94 i	10.11 i	41.37 ef	41.42 f
N_0W_2	4.81 fg	4.89 fg	4.85 fg	6.52 fg	6.63 ef	11.32 fg	11.52 fg	42.52 de	42.50 ef
N_0W_3	4.53 h	4.62 h	4.57 h	6.37 g	6.47 f	10.90 gh	11.09 gh	41.50 ef	41.64 f
N_1W_0	4.86 f	4.96 f	4.91 f	6.66 e-g	6.74 d-f	11.52 ef	11.70 ef	42.22 d-f	42.38 ef
N_1W_1	5.96 c	6.05 c	6.00 c	6.73 c-g	6.80 c-f	12.68 cd	12.85 cd	46.96 a	47.08 a
N_1W_2	6.75 a	6.85 a	6.80 a	7.77 a	7.84 a	14.52 a	14.69 a	46.52 a	46.63 ab
N_1W_3	6.29 b	6.38 b	6.34 b	7.16 b	7.26 b	13.46 b	13.64 b	46.73 a	46.72 ab
N_2W_0	4.59 gh	4.70 gh	4.64 gh	6.72 c-g	6.80 c-f	11.31 fg	11.50 f-h	40.61 f	40.83 f
N_2W_1	5.59 d	5.68 d	5.64 d	7.03 b-e	7.13 b-d	12.62 cd	12.81 cd	44.23 bc	44.27 cd
N_2W_2	5.94 c	6.05 c	6.00 c	6.73 c-g	6.81 c-f	12.68 cd	12.87 cd	46.89 a	47.04 a
N_2W_3	6.00 c	6.08 c	6.04 c	7.06 b-d	7.18 bc	13.07 bc	13.25 bc	45.89 ab	45.81 a-c
N_3W_0	4.48 h	4.61 h	4.54 h	6.36 g	6.45 f	10.84 h	11.06 h	41.19 ef	41.54 f
N_3W_1	5.22 e	5.32 e	5.27 e	6.68 d-g	6.78 d-f	11.90 e	12.09 e	43.81 cd	43.92 de
N_3W_2	5.97 c	6.08 c	6.03 c	7.11 bc	7.12 b-d	13.08 bc	13.20 bc	45.63 ab	46.04 ab
N_3W_3	5.55 d	5.74 d	5.64 d	6.87 b-f	6.97 b-e	12.42 d	12.71 d	44.59 bc	45.01 b-d
SE value	0.078	0.086	0.080	0.124	0.119	0.156	0.152	0.547	0.567
Level of significance	*	*	*	*	*	*	*	*	*
CV (%)	4.32	4.70	4.44	4.88	5.37	3.50	3.84	3.35	3.63

*: Significant at 0.05 level of probability

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

N_0: No urea (control), N_1: Urea super granules (77 kg N ha^{-1}), N_2: Prilled urea at recommended dose (150 kg N ha^{-1}) as 325 kg urea ha^{-1} and N_3= ½ of the recommended dose (75 kg N ha^{-1}) as163 kg urea ha^{-1}

W_0: No weeding (control), W_1: Two hand weeding (20 DAT and 40 DAT), W_2: Pre emergence herbicide (Butachor) and W_3: Post emergence herbicide (Prityloclor)

Table 4.8.3 Combined effect of different levels of nitrogen and irrigation management on grain, straw, biological yield and harvest index of BRRI dhan29.

Treatments	Grain yield (t ha^{-1})			Straw yield (t ha^{-1})		Biological yield (t ha^{-1})		Harvest index (%)	
	2014-2015	2015-2016	Pooled	2014-2015	2015-2016	2014-2015	2015-2016	2014-2015	2015-2016
N_0I_1	3.77 h	3.83 i	3.80 i	5.36 i	5.46 i	9.13 j	9.29 j	41.18 d	41.15 f
N_1I_1	5.43 d	5.53 e	5.48 e	6.60 ef	6.68 ef	12.04 f	12.21 f	44.97 b	45.09 a-c
N_2I_1	4.80 e	4.90 f	4.85 f	6.35 fg	6.46 fg	11.15 g	11.36 g	42.97 c	43.06 de
N_3I_1	4.62 ef	4.72 fg	4.67 fg	6.36 fg	6.46 fg	10.98 gh	11.18 gh	42.01 cd	42.15 ef
N_0I_2	4.51 f	4.61 g	4.56 g	6.18 gh	6.26 gh	10.69 h	10.87 h	42.22 cd	42.40 d-f
N_1I_2	6.14 ab	6.26 a-c	6.20 a-c	7.46 ab	7.52 ab	13.60 a	13.78 ab	45.06 b	45.29 a-c
N_2I_2	5.65 c	5.76 d	5.70 d	6.95 cd	7.04 cd	12.61 e	12.79 de	44.74 b	44.89 bc
N_3I_2	5.61 cd	5.81 d	5.71 d	6.78 de	6.88 de	12.39 ef	12.68 e	45.11 b	45.63 ab
N_0I_3	4.15 g	4.26 h	4.21 h	5.99 h	6.09 h	10.14 i	10.35 i	41.07 d	41.25 f
N_1I_3	5.96 b	6.06 c	6.01 c	7.02 cd	7.12 cd	12.98 cd	13.18 cd	45.88 ab	45.95 ab
N_2I_3	5.68 c	5.77 d	5.72 d	7.01 cd	7.11 cd	12.69 de	12.88 de	44.73 b	44.77 bc
N_3I_3	4.80 e	4.91 f	4.86 f	6.25 gh	6.27 gh	11.05 gh	11.18 gh	43.25 c	43.82 cd
N_0I_4	4.82 e	4.89 f	4.86 f	6.44 fg	6.55 fg	11.26 g	11.44 g	42.82 c	42.82 de
N_1I_4	6.33 a	6.40 a	6.36 a	7.23 bc	7.32 bc	13.56 ab	13.72 ab	46.52 a	46.47 a
N_2I_4	6.00 b	6.09 bc	6.04 bc	7.22 bc	7.31 bc	13.22 bc	13.40 bc	45.18 b	45.24 a-c
N_3I_4	6.20 a	6.30 ab	6.25 ab	7.62 a	7.72 a	13.82 a	14.01 a	44.85 b	44.91 bc
SE value	0.066	0.073	0.068	0.094	0.105	0.121	0.135	0.425	0.461
Level of significance	*	*	*	*	*	*	*	*	*
CV (%)	5.07	5.55	5.20	6.44	6.11	4.51	4.34	4.32	4.46

*: Significant at 0.05 level of Probability

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

N_0: No urea (control), N_1: Urea super granules (77 kg N ha^{-1}), N_2: Prilled urea at recommended dose (150 kg N ha^{-1}) as 325 kg urea ha^{-1} and N_3= ½ of the recommended dose (75 kg N ha^{-1}) as163 kg urea ha^{-1}

I_1: Irrigating all time, I_2: Irrigating 3 days after drying, I_3: Irrigating 5 days after drying and I_4: Alternate wetting and drying (AWD) method

Table 4.8.4 Combined effect of weed and irrigation management on grain, straw, biological yield and harvest index of BRRI dhan29.

Treatments	Grain yield (t ha^{-1})			Straw yield (t ha^{-1})		Biological yield (t ha^{-1})		Harvest index (%)	
	2014-2015	2015-2016	Pooled	2014-2015	2015-2016	2014-2015	2015-2016	2014-2015	2015-2016
W_0I_1	3.81 i	3.89 j	3.85 i	5.74 h	5.83 h	9.54 h	9.73 h	39.86 h	39.96 h
W_1I_1	4.65 gh	4.73 hi	4.69 gh	6.17 g	6.25 fg	10.82 fg	10.98 g	42.91 e-g	43.02 e-g
W_2I_1	5.28 de	5.39 ef	5.34 de	6.41 fg	6.50 e-g	11.69 e	11.89 ef	45.09 a-c	45.23 a-c
W_3I_1	4.88 fg	4.96 gh	4.92 fg	6.36 fg	6.48 e-g	11.24 ef	11.44 f	43.29 d-g	43.24 d-g
W_0I_2	4.68 gh	4.80 hi	4.74 gh	6.57 d-f	6.65 de	11.26 ef	11.45 f	41.73 g	42.00 g
W_1I_2	5.34 d	5.44 e	5.39 d	6.80 c-e	6.87 cd	12.14 d	12.31 de	43.79 c-f	44.00 b-f
W_2I_2	6.02 b	6.13 bc	6.08 b	6.94 b-d	7.04 bc	12.96 c	13.17 c	46.38 a	46.48 a
W_3I_2	5.86 bc	6.05 c	5.96 bc	7.07 bc	7.14 bc	12.93 c	13.20 c	45.22 a-c	45.73 ab
W_0I_3	4.46 h	4.59 i	4.52 h	6.15 g	6.22 g	10.60 g	10.81 g	41.91 g	42.32 fg
W_1I_3	5.08 ef	5.17 fg	5.13 ef	6.24 fg	6.35 e-g	11.32 e	11.52 f	44.78 a-d	44.80 a-e
W_2I_3	5.70 c	5.79 d	5.74 c	7.08 bc	7.09 bc	12.78 c	12.88 c	44.42 b-e	44.81 a-e
W_3I_3	5.35 d	5.45 e	5.40 d	6.81 c-e	6.93 cd	12.16 d	12.38 d	43.82 c-f	43.85 c-f
W_0I_4	4.79 g	4.88 h	4.84 g	6.53 e-g	6.62 d-f	11.32 e	11.51 f	42.42 fg	42.53 fg
W_1I_4	5.80 bc	5.88 cd	5.84 bc	7.06 bc	7.16 bc	12.87 c	13.05 c	44.90 a-d	44.86 a-d
W_2I_4	6.47 a	6.56 a	6.52 a	7.69 a	7.79 a	14.16 a	14.35 a	45.67 ab	45.69 ab
W_3I_4	6.28 a	6.35 ab	6.31 a	7.23 b	7.32 b	13.51 b	13.67 b	46.38 a	46.36 a
SE value	0.078	0.086	0.080	0.124	0.119	0.156	0.152	0.547	0.567
Level of significance	*	*	*	*	*	*	*	*	*
CV (%)	5.07	5.55	5.20	6.44	6.11	4.51	4.34	4.32	4.46

*: Significant at 0.05 level of Probability

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

W_0: No weeding (control), W_1: Two hand weeding (20 DAT and 40 DAT), W_2: Pre emergence herbicide (Butachor) and W_3: Post emergence herbicide (Prityloclor)

I_1: Irrigating all time, I_2: Irrigating 3 days after drying, I_3: Irrigating 5 days after drying and I_4: Alternate wetting and drying (AWD) method

4.15.7 Combined effect of nitrogen, weed and irrigation management

Statistically significant variation was recorded due to the combined effect of different nitrogen, weed and irrigation management in terms of grain yield of BRRI dhan29 for the two subsequent years and also pooled of these years (Table 4.8.5). At pooled, the highest grain yield (6.99 t ha^{-1}) was recorded from $N_1W_2I_4$, while the lowest yield (3.18 t ha^{-1}) was observed from $N_0W_0I_1$. Latheef *et al.* (2013) reported that grain yield was not much varied between irrigation scheduled at 7 days interval during vegetative stage and 4 days interval during reproductive stage and irrigation once in 2 days.

4.16 Straw yield

Straw yield of BRRI dhan29 showed statistically significant differences due to different nitrogen, weed and irrigation management and also their combined effect (Appendix XI). In general irrespective of treatments and their combined effects, the highest straw yield was recorded in the 2nd year of the experimental period compared to 1st year (Table 4.8.1 to 4.8.5).

4.16.1 Effect of nitrogen management

Statistically significant variation was observed in terms of straw yield of BRRI dhan29 for different nitrogen management for the two subsequent years (Table 4.8.1). The highest straw yield (7.08 and 7.16 t ha^{-1}) was recorded from N_1, while the lowest (5.99 and6.09 t ha^{-1}) was found from N_0 which was followed (6.88 and 6.98t ha^{-1}) by N_2.

4.16.2 Effect of weed management

Straw yield of BRRI dhan29 showed statistically significant differences for different weed management for the two subsequent years (Table 4.8.1). The highest straw yield (7.03 and 7.10 t ha^{-1}) was recorded from W_2, which was statisticaaly identical (6.87 and 6.97 t ha^{-1}) by W_3, while the lowest straw yield (6.24 and 6.33 t ha^{-1}) was recorded from W_0 which was followed (6.57 and 6.66 t ha^{-1}) by W_1.

Table 4.8.5 Combined effect of different levels of nitrogen, weed and irrigation management on grain, straw, biological yield and harvest index of BRRI dhan29.

Treatments	Grain yield (t ha^{-1})			Straw yield (t ha^{-1})		Biological yield (t ha^{-1})		Harvest index (%)	
	2014-2015	2015-2016	Pooled	2014-2015	2015-2016	2014-2015	2015-2016	2014-2015	2015-2016
$N_0W_0I_1$	3.15 z	3.21 x	3.18 y	5.01 z	5.10 x	8.16 z	8.31 z	38.58 w	38.58 v
$N_0W_1I_1$	3.76 y	3.82 w	3.79 x	5.30 w-z	5.39 wx	9.06 yz	9.21 yz	41.52 m-w	41.48 m-v
$N_0W_2I_1$	4.10 w-y	4.18 t-w	4.14 u-x	5.33 v-z	5.46 v-x	9.44 yz	9.64 yz	43.51 e-r	43.35 e-s
$N_0W_3I_1$	4.05 w-y	4.12 u-w	4.09 v-x	5.80 q-z	5.89 s-x	9.85 x-z	10.02 x-z	41.13 n-w	41.18 n-v
$N_1W_0I_1$	4.10 w-y	4.18 t-w	4.14 u-x	5.66 s-z	5.77 t-x	9.76 yz	9.95 x-z	42.08 k-w	42.07 k-v
$N_1W_1I_1$	5.35 i-n	5.46 j-n	5.40 i-n	6.10 n-x	6.13 p-w	11.45 o-v	11.59 p-v	46.75 a-h	47.11 a-f
$N_1W_2I_1$	6.60 a-d	6.73 a-d	6.66 a-d	7.70 a-d	7.78 a-c	14.30 a-c	14.51 a-c	46.15 a-j	46.36 a-j
$N_1W_3I_1$	5.68 g-k	5.74 h-l	5.71 g-k	6.95 b-n	7.06 c-o	12.63 f-m	12.80 g-n	44.92 a-n	44.83 a-n
$N_2W_0I_1$	4.08 w-y	4.19 t-w	4.14 u-x	6.16 m-v	6.26 o-v	10.24 w-z	10.45 w-z	39.85 r-w	40.08 r-v
$N_2W_1I_1$	4.72 p-u	4.81 o-s	4.76 p-t	6.65 g-q	6.77 h-r	11.37 o-v	11.57 p-v	41.59 m-w	41.58 m-v
$N_2W_2I_1$	5.22 j-p	5.33 j-o	5.28 j-p	6.03 o-y	6.09 q-w	11.25 p-w	11.42 q-w	46.37 a-j	46.69 a-i
$N_2W_3I_1$	5.17 k-p	5.26 k-p	5.21 k-p	6.57 h-r	6.73 i-r	11.74 m-s	11.99 n-s	44.08 d-p	43.91 c-r
$N_3W_0I_1$	3.90 xy	3.99 vw	3.94 wx	6.12 n-w	6.21 p-v	10.01 x-z	10.20 x-z	38.91 vw	39.12 uv
$N_3W_1I_1$	4.75 p-t	4.84 o-s	4.80 p-t	6.62 g-q	6.72 j-r	11.37 o-v	11.56 p-v	41.80 l-w	41.92 l-v
$N_3W_2I_1$	5.22 j-p	5.34 j-o	5.28 j-p	6.57 h-r	6.65 k-s	11.79 m-s	11.98 n-s	44.31 c-o	44.51 a-o
$N_3W_3I_1$	4.61 q-v	4.71 p-t	4.66 q-u	6.13 n-w	6.25 o-v	10.74 s-z	10.97 s-x	43.02 g-t	43.04 g-u
$N_0W_0I_2$	4.10 w-y	4.20 t-w	4.15 u-x	5.46 t-z	5.54 u-x	9.56 yz	9.74 yz	42.89 h-u	43.12 f-t
$N_0W_1I_2$	4.35 s-x	4.44 r-v	4.39 s-w	6.45 j-s	6.52 l-t	10.80 r-y	10.96 s-x	40.24 q-w	40.46 p-v
$N_0W_2I_2$	4.86 n-s	4.94 n-r	4.90 n-s	6.15 m-v	6.26 o-v	11.01 q-x	11.20 r-w	44.20 c-p	44.10 c-q
$N_0W_3I_2$	4.72 p-u	4.85 o-s	4.79 p-t	6.66 f-p	6.73 i-r	11.39 o-v	11.58 p-v	41.54 m-w	41.92 l-v
$N_1W_0I_2$	5.13 l-q	5.23 k-p	5.18 k-q	7.45 a-g	7.50 a-j	12.58 g-n	12.73 h-o	40.81 o-w	41.10 n-v
$N_1W_1I_2$	6.38 b-e	6.45 a-f	6.41 b-e	7.37 a-h	7.41 a-k	13.75 b-e	13.86 b-f	46.39 a-i	46.55 a-j
$N_1W_2I_2$	6.62 a-d	6.77 a-d	6.70 a-d	7.65 a-d	7.74 a-d	14.27 a-c	14.51 a-c	46.38 a-j	46.66 a-i
$N_1W_3I_2$	6.44 b-e	6.57 a-f	6.50 a-e	7.37 a-h	7.45 a-k	13.81 b-e	14.02 a-f	46.66 a-h	46.85 a-g
$N_2W_0I_2$	4.72 p-u	4.83 o-s	4.77 p-t	7.21 a-k	7.27 a-l	11.93 k-q	12.10 m-r	39.59 t-w	39.91 s-v
$N_2W_1I_2$	5.48 i-m	5.60 i-m	5.54 h-m	6.75 e-p	6.82 f-r	12.23 i-p	12.43 k-q	44.83 a-n	45.08 a-n
$N_2W_2I_2$	6.13 d-g	6.25 d-h	6.19 d-g	6.74 e-p	6.84 f-r	12.87 e-l	13.09 f-m	47.66 a-d	47.77 a-c
$N_2W_3I_2$	6.28 c-f	6.35 b-g	6.31 c-f	7.13 a-l	7.22 a-m	13.41 c-h	13.56 c-i	46.86 a-g	46.80 a-h
$N_3W_0I_2$	4.79 o-s	4.92 n-r	4.86 o-s	6.17 m-v	6.29 n-u	10.96 q-x	11.21 r-w	43.64 e-r	43.88 c-s
$N_3W_1I_2$	5.16 l-p	5.28 k-p	5.22 k-p	6.63 g-q	6.73 i-r	11.79 m-s	12.01 n-r	43.71 e-q	43.91 c-r
$N_3W_2I_2$	6.47 a-e	6.57 a-f	6.52 a-e	7.22 a-k	7.30 a-l	13.69 b-e	13.87 b-f	47.28 a-e	47.38 a-d
$N_3W_3I_2$	6.00 e-h	6.46 a-f	6.23 d-g	7.11 a-l	7.18 a-m	13.11 e-j	13.63 c-h	45.81 a-k	47.35 a-e
$N_0W_0I_3$	3.82 y	3.95 vw	3.88 wx	5.28 x-z	5.37 wx	9.10 yz	9.32 yz	42.01 k-w	42.36 k-v
$N_0W_1I_3$	4.07 w-y	4.16 t-w	4.11 v-x	5.40 u-z	5.51 u-x	9.47 yz	9.67 yz	42.95 h-t	43.00 g-u
$N_0W_2I_3$	4.49 r-w	4.59 q-u	4.54 r-v	7.00 b-m	7.09 b-o	11.49 o-u	11.68 p-u	39.12 u-w	39.28 t-v

Cont'd

Treatments	Grain yield (t ha^{-1})			Straw yield (t ha^{-1})		Biological yield (t ha^{-1})		Harvest index (%)	
	2014-2015	2015-2016	Pooled	2014-2015	2015-2016	2014-2015	2015-2016	2014-2015	2015-2016
$N_0W_3I_3$	4.23 u-y	4.34 s-w	4.29 t-x	6.29 l-t	6.40 m-t	10.52 u-y	10.74 u-y	40.20 q-w	40.35 q-v
$N_1W_0I_3$	5.31 i-o	5.43 j-n	5.37 i-o	6.88 d-o	6.95 d-p	12.18 j-p	12.38 l-q	43.45 e-s	43.76 c-s
$N_1W_1I_3$	5.54 h-l	5.65 i-m	5.59 h-l	6.38 k-s	6.50 l-t	11.91 k-q	12.15 l-r	46.47 a-h	46.47 a-j
$N_1W_2I_3$	6.82 ab	6.88 a-c	6.85 a-c	7.81 ab	7.90 ab	14.63 ab	14.78 ab	46.65 a-h	46.56 a-j
$N_1W_3I_3$	6.19 c-g	6.29 c-h	6.24 d-g	7.01 b-m	7.11 b-n	13.19 d-j	13.40 e-k	46.95 a-f	47.00 a-g
$N_2W_0I_3$	4.96 n-r	5.07 m-q	5.01 m-r	6.72 e-p	6.79 g-r	11.68 m-t	11.86 n-t	42.52 j-v	42.79 h-u
$N_2W_1I_3$	6.00 e-h	6.07 e-i	6.04 e-h	7.25 a-j	7.36 a-k	13.25 c-i	13.44 d-j	45.27 a-m	45.21 a-m
$N_2W_2I_3$	5.77 f-i	5.88 g-j	5.83 f-i	6.63 g-q	6.71 j-s	12.40 h-o	12.59 i-p	46.57 a-h	46.74 a-i
$N_2W_3I_3$	5.99 e-h	6.04 f-i	6.02 e-h	7.45 a-g	7.59 a-h	13.44 c-h	13.63 c-h	44.57 a-o	44.35 a-p
$N_3W_0I_3$	3.74 y	3.90 vw	3.82 x	5.72 r-z	5.79 t-x	9.46 yz	9.70 yz	39.68 s-w	40.37 p-v
$N_3W_1I_3$	4.73 p-u	4.81 o-s	4.77 p-t	5.93 p-y	6.01 r-w	10.65 t-z	10.82 t-y	44.43 b-o	44.54 a-o
$N_3W_2I_3$	5.71 g-j	5.81 g-k	5.76 g-j	6.88 c-o	6.65 k-s	12.59 g-n	12.46 j-q	45.33 a-m	46.67 a-i
$N_3W_3I_3$	5.01 m-r	5.14 m-q	5.08 l-r	6.49 i-s	6.62 k-s	11.50 o-u	11.76 o-u	43.57 e-r	43.70 d-s
$N_0W_0I_4$	4.15 v-y	4.22 t-w	4.19 u-x	5.25 yz	5.34 wx	9.40 yz	9.56 yz	44.14 d-p	44.19 b-q
$N_0W_1I_4$	4.24 t-y	4.31 s-w	4.28 t-x	6.19 m-u	6.30 n-u	10.43 v-y	10.60 v-z	40.79 o-w	40.73 o-v
$N_0W_2I_4$	5.77 f-i	5.87 g-j	5.82 f-i	7.58 a-e	7.70 a-e	13.36 c-h	13.58 c-i	43.23 f-t	43.26 f-s
$N_0W_3I_4$	5.10 l-q	5.17 l-q	5.14 l-q	6.75 e-p	6.85 f-q	11.85 l-r	12.02 n-r	43.14 f-t	43.10 f-t
$N_1W_0I_4$	4.91 n-r	5.00 n-r	4.95 n-r	6.64 g-q	6.75 i-r	11.55 n-u	11.75 o-u	42.54 i-v	42.59 j-u
$N_1W_1I_4$	6.56 a-d	6.65 a-e	6.61 a-d	7.06 a-l	7.15 a-m	13.62 b-g	13.80 b-g	48.26 ab	48.18 ab
$N_1W_2I_4$	6.96 a	7.02 a	6.99 a	7.90 a	7.95 a	14.86 a	14.97 a	46.90 a-g	46.94 a-g
$N_1W_3I_4$	6.87 ab	6.92 ab	6.90 ab	7.33 a-i	7.44 a-k	14.20 a-d	14.36 a-e	48.39 a	48.19 a
$N_2W_0I_4$	4.61 q-v	4.70 p-t	4.66 q-u	6.78 e-p	6.89 e-q	11.39 o-v	11.60 p-v	40.47 p-w	40.56 o-v
$N_2W_1I_4$	6.16 c-g	6.24 d-h	6.20 d-g	7.46 a-g	7.57 a-i	13.62 b-g	13.81 b-g	45.24 a-m	45.21 a-m
$N_2W_2I_4$	6.66 a-c	6.75 a-d	6.70 a-d	7.52 a-f	7.62 a-g	14.18 a-d	14.36 a-e	46.96 a-f	46.98 a-g
$N_2W_3I_4$	6.57 a-d	6.66 a-d	6.61 a-d	7.11 a-l	7.17 a-m	13.68 b-f	13.83 b-f	48.04 a-c	48.19 a
$N_3W_0I_4$	5.50 h-m	5.61 i-m	5.56 h-l	7.43 a-h	7.51 a-j	12.93 e-k	13.12 f-l	42.54 i-v	42.77 i-u
$N_3W_1I_4$	6.25 c-f	6.34 b-g	6.30 d-f	7.55 a-e	7.64 a-f	13.80 b-e	13.98 a-f	45.32 a-m	45.33 a-m
$N_3W_2I_4$	6.49 a-e	6.60 a-f	6.54 a-e	7.75 a-c	7.88 a-c	14.24 a-d	14.48 a-c	45.60 a-l	45.60 a-l
$N_3W_3I_4$	6.57 a-d	6.65 a-e	6.61 a-d	7.74 a-d	7.83 a-c	14.32 a-c	14.47 a-d	45.94 a-j	45.95 a-k
SE value	0.155	0.172	0.160	0.248	0.239	0.311	0.304	1.095	1.134
Level of significance	*	*	*	*	*	*	*	*	*
CV (%)	5.07	5.55	5.20	6.44	6.11	4.51	4.34	4.32	4.46

*: Significant at 0.05 level of Probability

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

N_0: No urea (control), N_1: Urea super granules (77 kg N ha^{-1}), N_2: Prilled urea at recommended dose (150 kg N ha^{-1}) as 325 kg urea ha^{-1} and N_3= ½ of the recommended dose (75 kg N ha^{-1}) as163 kg urea ha^{-1}

W_0: No weeding (control), W_1: Two hand weeding (20 DAT and 40 DAT), W_2: Pre emergence herbicide (Butachor) and W_3: Post emergence herbicide (Prityloclor)

I_1: Irrigating all time, I_2: Irrigating 3 days after drying, I_3: Irrigating 5 days after drying and I_4: Alternate wetting and drying (AWD) method

4.16.3 Effect of irrigation management

Straw yield of BRRI dhan29 showed statistically significant differences due to different irrigation management (Table 4.8.1). Straw yield was significantly higher compared to control condition for the two subsequent years. The highest straw yield (7.13 and 7.22 t ha^{-1}) was found from I_4 which was closely followed (6.84 and 6.93 t ha^{-1}) by I_2, while the lowest (6.17 and 6.27 t ha^{-1}) was recorded from I_1 which was followed (6.57 and 6.65 t ha^{-1}) by I_3.

4.16.4 Combined effect of nitrogen and weed management

Straw yield of BRRI dhan29 varied significantly for the combined effect of different nitrogen and weed management for the two subsequent years (Table 4.8.2). The highest straw yield (7.77 and 7.84 t ha^{-1}) was recorded from N_1W_2, whereas the lowest (5.25 and 5.34 t ha^{-1}) was found from N_0W_0.

4.16.5 Combined effect of nitrogen and irrigation management

Straw yield of BRRI dhan29 varied significantly for the combined effect of different nitrogen and irrigation management for the two subsequent years (Table 4.8.3). The highest straw yield (7.62 and 7.72 t ha^{-1}) was recorded from N_3I_4, whereas the lowest (5.36 and 5.46 t ha^{-1}) from N_0I_1.

4.16.6 Combined effect of weed and irrigation management

Straw yield of BRRI dhan29 varied significantly for the combined effect of different irrigation and weed management for the two subsequent years (Table 4.8.4). The highest straw yield (7.69 and 7.79 t ha^{-1}) was found from W_2I_4, whereas the lowest (5.74 and 5.83 t ha^{-1}) from W_0I_1.

4.16.7 Combined effect of nitrogen, weed and irrigation management

Statistically significant variation was recorded due to the combined effect of different nitrogen, weed and irrigation, management in terms of straw yield of BRRI dhan29 for the two subsequent years (Table 4.8.5). The highest straw yield (7.90 and 7.95 t ha^{-1}) was recorded from $N_1W_2I_4$, while the lowest yield (5.01 and 5.10 t ha^{-1}) was observed from $N_0W_0I_1$.

4.17 Biological yield

Biological yield of BRRI dhan29 showed statistically significant differences due to different nitrogen, weed and irrigation management and also their combined effect (Appendix XI). In general irrespective of treatments and their combined effects, the highest biological yield was recorded in the 2^{nd} year of the experimental period compared to 1^{st} year (Table 4.8.1 to 4.8.5).

4.17.1 Effect of nitrogen management

Statistically significant variation was observed in terms of biological yield of BRRI dhan29 for different nitrogen management for the two subsequent years (Table 4.8.1). The highest biological yield (13.04 and 13.22 t ha^{-1}) was recorded from N_1 which was closely followed (12.42 and 12.61 t ha^{-1}) to N_2, while the lowest (10.31 and 10.49 t ha^{-1}) was found from N_0 which was followed (12.06 and 12.26 t ha^{-1}) by N_3.

4.17.2 Effect of weed management

Biological yield of BRRI dhan29 showed statistically significant differences for different weed management for the two subsequent years (Table 4.8.1). The highest biological yield (12.90 and 13.07 t ha^{-1}) was recorded from W_2, which was closely followed (12.46 and 12.67 t ha^{-1}) by W_3, while the lowest (10.68 and 10.87 t ha^{-1}) was found from W_0 which was followed (11.79 and 11.97 t ha^{-1}) by W_1.

4.17.3 Effect of irrigation management

Biological yield of BRRI dhan29 showed statistically significant differences due to different irrigation management for the two subsequent years (Table 4.8.1). Biological yield was significantly higher compared to control condition for the two subsequent years. The highest biological yield (12.97 and 13.14 t ha^{-1}) was found from I_4 which was closely followed (12.32 and 12.53 t ha^{-1}) by I_2, while the lowest (10.82 and 11.01 t ha^{-1}) was recorded from I_1 which was followed (11.72 and 11.90 t ha^{-1}) by I_3.

4.17.4 Combined effect of nitrogen and weed management

Biological yield of BRRI dhan29 varied significantly for the combined effect of different nitrogen and weed management for the two subsequent years (Table 4.8.2). The highest biological yield (14.52 and 14.69 t ha^{-1}) was recorded from N_1W_2, whereas the lowest (9.06 and 9.23 t ha^{-1}) was found from N_0W_0.

4.17.5 Combined effect of nitrogen and irrigation management

Biological yield of BRRI dhan29 varied significantly for the combined effect of different nitrogen and irrigation management for the two subsequent years (Table 4.8.3). The highest biological yield (13.82 and 14.01 t ha^{-1}) was recorded from N_3I_4, whereas the lowest (9.13 and 9.29 t ha^{-1}) from N_0I_1.

4.17.6 Combined effect of weed and irrigation management

Biological yield of BRRI dhan29 varied significantly for the combined effect of different irrigation and weed management for the two subsequent years (Table 4.8.4). The highest biological yield (14.16 and 14.35 t ha^{-1}) was recorded from W_2I_4, whereas the lowest (9.54 and 9.73 t ha^{-1}) from W_0I_1.

4.17.7 Combined effect of nitrogen, weed and irrigation management

Statistically significant variation was recorded due to the combined effect of different nitrogen, weed and irrigation management in terms of biological yield of BRRI dhan29 for the two subsequent years (Table 4.8.5). The highest biological yield (14.86 and 14.97 t ha^{-1}) was recorded from $N_1W_2I_4$, while the lowest yield (8.16 and 8.31 t ha^{-1}) was observed from $N_0W_0I_1$.

4.18 Harvest index

Harvest index of BRRI dhan29 showed statistically significant differences due to different nitrogen, weed and irrigation management and also their combined effect (Appendix XI). In general irrespective of treatments and their combined effects, comparatively the lowest harvest index was recorded in the 2^{nd} year of the experimental period compared to 1^{st} year (Table 4.8.1 to 4.8.5).

4.18.1 Effect of nitrogen management

Statistically significant variation was observed in terms of harvest index of BRRI dhan29 for different nitrogen management for the two subsequent years

(Table 4.8.1). The highest harvest index (45.61% and 45.70%) was recorded from N_1 which was closely followed (44.41% and 44.49%) by N_2 and (43.81% and 44.13%) by N_3 and they were statistically similar, whereas the lowest (41.82% and 41.90 %) were found from N_0.

4.18.2 Effect of weed management

Harvest index of BRRI dhan29 showed statistically significant differences for different weed management for the two subsequent years (Table 4.8.1). The highest harvest index (45.39% and 45.55%) was recorded from W_2, which was statistically similar (44.68% and 44.79%) by W_3, while the lowest (41.48% and 41.70%) was found from W_0 which was followed (44.10 and 44.17%) by W_1.

4.18.3 Effect of irrigation management

Harvest index of BRRI dhan29 showed statistically significant differences due to different irrigation management (Table 4.8.1). Harvest index was significantly higher compared to control condition for the two subsequent years. The highest harvest index (44.84% and 44.86%) was found from I_4 which was statistically similar (44.28% at the year 2014-15) to I_2 and (43.95% at the year 2015-16) to I_3, while the lowest (42.79% and 42.86%) was recorded from I_1.

4.18.4 Combined effect of nitrogen and weed management

Harvest index of BRRI dhan29 showed significant differences for the combined effect of different nitrogen and weed management for the two subsequent years and also at average of these years (Table 4.8.2). In an average, the highest harvest index (46.97%) was recorded from N_2W_2, whereas the lowest (40.72%) was found from N_2W_0.

4.18.5 Combined effect of nitrogen and irrigation management

Combined effect of different irrigation and nitrogen management varied significantly in terms of harvest index of BRRI dhan29 for the two subsequent years (Table 4.8.3). The highest harvest index (46.52% and 46.47%) was recorded from N_1I_4, which was statistically similar (45.88% and 45.95%) to N_1I_3, whereas the lowest (41.18% and 41.15%) was recorded from N_0I_1.

4.18.6 Combined effect of weed and irrigation management

Harvest index of BRRI dhan29 showed significant differences for the combined effect of different irrigation and weed management for the two subsequent years and also at average of these years (Table 4.8.4). The highest harvest index (42.12%) was recorded from W_2I_2, whereas the lowest (39.91%) from W_0I_1.

4.18.7 Combined effect of nitrogen, weed and irrigation management

Statistically significant variation was recorded due to the combined effect of different irrigation, nitrogen and weed management in terms of harvest index of BRRI dhan29 for the two subsequent years and also at average of these years (Table 4.8.5). In an average, the highest harvest index (48.29%) was recorded from $N_1W_2I_4$, while the lowest yield (38.58%) was observed from $N_0W_0I_1$.

CHAPTER V

SUMMARY AND CONCLUSION

Two field experiments were conducted at the Suapur Union of Dhamrai Upazila, Dhaka during the period of 2014-2015 and 2015-2016 to find out nitrogen, weed and irrigation management for maximizing growth and yield of boro rice (cv.BRRI dhan29). BRRI dhan29 was used as the test crop in this experiments. The experiment comprised of three factors as; Factor A: Nitrogen management (4 levels) N_0: No urea (control), N_1: Urea super granules (77 kg N ha^{-1}), N_2: Prilled urea at recommended dose (150 kg N ha^{-1}) as 325 kg urea ha^{-1} and N_3= ½ of the recommended dose (75 kg N ha^{-1}) as163 kg urea ha^{-1}; Factor B: Weed management (4 levels)- W_0: No weeding (control), W_1: Two hand weeding (20 and 40 DAT), W_2: Pre emergence herbicide (Butachor) and W_3: Post emergence herbicide (Prityloclor); Factor C: Irrigation Management (4 levels)- I_1: Irrigating all time, I_2: Irrigating 3 days after drying, I_3: Irrigating 5 days after drying, I_4: Alternate wetting and drying (AWD) method. The three factors experiment was laid out in split-split-plot design with three replications for two consecutive years. Data on different growth characters, yield components and yield was recorded and statistically significant variation was observed for different irrigation, nitrogen and weed management and also their combined effect.

For nitrogen management, for different growth characters, yield components and yield of BRRI dhan29 gave the best results for N_1, while the lowest performance was recorded from N_0. At 30, 50, 70 DAT and harvest for two consecutive years, the tallest plant (43.04, 64.66, 78.75, 83.73, 44.54, 65.68, 80.42 and 85.37 cm, respectively) was recorded from N_1, while the shortest plant (36.68, 54.36, 69.08, 75.21, 38.58, 55.54, 72.38 and 76.47cm, respectively) from N_0. At 30, 50, 70 DAT and harvest, the highest number of tillers $hill^{-1}$ (7.15, 14.57, 15.90, 17.10, 7.43, 15.24, 16.60 and 17.86, respectively) was recorded from N_1, while the minimum number (6.08, 12.20, 13.38, 14.82, 6.43, 12.81, 14.51 and 15.50, respectively) was found from N_0. At 30, 50 and 70 DAT, the highest leaf area index (1.48, 7.02, 13.54, 1.55, 7.34 and 14.28, respectively) was recorded from N_1, while the lowest (1.37, 6.66, 12.29, 1.43, 6.99 and 13.05, respectively) from N_0. At 30, 50 and 70 DAT, the highest total dry matter (160.00, 468.21, 781.30, 162.60, 481.70 and 802.13 g, respectively) was recorded from N_1, while the lowest (134.38, 389.14, 644.84, 136.88, 401.29 and 665.61 g, respectively) was found from N_0. At 30-50 and 50-70 DAT, the highest CGR (15.41, 15.65, 15.95 and 16.02 g m^{-2} day^{-1}, respectively) was recorded from N_1, while the lowest (12.74, 12.78, 13.22 and 13.23 g m^{-2} day^{-1}, respectively) was found from N_0. Data revealed that at 30-50 and 50-70 DAT, the highest RGR (23.18, 11.18. 23.45 and 11.14 mg g^{-1} day^{-1}, respectively) was recorded from N_1, while the lowest (22.82, 10.83, 23.08 and 10.81 mg g^{-1} day^{-1}, respectively) was found from N_3. At 30-50 and 50-70 DAT, the highest NAR (7.12, 2.59, 7.05 and 2.52g m^{-2} day^{-1}, respectively) was recorded from N_1, while the lowest (6.29, 2.29, 6.22 and 2.25 g m^{-2} day^{-1}, respectively) was found from N_0. The highest number of effective tillers $hill^{-1}$ (15.46) was recorded from N_1, while the lowest number (12.38) was found from N_0. The lowest number of non-effective tillers $hill^{-1}$ (1.63 and 1.58) was recorded from N_1, while the highest number (2.44 and 2.32) was found from N_0. The longest panicle (24.35 and 24.57 cm) was recorded from N_1, while the shortest panicle (20.00 and 20.35 cm) was found from N_0. The highest number of filled grains $panicle^{-1}$ (76.57 and 78.04) was recorded from N_1, while the lowest number (65.90 and 67.71) was found from N_0. The lowest number of unfilled grains $panicle^{-1}$ (4.91 and 4.72) was recorded from N_1, while the highest number (7.32 and 6.96) was found from N_0. The highest number of total grains $panicle^{-1}$ (81.49 and 82.77) was recorded from N_1, while the lowest number (73.21 and 74.67) was found from N_0. The maximum weight of 1000-grains (26.18 and 26.41 g) was recorded from N_1, while the minimum weight (21.13 and 21.40 g) was found from N_0. At pooled, the highest grain yield (6.01 t ha^{-1}) was recorded from N_1, while the lowest (4.35 t ha^{-1}) was found from N_0. The highest straw yield (7.08 and 7.16 t ha^{-1}) was recorded from N_1, while the lowest (5.99 and6.09 t ha^{-1}) was found from N_0. The highest biological yield (13.04 and 13.22 t ha^{-1}) was recorded from N_1, while the lowest (10.31 and 10.49 t ha^{-1}) was found from N_0. The highest harvest index (45.61% and 45.70%) was recorded from N_1, whereas the lowest (41.82% and 41.90 %) was found from N_0.

In weed management, the highest performance in terms of different growth characters, yield components and yield of BRRI dhan29 was recorded from W_2, whereas the lowest was found from W_0. At 30, 50, 70 DAT and harvest for two consecutive years, the tallest plant (42.95, 64.61, 79.32, 84.85, 44.40, 65.72, 81.06 and 86.44 cm, respectively) was recorded from W_2, whereas the shortest plant (37.71, 55.85, 69.22, 74.99, 39.67, 57.21, 71.86 and 76.33 cm, respectively) was found from W_0. At 30, 50, 70 DAT and harvest, the highest number of tillers $hill^{-1}$ (7.12, 14.55, 16.05, 17.37, 7.39, 15.27, 16.78 and 18.17, respectively) by W_2, while the minimum number (6.27, 12.56, 13.42, 14.78, 6.62, 13.25, 14.38 and 15.45, respectively) was found from W_0. At 30, 50 and 70 DAT, the highest leaf area index (1.50, 7.07, 13.59, 1.56, 7.40 and 14.35, respectively) was recorded from W_2, while the lowest (1.36, 6.65, 12.37, 1.43, 6.99 and 13.13, respectively) was found from W_0. At 30, 50 and 70 DAT, the highest total dry matter (159.81, 469.81, 788.38, 162.57, 483.34 and 809.27 g, respectively) was recorded from W_2, while the lowest (138.84, 399.30, 653.03, 141.55, 411.59 and 673.69 g, respectively) was found from W_0. At 30-50 and 50-70 DAT, the highest CGR (15.50, 15.93, 16.04 and 16.30 g m^{-2} d^{-1}, respectively) was recorded from W_2, while the lowest (13.02, 12.69, 13.50 and 13.11 g m^{-2} day^{-1}, respectively) was found from W_0. At 30-50 and 50-70 DAT, the highest RGR (23.31, 11.33, 23.55 and 11.28 mg g^{-1} day^{-1}, respectively) was recorded from W_2, while the lowest (22.67, 10.78, 22.92 and 10.80 mg g^{-1} day^{-1}, respectively) was found from W_0. At 30-50 and 50-70 DAT, the highest NAR (7.10, 2.63, 7.03 and 2.56 g m^{-2} day^{-1}, respectively) was recorded from W_2, while the lowest (6.29, 2.29, 6.22 and 2.25 g m^{-2} day^{-1}, respectively) was found from W_0. The highest number of effective tillers $hill^{-1}$ (15.60) was recorded from W_2, while the lowest number (12.56) was found from W_0. The lowest number of non-effective tillers hill^{-1} (1.78 and 1.70) was recorded from W_2, whereas the highest number (2.22 and 2.11) was found from W_0. The longest panicle (24.11 and 24.38 cm) was recorded from W_2, while the shortest panicle (20.52 and 20.76 cm) was found from W_0. The highest number of filled grains panicle^{-1} (77.39 and 79.12) was recorded from W_2, while the lowest number (65.86 and 67.44) was found from W_0. The lowest number of unfilled grains panicle^{-1} (5.33 and 5.10) was recorded from W_2, while the highest number (6.69 and 6.34) was found from W_0. The highest number of total grains panicle^{-1} (82.72 and 84.23) was recorded from W_2, while the lowest number (72.55 and 73.78) was found from W_0. The maximum weight of 1000-grains (25.91 and 26.14 g) was recorded from W_2, while the minimum weight (21.80 and 22.11 g) was found from W_0. At pooled, the highest grain yield (5.92 t ha^{-1}) was recorded from W_2, while the lowest (4.49 t ha^{-1}) was found from W_0. The highest straw yield (7.03 and 7.10 t ha^{-1}) was recorded from W_2, while the lowest straw yield (6.24 and 6.33 t ha^{-1}) was recorded from W_0. The highest biological yield (12.90 and 13.07 t ha^{-1}) was recorded from W_2, while the lowest (10.68 and 10.87 t ha^{-1}) was found from W_0. The highest harvest index (45.39% and 45.55%) was recorded from W_2, while the lowest (41.48% and 41.70%) was found from W_0.

In case of irrigation management, I_4 perform the best results in terms of different growth characters, yield components and yield of BRRI dhan29 compare to others, whereas the lowest results was recorded from I_1. At 30, 50, 70 DAT and harvest for two consecutive years, the tallest plant (42.11, 64.57, 79.13, 84.37, 43.70, 65.83, 81.05 and 85.82 cm, respectively) was found from I_4, whereas the shortest plant (38.23, 56.61, 71.24, 76.44, 39.70, 57.99, 73.32 and 78.07 cm, respectively) from I_1. At 30, 50, 70 DAT and harvest the highest number of tillers hill^{-1} (6.99, 14.66, 16.00, 17.27, 7.30, 15.39, 16.78 and 17.98, respectively) was found from I_4, whereas the lowest number (6.36, 12.53, 13.95, 15.18, 6.62, 13.27, 14.78 and 15.91, respectively) was recorded from I_1. At 30, 50 and 70 DAT, the highest leaf area index (1.49, 7.04, 13.61, 1.56, 7.41 and 14.40, respectively) was found from I_4, whereas the lowest (1.39, 6.72, 12.51, 1.45, 7.03 and 13.26, respectively) was found from I_1. At 30, 50 and 70 DAT, the highest total dry matter (159.69, 478.94, 794.60, 162.74, 492.70 and 815.73 g, respectively) was found from I_4, whereas the lowest (138.47, 393.25, 645.49, 140.72, 405.40 and 666.03 g, respectively) was found from I_1. At 30-50 and 50-70 DAT, the highest CGR (15.96, 15.78, 16.50 and 16.15, g m^{-2} day^{-1}, respectively) was found from I_4, while the lowest (12.74, 12.61, 13.23 and 13.03, g m^{-2} day^{-1}, respectively) was recorded from I_1. At 30-50 and 50-70 DAT, the highest RGR (23.77, 11.16, 23.98 and 11.14 mg g^{-1} day^{-1}, respectively) was recorded from I_4 whereas the lowest (22.61, 10.72, 22.91 and 10.75 mg g^{-1} day^{-1}, respectively) was observed from I_1. At 30-50 and 50-70 DAT, the highest NAR (7.35, 2.60, 7.23 and 2.53 g m^{-2} day^{-1}, respectively) was found from I_4, whereas the lowest (6.22, 2.22, 6.18 and 2.18 g m^{-2} day^{-1}, respectively) was found from I_1. The highest number of effective tillers $hill^{-1}$ (15.59) was found from I_4, whereas the lowest number (12.95) was recorded from I_1. The lowest number of non-effective tillers $hill^{-1}$ (1.68 and 1.60) was found from I_4, whereas the highest number (2.23 and 2.13) was recorded from I_1. The longest panicle (24.12 and 24.35 cm) was found from I_4, while the shortest panicle (20.87 and 21.04 cm) was recorded from I_1. The highest number of filled grains $panicle^{-1}$ (77.92 and 79.62) was found from I_4, whereas the lowest number (66.78 and 68.53) was recorded from I_1. The lowest number of unfilled grains $panicle^{-1}$ (5.05 and 4.79) was found from I_4, whereas the highest number (6.70 and 6.41) was recorded from I_1. The highest number of total grains $panicle^{-1}$ (82.97 and 84.41) was found from I_4, while the lowest number (74.94 and 74.21) was recorded from I_1. The maximum weight of 1000-grains (26.08 and 26.33 g) was found from I_4, while the minimum weight (22.08 and 22.30 g) was recorded from I_1. At pooled, the highest grain yield (5.88 t ha^{-1}) was found from I_4, while the lowest (4.70 t ha^{-1}) was recorded from I_1. The highest straw yield (7.13 and 7.22 t ha^{-1}) was found from I_4, while the lowest (6.17 and 6.27 t ha^{-1}) was recorded from I_1. The highest biological yield (12.97 and 13.14 t ha^{-1}) was found from I_4, while the lowest (10.82 and 11.01 t ha^{-1}) was recorded from I_1. The highest harvest index

(44.84% and 44.86%) was found from I_4, while the lowest (42.79% and 42.86%) was recorded from I_1.

For the combined effect of different nitrogen and weed management, in terms of different growth characters, yield components and yield of BRRI dhan29 the highest results gave N_1W_2, whereas the lowest was recorded from N_0W_0. At 30, 50, 70 DAT and harvest for two consecutive years, the tallest plant (48.88, 71.64, 87.15, 93.49, 50.10, 72.57, 88.89 and 94.89 cm, respectively) was recorded from N_1W_2, whereas the shortest plant (31.26, 43.06, 61.42, 68.24, 33.69, 44.13, 66.80 and 68.33 cm, respectively) from N_0W_0. At 30, 50, 70 DAT and harvest, the highest number of tillers hill^{-1} (8.12, 16.50, 18.15, 19.67, 8.33, 17.17, 18.85 and 20.42, respectively) was recorded from N_1W_2, whereas the minimum number (5.22, 10.33, 11.57, 13.00, 5.63, 10.63, 13.13 and 13.33, respectively) from N_0W_0. At 30, 50 and 70 DAT, the highest leaf area index (1.61, 7.42, 14.63, 1.67, 7.74 and 15.37, respectively) was recorded from N_1W_2, whereas the lowest (1.27, 6.34, 11.31, 1.34, 6.64 and 12.05, respectively) from N_0W_0. At 30, 50 and 70 DAT, the highest total dry matter (183.48, 549.47, 914.39, 186.24, 564.40 and 935.53 g, respectively) was recorded from N_1W_2, whereas the lowest (114.87, 341.28, 586.10, 117.55, 352.72 and 607.14 g, respectively) from N_0W_0. At 30-50 and 50-70 DAT, the highest CGR (18.30, 18.25, 18.91 and 18.56 g m^{-2} day^{-1}, respectively) was recorded from N_1W_2, whereas the lowest (11.32, 12.24, 11.76 and 12.72 g m^{-2} day^{-1}, respectively) from N_0W_0. At 30-50 and 50-70 DAT, the highest RGR (23.80, 11.75, 24.07 and 11.73 mg g^{-1} day^{-1}, respectively) was recorded from N_1W_2, whereas the lowest (22.06, 10.21, 24.07 and 10.22 mg g^{-1} day^{-1}, respectively) from N_0W_0. At 30-50 and 50-70 DAT, the highest NAR (7.93, 2.83, 7.87 and 2.75 g m^{-2} day^{-1}, respectively) was recorded from N_1W_2, whereas the lowest (5.92, 2.10, 5.87 and 2.06 g m^{-2} day^{-1}, respectively) from N_0W_0. The highest number of effective tillers hill^{-1} (18.03) was recorded from N_1W_2, whereas the lowest number (10.38) from N_0W_0. The lowest number of non-effective tillers hill^{-1} (1.47 and 1.38) was recorded from N_2W_2, whereas the highest number (2.62 and 2.47) from N_0W_0.

The longest panicle (26.61 and 26.89 cm) was recorded from N_1W_2, whereas the shortest panicle (18.44 and 18.71 cm) from N_0W_0. The highest number of filled grains panicle^{-1} (88.95 and 90.62) was recorded from N_1W_2, whereas the lowest number (60.85 and 62.40) from N_0W_0. The lowest number of unfilled grains panicle^{-1} (4.92 and 4.65) was recorded from N_1W_2, whereas the highest number (7.90 and 7.42) from N_0W_0. The highest number of total grains panicle^{-1} (93.87 and 95.27) was recorded from N_1W_2, whereas the lowest number (68.75 and 69.82) from N_0W_0. The maximum weight of 1000-grains (28.86 and 28.98 g) was recorded from N_1W_2, whereas the minimum weight (19.25 and 19.54 g) from N_0W_0. At pooled, the highest grain yield (6.80 t ha^{-1}) was recorded from N_1W_2, whereas the lowest (3.85 t ha^{-1}) was found from N_0W_0. The highest straw yield (7.77 and 7.84 t ha^{-1}) was recorded from N_1W_2, whereas the lowest (5.25 and 5.34 t ha^{-1}) was found from N_0W_0. The highest biological yield (14.52 and 14.69 t ha^{-1}) was recorded from N_1W_2, whereas the lowest (9.06 and 9.23 t ha^{-1}) was found from N_0W_0. In an average, the highest harvest index (46.97%) was recorded from N_2W_2, whereas the lowest (40.72%) was found from N_2W_0.

Due to the combined effect of different nitrogen and irrigation management, the highest results in terms of different growth characters, yield components and yield of BRRI dhan29 was recorded from N_1I_4, whereas the lowest from N_0I_1. At 30, 50, 70 DAT and harvest for two consequtatives years, the tallest plant (43.77, 69.28, 82.85, 87.73, 45.52, 70.61, 84.57 and 89.10 cm, respectively) was recorded from N_1I_4, whereas the shortest plant (31.98, 48.73, 64.63, 70.63, 33.57, 49.89, 67.35 and 71.62 cm, respectively) from N_0I_1. At 30, 50, 70 DAT and harvest, the highest number of tillers hill^{-1} (7.38, 15.78, 17.02, 18.20, 7.68, 16.68, 17.68 and 18.85, respectively) was recorded from N_1I_4, whereas the lowest number (5.30, 10.88, 12.40, 13.62, 5.60, 11.53, 13.32 and 14.20 respectively) from N_0I_1. At 30, 50 and 70 DAT, the highest leaf area index (1.54, 7.18, 14.14, 1.61, 7.59 and 14.95, respectively) was recorded from N_1I_4, whereas the lowest (1.31, 6.47, 11.69, 1.37, 6.80 and 12.48, respectively) from N_0I_1. At 30, 50 and 70 DAT, the highest total dry matter (172.19, 525.28, 844.33, 174.97, 539.89 and 865.31 g, respectively) was recorded from N_1I_4, whereas the lowest (118.00, 348.22, 570.80, 120.09, 359.75 and 591.79 g, respectively) from N_0I_1. At 30-50 and 50-70 DAT, the highest CGR (17.65, 17.83, 18.25 and 18.18 g m^{-2} day^{-1}, respectively) was recorded from N_1I_4, whereas the lowest (11.51, 11.13, 11.98 and 11.60 g m^{-2} day^{-1}, respectively) from N_0I_1. At 30-50 and 50-70 DAT, the highest RGR (24.04, 12.54, 24.43 and 12.51 mg g^{-1} day^{-1}, respectively) was recorded from N_3I_3, whereas the lowest (22.26, 970, 22.54 and 9.57 mg g^{-1} day^{-1}, respectively) from N_0I_1. At 30-50 and 50-70 DAT, the highest NAR (7.97, 2.87, 7.82 and 2.77 g m^{-2} day^{-1}, respectively) was recorded from N_1I_4, whereas the lowest (5.92, 2.01, 5.87 and 1.98 g m^{-2} day^{-1}, respectively) from N_0I_1. The highest number of effective tillers $hill^{-1}$ (17.00) was recorded from N_1I_4, whereas the lowest number (10.98) from N_0I_1. The lowest number of non-effective tillers $hill^{-1}$ (1.20 and 1.17) was recorded from N_1I_4, whereas the highest number (2.63 and 2.53) from N_0I_1. The longest panicle (25.36 and 25.59 cm) was recorded from N_1I_4, whereas the shortest panicle (18.45 and 18.57 cm) from N_0I_1. The highest number of filled grains $panicle^{-1}$ (82.58 and 84.77) was recorded from N_1I_4, whereas the lowest number (61.35 and 63.47) from N_0I_1. The lowest number of unfilled grains $panicle^{-1}$ (3.60 3.50) was recorded from N_1I_4, whereas the highest number (7.95 and 7.63) from N_0I_1. The highest number of total grains $panicle^{-1}$ (88.28 and 90.22) was recorded from N_1I_4, whereas the lowest number (69.30 and 71.10) from N_0I_1. The maximum weight of 1000-grains (27.84 and 28.07 g) was recorded from N_1I_4, whereas the minimum weight (19.41 and 19.63 g) from N_0I_1. At pooled, the highest grain yield (6.36 t ha^{-1}) was recorded from N_1I_4, whereas the lowest (3.80 t ha^{-1}) from N_0I_1. The highest straw yield (7.62 and 7.72 t ha^{-1}) was recorded from N_3I_4, whereas the lowest (5.36 and 5.46 t ha^{-1}) from N_0I_1. The highest biological yield (13.82 and 14.01 t ha^{-1}) was recorded from N_3I_4, whereas the lowest (9.13 and 9.29 t ha^{-1}) from N_0I_1. The highest harvest index (46.52% and 46.47%) was recorded from N_1I_4, whereas the lowest (41.18% and 41.15%) from N_0I_1.

In case of combined effect of different weed and irrigation management, in terms of different growth characters, yield components and yield of BRRI dhan29 I_4W_2 perform better, whereas the W_0I_1 was the lowest. At 30, 50, 70 DAT and harvest for two consecutive years, the tallest plant (45.13, 70.50, 84.11, 89.67, 46.57, 71.68, 85.94 and 91.11 cm, respectively) was recorded from W_2I_4, whereas the shortest plant (35.83, 51.75, 64.56, 70.33, 37.34, 53.56, 66.20 and 71.69 cm, respectively) from W_0I_1. At 30, 50, 70 DAT and harvest, the highest number of tillers hill^{-1} (7.47, 16.18, 17.35, 18.67, 7.78, 16.92, 18.10 and 19.42, respectively) was recorded from W_2I_4, whereas the lowest number (5.97, 11.52, 12.38, 13.57, 6.25, 12.38, 13.15 and 14.20, respectively) from W_0I_1. At 30, 50 and 70 DAT, the highest leaf area index (1.56, 7.26, 14.33, 1.63, 7.60 and 15.23, respectively) was recorded from W_2I_4, whereas the lowest (1.31, 6.45, 11.82, 1.39, 6.76 and 12.58, respectively) from W_0I_1. At 30, 50 and 70 DAT, the highest total dry matter (175.16, 538.29, 879.23, 178.06, 553.15 and 900.67 g, respectively) was recorded from W_2I_4, whereas the lowest (129.05, 359.19, 574.86, 131.23, 370.72 and 595.19 g, respectively) from W_0I_1. At 30-50 and 50-70 DAT, the highest CGR (18.16, 18.01, 18.75 and 18.39 g m^{-2} day^{-1}, respectively) was recorded from W_2I_4, whereas the lowest (11.51, 10.78, 11.97 and 11.22 g m^{-2} day^{-1}, respectively) from W_0I_1. At 30-50 and 50-70 DAT, the highest RGR (24.38, 12.79, 24.61 and 12.71 mg g^{-1} day^{-1}, respectively) was recorded from W_2I_4, whereas the lowest (22.00, 9.99, 22.18 and 10.05 mg g^{-1} day^{-1}, respectively) from W_0I_1. At 30-50 and 50-70 DAT, the highest NAR (8.08, 2.97, 7.98 and 2.88 g m^{-2} day^{-1}, respectively) was recorded from W_2I_4, whereas the lowest (5.89, 2.00, 5.83 and 1.97 g m^{-2} day^{-1}, respectively) from W_0I_1. The highest number of effective tillers hill^{-1} (17.02) was recorded from I_4W_2, whereas the lowest number (10.95) from W_0I_1. The lowest number of non-effective tillers hill^{-1} (1.65 and 1.57) was recorded from W_2I_4, whereas the highest number (2.62 and 2.48) from W_0I_1. The longest panicle (26.96 and 26.22 cm) was recorded from W_2I_4, whereas the shortest panicle (18.92 and 19.10 cm) from W_0I_1. The highest number of filled grains panicle^{-1} (84.72 and 86.63) was recorded from W_2I_4, whereas the lowest number (60.82 and 62.25) from W_0I_1. The lowest number of unfilled grains panicle^{-1} (4.93 and 4.72) was recorded from W_2 I_4, whereas the highest number (7.92 and 7.47) from W_0I_1. The highest number of total grains panicle^{-1} (89.65 and 91.35) was recorded from W_2I_4, whereas the lowest number (68.73 and 69.72) from W_0I_1. The maximum weight of 1000-grains (28.28 and 28.53 g) was recorded from W_2I_4, whereas the minimum weight (19.85 and 20.14 g) from W_0I_1. At pooled, the highest grain yield (6.52 t ha^{-1}) was recorded from W_2I_4, whereas the lowest (3.85 t ha^{-1}) was observed from W_0I_1. The highest straw yield (7.69 and 7.79 t ha^{-1}) was found from W_2I_4, whereas the lowest (5.74 and 5.83 t ha^{-1}) from W_0I_1. The highest biological yield (14.16 and 14.35 t ha^{-1}) was recorded from W_2I_4, whereas the lowest (9.54 and 9.73 t ha^{-1}) from W_0I_1. The highest harvest index (42.12%) was recorded from W_2I_2, whereas the lowest (39.91%) from W_0I_1.

Due to the combined effect of different irrigation, nitrogen and weed management, the highest results in terms of different growth characters, yield components and yield of BRRI dhan29 was observed from $N_1W_2I_4$, while the lowest from $N_0W_0I_1$. At 30, 50, 70 DAT and harvest for two consecutive years, the tallest plant (52.15, 74.79, 92.13, 98.18, 54.19, 75.63, 93.88 and 99.10 cm, respectively) was recorded from $N_1W_2I_4$, while the shortest plant (30.22, 41.01, 54.45, 61.29, 31.68, 41.59, 56.02 and 60.49 cm, respectively) from N_0W_0 I_1. At 30, 50, 70 DAT and harvest, the highest number of tillers hill^{-1} (8.67, 17.40, 19.53, 20.93, 9.07, 18.00, 20.13 and 21.53, respectively) was recorded from N_1W_2 I_4, while the lowest number (5.00, 10.07, 10.53, 11.13, 5.33, 10.60, 10.87 and 11.20 respectively) from $N_0W_0I_{1.}$ The recorded data revealed that at 30, 50 and 70 DAT, the highest leaf area index (1.67, 7.61, 14.94, 1.74, 7.89 and 15.92, respectively) was recorded from N_1W_2 I_4, while the lowest (1.22, 6.03, 10.89, 1.29, 6.35 and 11.76, respectively) from $N_0W_0I_{1.}$ At 30, 50 and 70 DAT, the highest total dry matter (196.97, 585.70, 990.02, 199.40, 601.19 and 1011.07 g, respectively) was recorded from N_1W_2 I_4, while the lowest (112.28, 329.33, 519.46, 114.66, 340.54 and 540.39 g, respectively) from $N_0W_0I_{1.}$ At 30-50 and

50-70 DAT, the highest CGR (19.44, 20.89, 20.09 and 21.26 g m^{-2} day^{-1}, respectively) was recorded from N_1W_2 I_4, while the lowest (10.37, 6.59, 10.84 and 6.98 g m^{-2} day^{-1}, respectively) from $N_0W_0I_{1.}$ At 30-50 and 50-70 DAT, the highest RGR (25.15, 14.56, 25.36 and 14.47 mg g^{-1} day^{-1}, respectively) was recorded from N_1W_2 I_4, while the lowest (20.46, 5.94, 20.90 and 6.09 mg g^{-1} day^{-1}, respectively) from $N_0W_0I_{1.}$ At 30-50 and 50-70 DAT, the highest NAR (8.51, 3.32, 8.34 and 3.21 g m^{-2} day^{-1}, respectively) was recorded from $N_3W_3I_4$, while the lowest (5.11, 1.19, 5.10 and 1.20 g m^{-2} day^{-1}, respectively) from $N_0W_0I_{1.}$ The highest number of effective tillers $hill^{-1}$ (19.80) was recorded from N_1W_2 I_4, while the lowest number (8.27) from N_0W_0 I_1. The lowest number of non-effective tillers $hill^{-1}$ (1.13 and 1.07) was recorded from N_1W_2 I_4, while the highest number (2.87 and 2.73) from $N_3W_0I_1$. The longest panicle (27.12 and 27.51 cm) was recorded from $N_1W_2I_4$, while the shortest panicle (17.61 and 17.69 cm) from N_0W_0 I_1. The highest number of filled grains $panicle^{-1}$ (91.60 and 93.33) was recorded from N_1W_2 I_4, while the lowest number (58.27 and 59.47) from N_0W_0 I_1. The lowest number of unfilled grains $panicle^{-1}$ (3.40 and 3.20) was recorded from N_1W_2 I_4, while the highest number (7.00 and 6.80) from N_0W_0 I_1. The highest number of total grains $panicle^{-1}$ (95.00) was recorded from N_1W_2 I_4, while the lowest number (67.07 and 67.73) from N_0W_0 I_1. The maximum weight of 1000-grains (28.93 and 29.15g) was recorded from $N_1W_2I_4$, while the minimum weight (18.78 and 18.93 g) from N_0W_0 I_1. At pooled, the highest grain yield (6.99 t ha^{-1}) was recorded from $N_1W_2I_4$, while the lowest yield (3.18 t ha^{-1}) was observed from $N_0W_0I_1$. The highest straw yield (7.90 and 7.95 t ha^{-1}) was recorded from $N_1W_2I_4$, while the lowest yield (5.01 and 5.10 t ha^{-1}) from $N_0W_0I_1$. The highest biological yield (14.86 and 14.97 t ha^{-1}) was recorded from $N_1W_2I_4$, while the lowest yield (8.16 and 8.31 t ha^{-1}) was observed from $N_0W_0I_1$. In an average, the highest harvest index (48.29%) was recorded from $I_4N_1W_2$, while the lowest yield (38.58%) from $I_1N_0W_0$.

Conclusion:

Considering the findings of the present experiment, following conclusions may be drawn:

- It was observed that either N_1 (Urea super granules-USG, 77 kg N ha^{-1}), with W_1 (Two hand weeding-20 and 40 DAT); W_3 (Post emergence herbicide-Prityloclor) and I_4 (Alternate wetting and drying-AWD) ; N_2 (Prilled urea at the recommended dose-150 kg N ha^{-1}) with W_2 (Pre emergence herbicide- Butachor); W_3 (Post emergence herbicide-Prityloclor) and I_4 (Alternate wetting and drying-AWD) gave significantly higher grain yields (6.54-6.99 t ha^{-1}) than others.
- Significantly higher grains was obtained either using USG, AWD irrigatin under any weeding method (6.61-6.90 t ha^{-1}), or using Prilled Urea at the recommended dose; half of the recommended dose controlling weeds applying herbicide Butachor and Prityloclor along with AWD irrigation gave (6.54-6.61 t ha^{-1}).

Recommendation:

Before recommendation of nitrogen, weed and irrigation management to optimize BRRI dhan29 production further study is needed in different agro-ecological zones of Bangladesh for regional adaptability.

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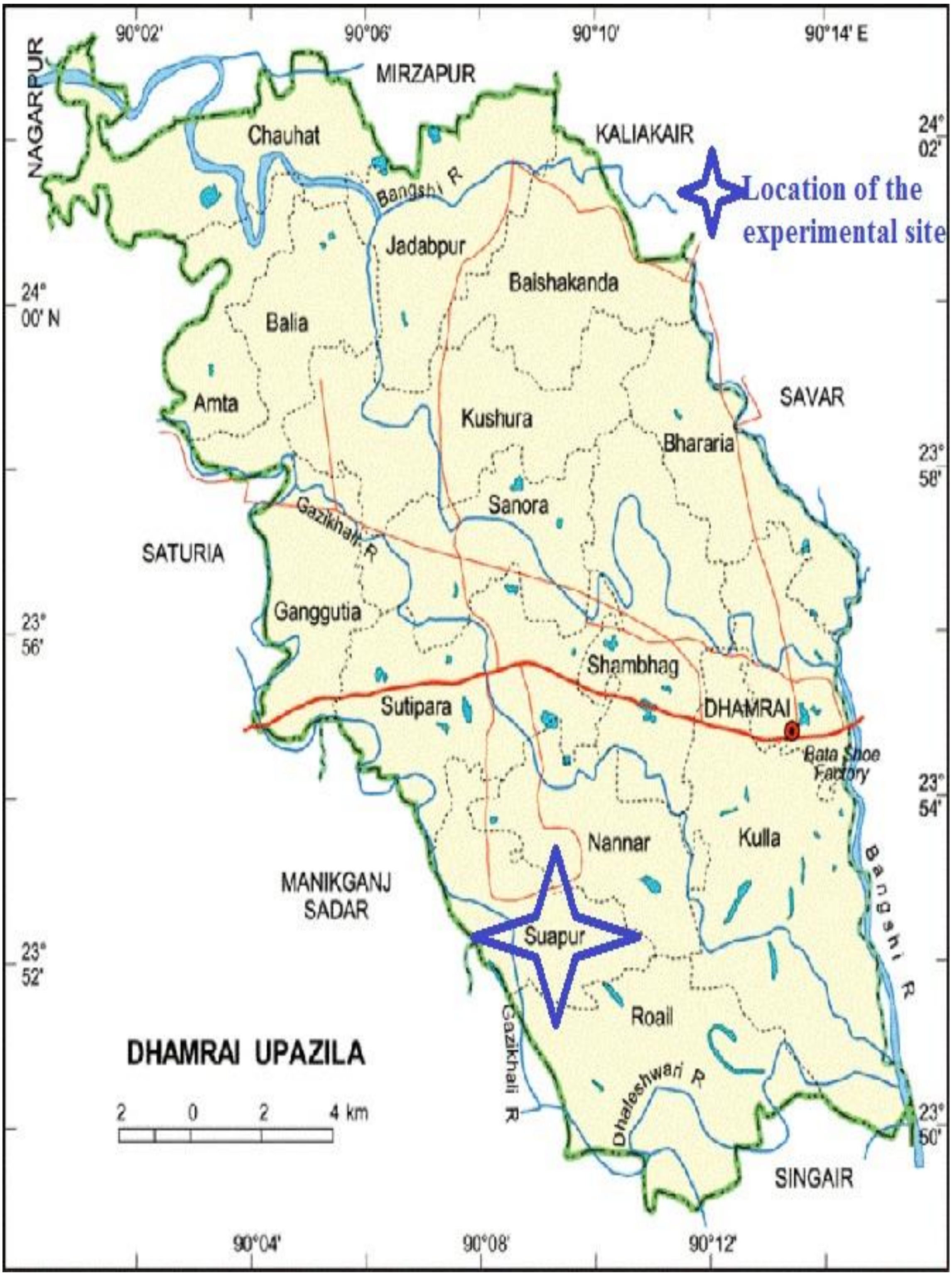
APPENDICES

Appendix I. The Map of the experimental site



Appendix II. Soil analysis of the experimental land (0-15 cm depth)

Properties	Value	
	2015	2016
Electrical conductivity (dS m^{-1})	1.30	0.54
Soil pH	6.9	6.3
Organic Matter (%)	1.45	1.26
Total N (%)	0.123	0.113
Exchangeable K (meq/100 g soil)	0.115	0.105
Available P (µg kg^{-1} soil)	13.0	10.49
Available S (µg kg^{-1})	20.7	2.15
Available B (µg kg^{-1})	0.42	0.13
Available Zn (µg kg^{-1})	1.55	0.43

Appendix III. Weather data, 2015 and 2016, Suapur, Dhamrai, Dhaka

Month	Average Relative Humidity (%)		Average Temperature (^{o}C)				Total Rainfall (mm)		Average wind speed (km/hr)	
			Minimum		Maximum					
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
January	65	79	10.3	11.4	24.2	26.4	1.05	0.69	3	3
February	74	74	14.5	12.3	28.3	28.9	11.47	35.65	1	3
March	79	70	22.1	17.5	33.4	34.6	8.60	13.96	2	5
April	62	66	24.4	21.7	34.2	37.3	111.98	61.50	6	7
May	79	72	24.8	23.2	32.7	35.8	276.49	173.85	5	11
June	76	81	27.2	25.6	33.7	36.2	347.17	333.01	4	11

Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka-1207

Appendix IV. Analysis of variance of the data on plant height at different DAT (days after transplanting) and harvest of BRRI dhan29 as influenced by nitrogen, weed and irrigation management

Source of variation	Degrees of freedom	Mean square							
		Plant height (cm) at year 2014-2015				Plant height (cm) at year 2015-2016			
		30 DAT	50 DAT	70 DAT	Harvest	30 DAT	50 DAT	70 DAT	Harvest
Replication	2	0.137	6.742	0.224	3.465	0.932	8.852	1.906	3.201
Irrigation (A)	3	133.22*	542.53*	500.96*	507.28*	149.84*	513.93*	479.42*	484.89*
Error	6	2.318	8.340	2.665	3.301	1.756	12.060	8.383	2.677
Nitrogen (B)	3	359.44*	963.07*	903.21*	684.91*	315.24*	953.84*	601.26*	752.55*
Interaction (A×B)	9	47.308*	56.415*	31.448*	39.414*	52.857*	54.865*	34.984*	42.109*
Error	24	1.618	4.607	15.324	14.300	2.485	5.475	15.402	12.550
Weeding (C)	3	235.44*	694.97*	869.40*	804.34*	185.94*	658.58*	716.54*	852.90*
Interaction (A×C)	9	6.458*	28.680*	30.898*	25.494*	6.283*	30.839*	32.258*	27.423*
Interaction (B×C)	9	65.623*	163.35*	109.06*	139.77*	58.889*	169.11*	87.766*	147.18*
Interaction (A×B×C)	27	16.581*	22.336*	28.726*	28.414*	14.323*	21.838*	32.412*	28.621*
Error	96	2.776	12.697	9.017	10.158	3.277	12.175	11.893	9.230

*: Significant at 0.05 level of Probability

Appendix V. Analysis of variance of the data on number of tillers hill^{-1} at different DAT (days after transplanting) and harvest of BRRI dhan29 as influenced by nitrogen, weed and irrigation management

Source of variation	Degrees of freedom	Mean Square							
		Number of tillers hill^{-1} at year 2014-2015				Number of tillers hill^{-1} at year 2015-2016			
		30 DAT	50 DAT	70 DAT	Harvest	30 DAT	50 DAT	70 DAT	Harvest
Replication	2	0.041	0.632	0.047	0.263	0.035	0.884	0.069	0.317
Irrigation (A)	3	3.501*	38.210*	33.847*	35.103*	4.186*	37.233*	31.911*	34.577*
Error	6	0.098	0.602	0.236	0.243	0.063	1.004	0.625	0.174
Nitrogen (B)	3	10.071*	49.050*	61.270*	49.111*	8.824*	53.522*	41.101*	53.129*
Interaction (A×B)	9	1.317*	3.872*	2.459*	2.768*	1.446*	4.069*	2.408*	2.922*
Error	24	0.063	0.380	1.137	0.975	0.069	0.383	1.020	0.917
Weeding (C)	3	6.192*	36.091*	58.431*	55.698*	5.043	37.305*	48.409*	61.234*
Interaction (A×C)	9	0.184*	2.059*	2.074*	1.833*	0.373	2.307*	2.032*	1.996*
Interaction (B×C)	9	1.813*	6.509*	7.484*	9.819*	1.552*	7.812*	6.385*	10.581*
Interaction (A×B×C)	27	0.470*	1.704*	1.951*	2.005*	0.379*	1.797*	2.089*	2.113*
Error	96	0.088	0.961	0.626	0.706	0.103	0.929	0.837	0.653

*: Significant at 0.05 level of Probability

Appendix VI. Analysis of variance of the data on Leaf Area Index (LAI) at different DAT (days after transplanting) of BRRI dhan29 as influenced by nitrogen, weed and irrigation management

Source of variation	Degrees of freedom	Mean square					
		Leaf area index (LAI) 2014-2015			Leaf area index (LAI) 2015-2016		
		30 DAT	50 DAT	70 DAT	30 DAT	50 DAT	70 DAT
Replication	2	0.0001	0.004	0.035	0.002	0.002	0.067
Irrigation (A)	3	0.084*	0.858*	9.862*	0.095*	1.195*	10.661*
Error	6	0.001	0.027	0.280	0.002	0.033	0.392
Nitrogen (B)	3	0.127*	1.243*	14.441*	0.130*	1.214*	14.188*
Interaction (A×B)	9	0.007*	0.071*	0.729*	0.008*	0.096*	0.769*
Error	24	0.002	0.030	0.246	0.003	0.025	0.290
Weeding (C)	3	0.147*	1.470*	12.607*	0.145*	1.385*	12.803*
Interaction (A×C)	9	0.009*	0.146*	0.415*	0.026*	0.932*	0.545*
Interaction (B×C)	9	0.026*	0.253	1.776*	0.025*	0.284*	1.847*
Interaction (A×B×C)	27	0.008*	0.051*	0.865*	0.035*	0.068	1.282*
Error	96	0.003	0.035	0.197	0.004	0.046	0.271

*: Significant at 0.05 level of Probability

Appendix VII. Analysis of variance of the data on Total Dry Matter (TDM) m^{-2} at different DAT (days after transplanting) of BRRI dhan29 as influenced by nitrogen, weed and irrigation management

Source of variation	Degrees of freedom	Mean square					
		Total dry matter m^{-2} (g) 2014-2015			Total dry matter m^{-2} (g) 2015-2016		
		30 DAT	50 DAT	70 DAT	30 DAT	50 DAT	70 DAT
Replication	2	19.462	923.812	266.429	32.611	963.785	254.465
Irrigation (A)	3	3786.310*	61013.283*	186757.188*	4044.301*	63335.039*	188207.051*
Error	6	46.941	1372.999	739.302	42.721	1430.557	740.801
Nitrogen (B)	3	5769.611*	52874.340*	155843.006*	5877.681*	54662.906*	155947.922*
Interaction (A×B)	9	582.031*	6813.031*	5221.770*	560.708*	7069.780*	5222.418*
Error	24	40.090	701.322	2576.975	38.555	729.691	2578.663
Weeding (C)	3	3807.931*	45621.018*	167084.479*	3810.955*	47262.677*	167801.985*
Interaction (A×C)	9	184.626*	3478.521*	4768.099*	184.265*	3616.668*	8772.825*
Interaction (B×C)	9	899.436*	8954.553*	17195.040*	899.156*	9270.187*	17312.841*
Interaction (A×B×C)	27	198.038*	2833.857*	5378.883*	203.843*	2943.538*	5364.240*
Error	96	70.840	1756.172	2843.042	71.493	1829.289	2853.095

*: Significant at 0.05 level of Probability

Appendix VIII. Analysis of variance of the data on Crop Growth Rate (CGR), Relative Growth Rate (RGR) and Net Assimilation Rate (NAR) as influenced by nitrogen, weed and irrigation management

Source of variation	Degrees of freedom	Mean square											
		Crop Growth Rate-CGR (g $m^{-2}day^{-1}$)				Relative Growth Rate-RGR (mg $g^{-1}day^{-1}$)				Net Assimilation Rate-NAR (g $m^{-2}day^{-1}$)			
		2014-2015		2015-2016		2014-2015		2015-2016		2014-2015		2015-2016	
		30-50 DAT	50-70 DAT	30-50 DAT	50-70 DAT	30-50 DAT	50-70 DAT	30-50 DAT	50-70 DAT	30-50 DAT	50-70 DAT	30-50 DAT	50-70 DAT
Replication	2	1.694	5.245	1.658	5.300	0.678	3.753	0.540	3.592	0.427	0.137	0.283	0.124
Irrigation (A)	3	86.934*	86.772*	89.488*	84.036*	13.358*	1.896	11.854*	1.431	11.050*	1.305*	9.633*	1.081*
Error	6	2.381	4.188	2.567	4.206	1.787	4.709	1.942	4.499	0.614	0.140	0.626	0.121
Nitrogen (B)	3	59.604*	69.249*	62.146*	66.258*	2.072*	1.017	3.212*	0.895	5.656*	0.751*	5.645*	0.655*
Interaction (A×B)	9	9.851*	23.298*	10.469*	23.433*	4.487*	12.582*	4.539*	12.155*	1.947*	0.703*	1.881*	0.374*
Error	24	1.155	6.996	1.251	7.011	0.571	3.517	0.647	3.353	0.232	0.180	0.219	0.169
Weeding (C)	3	58.177*	95.251*	61.135*	92.410*	4.450*	2.665	4.657*	2.067	5.603*	1.299*	5.563*	1.138*
Interaction (A×C)	9	5.444*	34.488*	5.719*	24.578*	3.943*	13.424*	5.938*	19.046*	6.054*	1.387*	3.040*	1.356*
Interaction (B×C)	9	11.147*	27.732*	11.713*	27.632*	5.444*	4.202	4.408*	14.133*	4.962*	0.977*	3.952*	0.974*
Interaction (A×B×C)	27	9.272*	21.576*	6.453*	21.712*	6.889*	13.613*	7.842*	13.032*	5.095*	0.576*	1.036*	0.522*
Error	96	3.023	10.484	3.177	10.555	1.575	6.510	1.593	6.240	0.682	0.299	0.640	0.279

*: Significant at 0.05 level of Probability

Appendix IX. Analysis of variance of the data on number of effective, non-effective tillers $hill^{-1}$ and panicle length of BRRI dhan29 as influenced by by nitrogen, weed and irrigation management

Source of variation	Degrees of freedom	Mean square					
		Effective tillers $hill^{-1}$ (No.)		Non-effective tillers $hill^{-1}$ (No.)		Panicle length (cm)	
		2014-2015	2015-2016	2014-2015	2015-2016	2014-2015	2015-2016
Replication	2	0.174	0.256	0.013	0.004	0.019	0.019
Irrigation (A)	3	56.191*	54.866*	2.629*	2.547*	92.725*	97.267*
Error	6	0.274	0.176	0.030	0.028	0.342	0.442
Nitrogen (B)	3	87.439*	89.463*	5.684*	4.948*	164.348*	162.802*
Interaction (A×B)	9	2.292*	2.412*	0.158*	0.133	5.421*	5.207*
Error	24	0.980	0.846	0.025	0.026	0.367	0.398
Weeding (C)	3	75.957*	80.426*	1.603*	1.366*	116.865*	119.124*
Interaction (A×C)	9	1.541*	1.758*	0.225*	0.207*	1.367*	1.488*
Interaction (B×C)	9	7.592*	8.484*	0.213*	0.166*	3.171*	3.350*
Interaction (A×B×C)	27	1.917*	1.950*	0.091*	0.087*	2.414*	2.466*
Error	96	0.717	0.652	0.040	0.034	0.712	0.715

*: Significant at 0.05 level of Probability

Appendix X. Analysis of variance of the data on filled, unfilled, total grans panicle^{-1} and weight of 1000-grains of BRRI dhan29 as influenced by nitrogen, weed and irrigation management

Source of variation	Degrees of freedom	Mean square							
		Filled grains panicle^{-1} (No.)		Unfilled grains panicle^{-1} (No.)		Total grains panicle^{-1} (No.)		Weight of 1000-grains (g)	
		2014-2015	2015-2016	2014-2015	2015-2016	2014-2015	2015-2016	2014-2015	2015-2016
Replication	2	1.738	4.588	0.141	0.046	2.513	5.532	0.010	0.027
Irrigation (A)	3	1006.769*	995.483*	24.196*	22.976*	725.623*	722.663*	140.225*	141.844*
Error	6	6.610	7.693	0.272	0.244	6.478	8.295	0.937	0.979
Nitrogen (B)	3	1037.277*	973.225*	50.800*	45.022*	632.406*	604.655*	224.742*	222.339*
Interaction (A×B)	9	70.334*	81.986*	1.441*	1.200*	81.786*	93.545*	10.939*	10.913*
Error	24	17.634	16.691	0.243	0.236	18.357	18.189	0.771	0.728
Weeding (C)	3	1097.486*	1126.457*	14.883*	12.295*	858.576*	907.226*	155.267*	148.584*
Interaction (A×C)	9	31.569*	37.925*	2.142*	1.923*	44.648*	49.709*	2.679*	2.784*
Interaction (B×C)	9	208.388*	213.008*	1.935*	1.499*	241.540*	242.471*	5.261*	4.970*
Interaction (A×B×C)	27	41.560*	39.559*	0.795*	0.783*	45.770*	44.095*	5.000*	4.873*
Error	96	14.202	14.441	0.352	0.307	15.151	15.305	1.476	1.211

*: Significant at 0.05 level of Probability

Appendix XI. Analysis of variance of the data on grain, straw, biological yield and harvest index of BRRI dhan29 as influenced by nitrogen, weed and irrigation management

Source of variation	Degrees of freedom	Mean square								
		Grain yield (t ha^{-1})			Straw yield (t ha^{-1})		Biological yield (t ha^{-1})		Harvest index (%)	
		2014-2015	2015-2016	Pooled	2014-2015	2015-2016	2014-2015	2015-2016	2014-2015	2015-2016
Replication	2	0.0001	0.019	0.006	0.083	0.008	0.075	0.003	1.236	0.900
Irrigation (A)	3	12.130*	12.211*	12.166*	8.025*	7.978*	39.887*	39.899*	36.902*	37.246*
Error	6	0.031	0.051	0.037	0.173	0.231	0.216	0.249	3.195	4.728
Nitrogen (B)	3	23.575*	23.916*	23.741*	10.829*	10.581*	66.139*	66.146*	119.820*	120.533*
Interaction (A×B)	9	0.601*	0.613*	0.605*	0.801*	0.886*	2.481*	2.646	4.946*	4.913*
Error	24	0.052	0.064	0.056	0.106	0.132	0.175	0.218	2.164	2.551
Weeding (C)	3	18.600*	18.589*	18.594*	5.749*	5.656*	44.803*	44.575*	139.410*	133.361*
Interaction (A×C)	9	0.167*	0.200*	0.181*	0.373*	0.331*	0.655*	0.629*	6.814*	6.983*
Interaction (B×C)	9	0.471*	0.449*	0.458*	0.990*	1.025*	1.500*	1.477*	19.943*	20.047*
Interaction (A×B×C)	27	0.264*	0.269*	0.265*	0.411*	0.398*	1.101*	1.064*	30.524*	19.706*
Error	96	0.072	0.089	0.077	0.185	0.171	0.291	0.278	3.595	3.856

*: Significant at 0.05 level of Probability

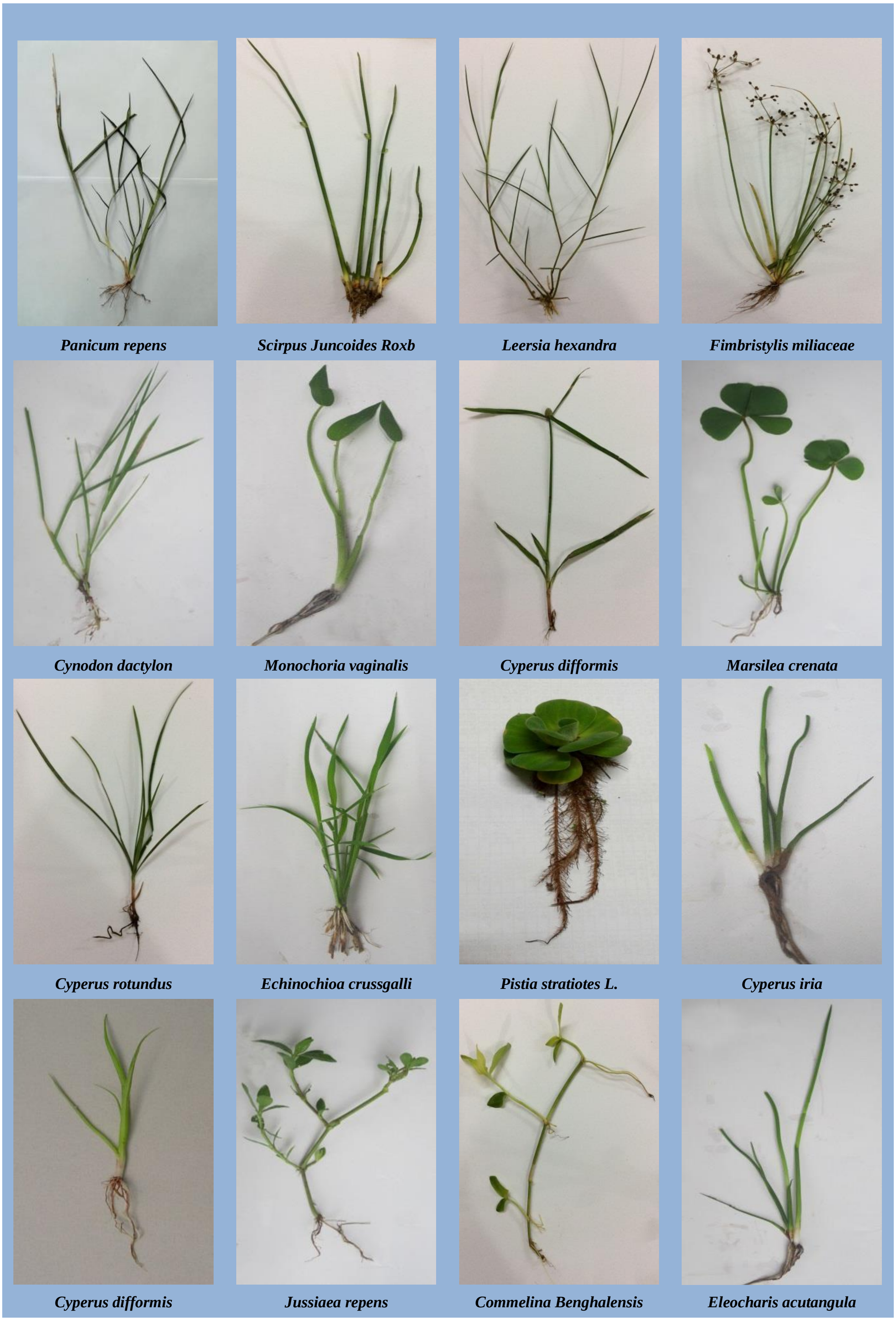


Plate 1. Different weed that was observed in the experimental plot.

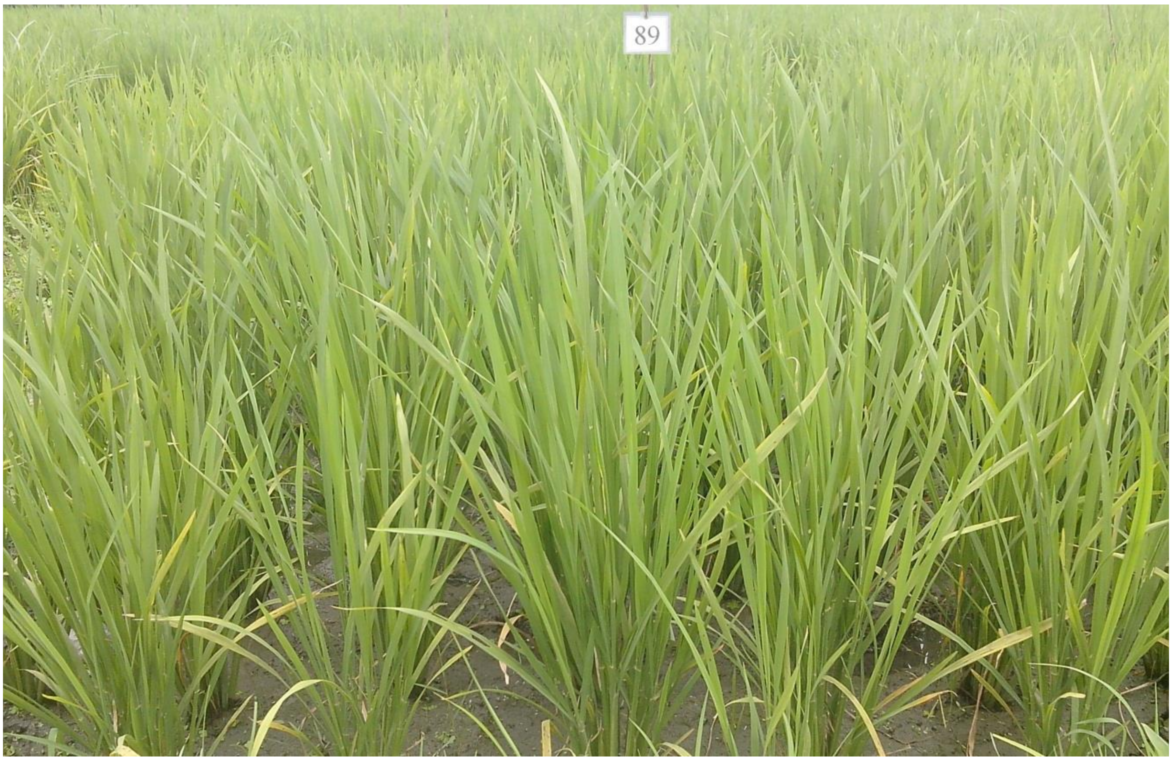


Plate 2. Urea super granules (2.7 g), Pre herbicide (Butachor) & AWD treated plot of Seedling Stage.

Plate 3. No Urea (Control), No weeding (Control) & Irrigation (Continuous) treated plot of Seedling Stage.

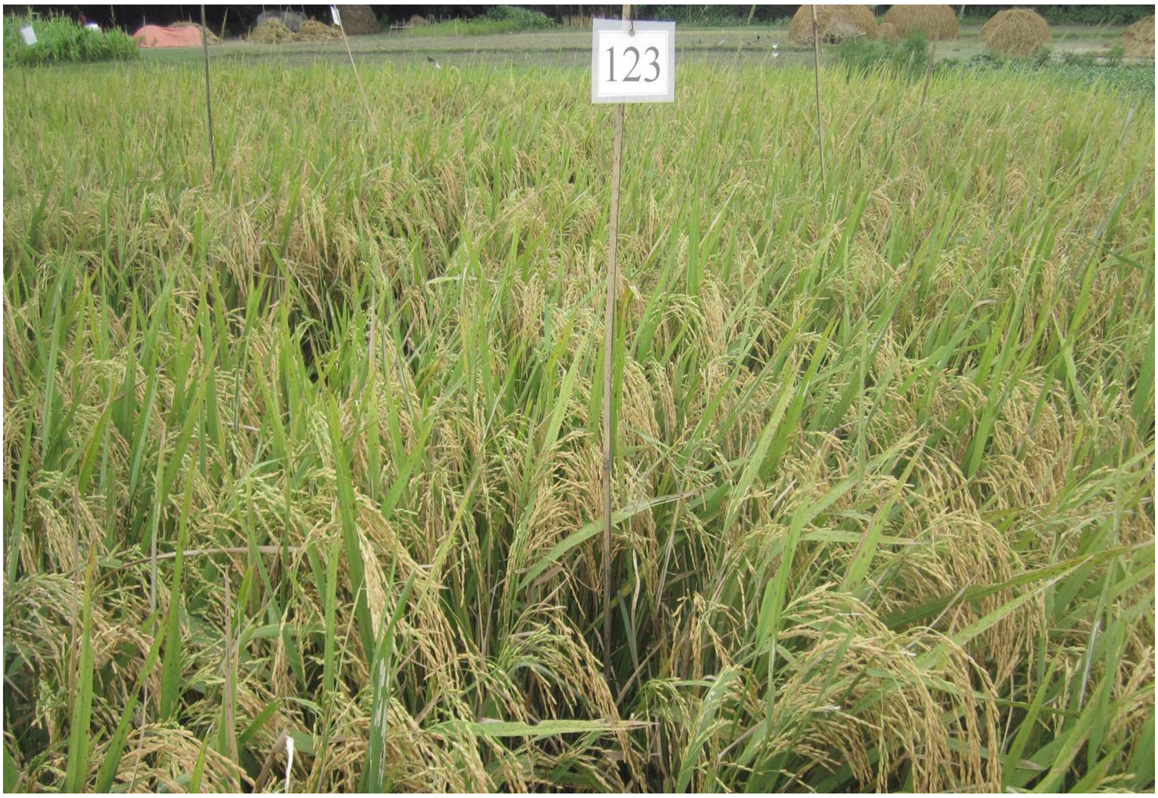


Plate 4. Urea super granules (2.7 g), Pre herbicide (Butachor) & AWD treated plot.

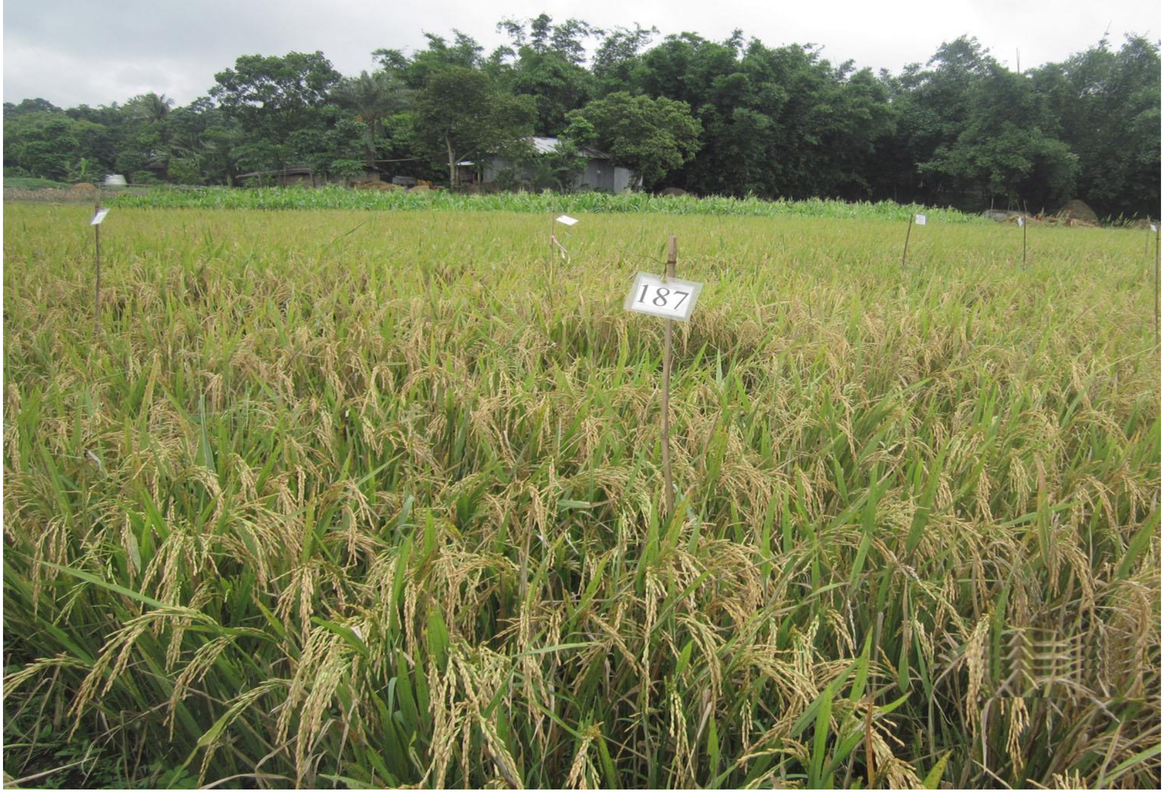


Plate 5. No Urea (Control), No weeding (Control) & Irrigation (Continuous) treated plot.

Plate 6. Using AWD pipe in experimental plot.

Plate 7. Experiment display board and Experiment field.