EFFICACY OF DIFFERENT LEVELS OF NITROGEN AND METHODS OF WEEDING ON THE GROWTH AND YIELD OF HYBRID BORO RICE

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CERTIFICATE

This is to certify that the thesis entitled ***"EFFICACY OF DIFFERENT LEVELS OF NITROGEN AND METHODS OF WEEDING ON THE GROWTH AND YIELD OF HYBRID BORO RICE"*** *submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of* ***MASTER OF SCIENCE IN AGRONOMY****, embodies the result of a piece of bonafide research work carried out by* ***SHIMUL CHANDRA SARKER, Registration No. 02-02040,*** *under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma.*

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

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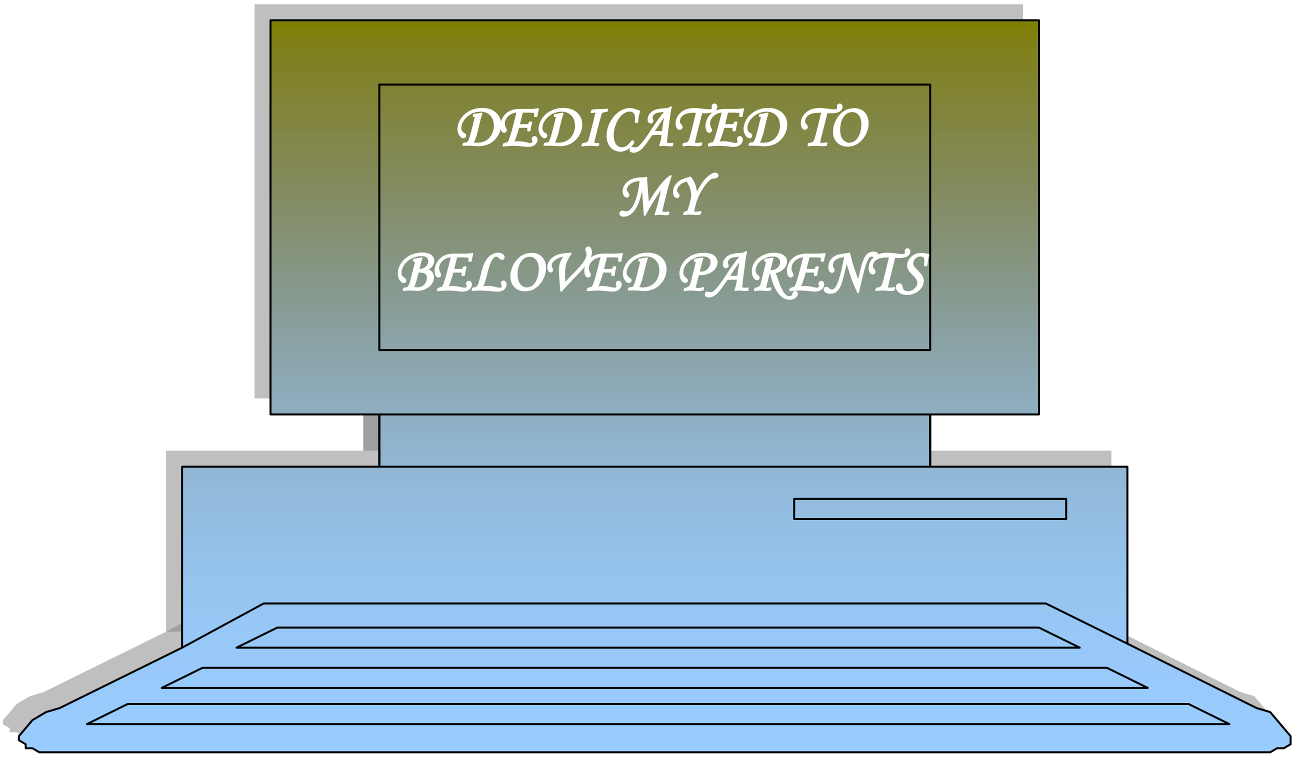
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ABSTRACT

The experiment was conducted at the Agronomy Field of Sher-e-Bangla Agricultural University, Dhaka during the period from December, 2011 to May, 2012 to study the efficacy of different levels of nitrogen (N) and methods of weeding on the growth and yield of hybrid boro rice (Heera 4). The treatments consisted of four N levels viz., N_o = 0 kg N ha^{-1}, N_1 = Urea super granules (2.7 g) @ 75 kg N ha^{-1}, N_2 = 140 kg N ha^{-1}, N_3 = 180 kg N ha^{-1} and five different weed control methods viz., W_0 =No weeding (Control), W_1= One weeding (30 days after transplanting), W_2= Two weeding (30 DAT & 50 DAT), W_3= Sunrice 50WG at recommended dose (100 g ha^{-1}), W_4=Topstar 80WG at the recommended dose (80g ha^{-1}). The experiment was laid out in a split-plot design with three replications having nitrogen doses in the main plots, weed control in the sub plots. Necessary intercultural operations were done as and when necessary. Nitrogen and weed control had significant influence on growth, yield and yield components of hybrid rice. The tallest plant was observed with urea super granules (USG). The maximum tillers number $hill^{-1}$(16.8), LAI (6.21), total dry matter (90.33g $hill^{-1}$), effective tillers $hill^{-1}$(13.40), the longest panicle (24.17cm) and number of filled grains $panicle^{-1}$(176.50) were obtained with USG. The maximum 1000-grain weight (29.20g) was obtained from USG treatment. The highest grain yield (8.10 t ha^{-1}) was obtained from Urea super granules. The lowest grain yield (5.44 t ha^{-1}) was observed in control. The highest straw yield and biological yield were observed in USG. The highest plant height (95.39cm), number of tillers $hill^{-1}$(15.22), LAI (6.47), CGR (3.30 g $hill^{-1}$ day^{-1}), effective tiller (11.61), panicle length (24.29cm) and filled grain $panicle^{-1}$ (173.00) were found in Sunrice 150WG. The highest total grain $panicle^{-1}$(185.48), 1000 grain weight (30.36g) were recorded from Sunrice 150WG. The highest yield (7.97 t ha^{-1}) was recorded from Sunrice 150WG and the lowest yield (5.79 t ha^{-1}) was obtained from no weeding treatment. The highest straw yield (10.68 t ha^{-1}) and biological yield (19.13 t ha^{-1}) were recorded from Sunrice 150WG. Significant highest (9.48 t ha^{-1}) grain yield was found from the combination of USG with Sunrice 150 WG and the lowest (4.66 t ha^{-1}) from combination of no nitrogen and no weeding.

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LIST OF ACRONYMS

AEZ	=	Agro- Ecological Zone
AIS	=	Agricultural Information System
BARC	=	Bangladesh Agricultural Research Council
BBS	=	Bangladesh Bureau of Statistics
BINA	=	Bangladesh Institute of Nuclear Agriculture
BRRI	=	Bangladesh Rice Research Institute
cm	=	Centimeter
cv.	=	Cultivar
CGR	=	Crop growth rate
CAR	=	Conventional application rate
DAT	=	Days after transplanting
^{0} C	=	Degree Centigrade
DF	=	Degree of freedom
DAP	=	Diammonium phosphate
DMA	=	Dry matter accumulation
DMRT	=	Duncan' Multiple Range Test
EC	=	Emulsifiable Concentrate
et al.	=	and others
etc.	=	Etcetera
FAO	=	Food and Agriculture Organization
FYM	=	Farmyard manure
g	=	Gram
GDP	=	Gross domestic product
HI	=	Harvest Index
HYV	=	High yielding variety
hr	=	hour
IRRI	=	International Rice Research Institute
Kg	=	kilogram
LV	=	Local variety
LAI	=	Leaf area index
m	=	Meter
m^2	=	meter squares
MPCU	=	Mussorie phos-coated urea

MV	=	Modern variety
MoP	=	Murate of potash
mm	=	Millimeter
viz.	=	namely
N	=	Nitrogen
NFAA	=	Nitrogen fertilizer application amount
ns	=	Non significant
%	=	Percent
CV %	=	Percentage of Coefficient of Variance
P	=	Phosphorus
K	=	Potassium
ppm	=	Parts per million
PU	=	Prilled urea
SAU	=	Sher-e- Bangla Agricultural University
S	=	Sulphur
SRDI	=	Soil Resource and Development Institute
SCU	=	Sulphur coated urea
SHR	=	Super hybrid rice
$t\ ha^{-1}$	=	Tons per hectare
USG	=	Urea supergranules
UDP	=	Urea deep placement
Zn	=	Zinc
TSP	=	Triple super phosphate
TDM	=	Total dry matter
$Kg\ ha^{-1}$	=	Kilogram per hectare

CHAPTER 1

INTRODUCTION

INTRODUCTION

Rice (*Oryza sativa L.*) is one of the most important cereal crops of the world, grown in wide range of climatic zones, to nourish the mankind (Chaturvedi, 2006). It is an excellent source of complex carbohydrates the best source of energy about 70% of direct human calorie intake, making it the most important food crop in Bangladesh (BBS, 2011).

The area and production of total rice in Bangladesh are about 11.53 million hectare and 33.91 million metric tons, respectively where boro covers the largest part of about 4.81 million hectare with the production 18.78 million metric tons. The area and production of hybrid rice in boro season were about 0.658 hectares and 33.01 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 few 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. The population of Bangladesh is still growing by two million every year and may increase by another 30 million over the next 20 years. Thus, Bangladesh will require about 27.26 million tons of rice for the year 2020. But the average yield of rice is poor (4.34 t ha^{-1}) in Bangladesh (BRRI, 2011). Whereas the average rice yield in China is about 6.30 t ha^{-1}, Japan is 6.60 t ha^{-1} and Korea is 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, attempts should be taken to increase the yield per unit area through use of comparatively high yielding varieties along with judicial 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. 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. Nutrient imbalance can be minimized by judicious application of different fertilizers.

The efficient N management can increase crop yield and reduce production cost. Inadequate and improper applications of N are now considered one of the major reasons for low yield of rice in Bangladesh. Nitrogen 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 nitrogen use efficiency is be in the range of 40 to 60 percent, application of nitrogen at right time is perhaps the simplest agronomic solution for improving the use efficiency of nitrogen (Ganga Devi *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). The utilization efficiency of applied N by the rice plant is very low. The submerged condition of wetland soils produces N losses through NH_3-volatilization, denitrification, leaching, surface runoff, and chemical fixation.

Nitrogen (N) is an essential nutrient of rice production, 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. Nitrogen 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*, 2001a). Rate and timing of nitrogen application are critical in terms of their effects on yield, nitrogen increase plant height, panicle number, leaf size, spikelet number and number of filled spikelets (Shakouri *et al*, 2012). According to Crasswell and De datta (1980) broadcast application of urea on the surface soil causes losses up to 50% but point placement of urea super granules (USG) in 10 cm depth results negligible loss.

Weeds are often called plants out of place. 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. The average yield of rice in Bangladesh is very low due to several constrains. Among them, weeds pose a major threat for increasing rice productivity. Uncontrolled weed growth caused significant loss of grain yield of rice (Hasanuzzaman *et a.*, 2007, 2008, 2009; Parthipan *et al.*, 2013). Any delay in weeding will lead to increased weed biomass as a result drastic reduction in yield.

Rice is very competitive against weed and therefore weed control is essential for rice production. Mamun (1990) reported that weed growth reduced the grain yield by 68-100% for direct seeded aus rice, 16-48% for transplanted aman rice and 22.36 % for modern boro rice. Subsistence farmers of the tropics spend more time and energy on weed control than any other aspects of rice cultivation. In Bangladesh the traditional methods of weed control practices include preparatory land tillage, hand weeding by hoe and hand pulling. But the availability of agricultural laborers has now decreased due to employment scope of the laborers in other sectors. Besides hand weeding is highly labor-intensive (as much as 190 person days ha^{-1}) (Roder, 2001).So it is not economically viable option for the farmer in rice production. Herbicides are the alternatives to hand weeding. On the other hand chemical methods creat many environmental pollution and negative impact on human health (Phuhong *et al*., 2005). However, herbicide selectivity and application dose may reduce the pollution in some extent. This issue needs to examine weed management practices that help keeping lower weed population and better control. Under this circumstance the present research work has been taken with the following objectives:

1. Evaluate the yield performance of hybrid rice cv. Heera 4.
2. Find out the optimum nitrogen dose that gives higher yield.
3. Study the effect of urea super granules on hybrid rice.
4. Identify the suitable weed control method for boro rice cultivation.
5. Observe the interaction effects of nitrogen dose and weed management on growth and yield performance of rice.

CHAPTER 2
REVIEW OF LITERATURE

REVIEW OF LITERATURE

Nitrogen and weed control are an important factor that influences the plant population unit area^{-1}, availability of sunlight, nutrient competition, photosynthesis, respiration etc. which ultimately influence the growth and development of the crops. Researcher's relevant to N fertilizer and methods of weeding effects on crop plants are done in different parts of the world are reviewed in this chapter.

2.1 Effect of nitrogen

2.1.1 Effect on growth character

2.1.1.1 Plant height

Salem (2006) reported that, the N levels had a positive and significant effect on growth parameters of rice plants in boro season. Increasing_N levels up to 70 kg ha^{-1} significantly increased plant height. The highest plant height at harvest was recorded about 92.81 cm when rice plants were fertilized with the highest N level of 70 kg ha^{-1}. On contrary, the lowest value of the height was recorded about 80.21 cm when rice plants received no N fertilizer.

Ahmed *et al*. (2005) observed that among 5 levels, 80 kg N ha^{-1} gave the highest plant height (155.86 cm) and the height decreased gradually with decreased levels of N fertilizer application.

Meena *et al*. (2003) reported that between two levels of N 100 and 200 kg ha^{-1}, application of 200 kg ha^{-1} significantly increased the plant height (127.9 cm) of rice and total number of tillers hill^{-1} (16.3).

Ravisankar *et al*. (2003) conducted a field experiment during the 2000 and 2001 rainy seasons in Port Blari, Andaman and Nicobar Island, India to study the effect of rice cv. Mansarovar cultivated wider lowland conditions. The treatments comprised no N, 30 kg N ha^{-1} at basal, 30 and 70 days after planting (DAP); 45 kg N ha^{-1} at 30 and 70 DAP, 32 kg N ha^{-1} at basal, 30 and 70 DAP and 25 kg N ha^{-1} at panicle initiation stage, 4.5% controlled release N at 60% of the recommended dose and 6.0% controlled release N at 6o% of the recommended dose. The longest plant at harvest (106 cm) was obtained with T_3 treatment.

Lawal and Lawal (2002) disclosed that N (120 kg ha^{-1}) significantly increased plant height. A basal N application increased the plant height significantly.

Ebaid and Ghanem (2000) conducted a field experiment during the year of 1996-97 to find out the productivity and also the plant height of Giza 177 rice (*Oryza sativa*), N fertilizer was applied to the rice crop at the rate of 0, 96 and 144 kg N ha^{-1} in urea form and they found that increasing N level up to 144 kg ha^{-1} significantly increased plant height.

Mishra *et al*. (2000) carried out a field experiment in 1994-95 in Bhubaneswar, Orissa, India, and reported that rice cv. Lalate was given 76 kg N ha^{-1} as USG at 0, 7, 14 for 21 days after transplanting (DAT), and these treated control. N increased plant height, panicle length, N up take and consequently the grain and straw yields of lowland rice. Best results were obtained with USG applied 14 DAT.

Idris and Matin (1990) noted that plant height of rice increased up to 120 kg N ha^{-1} compared to the control and there after the height declined at 140 kg N ha^{-1}.

2.1.1.2. Tillering pattern

BRRI (2008a) conducted an experiment to study of some promising lines with BRRI modern rice varieties to different N levels viz. 0, 30, 60, 90, 120 and 150 kg N ha^{-1}. It was reported that tiller production with N @ 120 kg ha^{-1} produced significantly higher tiller than those of lower N levels.

BRRI (2006) reported that the maximum tillers $hill^{-1}$ (10.2) was produced with 120 kg N ha^{-1} compared to 90 and 0 kg N ha^{-1} application.

A field experiment was conducted by Lang *et al.* (2003) to study the effect of different fertilizer application rates on seedling of Jinyou 207, Guihuanian and Teyou 524 were sown in no-tillage plots situated in 3 different counties in Guangxi, China. At an early stage of growth, the seedlings were subjected to one of three N fertilizer treatments. Treatment A used a conventional application rate

(CAR) of 157-5-172.5 kg N ha^{-1}, treatments B and C used CAR + 10% and CAR + 20%, respectively. They found that the increase in N fertilizer application rate increased the speed of seedling establishment and tillering peak.

Wang *et al*. (2002) reported that the tiller number increased with increasing N levels.

Lawal and Lawal (2002) carried out 3 field experiments during the rainy season of 1996, 1997 and 1998 in Nigeria to evaluate the growth and yield response of low land rice to varying N rates and placement methods. The treatment consisted of 4 N rates (0, 40, 80 and 120 kg ha^{-1}) and 2 fertilizer placement method of (deep and surface placement). They found that application of 80 kg N ha^{-1}significantly increased the number of tillers $hill^{-1}$. Singh and Singh (2002) recorded that increasing levels of N significantly increased total tiller $hill^{-1}$.

Ehsanullah *et al*. (2001a) carried out a field experiment to determine the effect of various methods of N application for increasing N use efficiency in fuse rice (*Oryza sativa* L.) using cv. supper Basmati. They found that the application of 100 kg N ha^{-1} showed the maximum number of tillers $hill^{-1}$ and 75 kg N ha^{-1} showed minimum tillers $hill^{-1}$. Similarly application of N by incorporating in between hills wrapped tissue paper produced more tillers $hill^{-1}$ than other treatments and the differences were significant.

Kumar and Subbaiah (2001) noted that application of DAP + urea resulted in the highest number of tillers m^{-2}.

Munnujan *et al*. (2001) conducted a field experiment at Gazipur in 1993 to determine the effects of N fertilizer and planting density on growth and yield of long grain rice. Tillers $plant^{-1}$ increased linearly with the increase in N fertilizer levels.

2.1.1.3 Leaf area index

Masum *et al*. (2008) conducted an experiment to study the effect of four levels of seedling $hill^{-1}$ viz; 1, 2, 3 and 4 and two forms of N – prilled urea (PU) and USG on yield and yield components of modern (BRRI dhan44) and traditional

(Nizershail) transplant aman rice. They reported that leaf area index significantly higher in USG receiving plant than prilled urea.

Hamidullah *et al*. (2006) conducted an experiment on growth and yield performance of BINA dhan 5 in boro season as affected by N levels viz. 80, 120 and 160 kg N ha^{-1}. They reported that leaf area index was peak at 60 DAT and decline thereafter, highest 5.53 obtained with 160 kg N ha^{-1} at 60 DAT. Miah *et al*. (2004) found that LAI was significantly higher in USG receiving plots than urea at heading.

A field test with the super hybrid rice (SHR) combination Liangyoupeijiu was conducted by Tang *et al*. (2003) in Changsha, Hunan, China. Nine treatments were used, including 0, 60, 120, 180, 240, 180, 130, 225 and 160 kg N ha^{-1}. They reported that higher N fertilizer application amount ensured a higher leaf area index.

2.1.1.4. Total dry matter production

Xia *et al*. (2007) reported that increased split application of N from control to 140 kg N ha^{-1}increased dry matter accumulation (DMA) of different growth stages of Jinzao22 and Shanyou63 rice varieties and after that dose the DMA reduced due to the losses of N by volatilization. Sing and Modgal (2005) noted that dry matter accumulation (DMA) and concentration and uptake of N increased with increasing level of N at all the stages of crop growth. Miah *et al.* (2004) noted that USG applied plots gave higher TDM compared to urea irrespective of number of seedling transplanted $hill^{-1}$.

Fu *et al*. (2000) conducted a field experiment in Zhejiang Province, China to evaluate the N fertilizers (0, 100, 150, 180, 225, 270, and 300 kg N ha^{-1} as urea, two-thirds top-dressed as basal and one third top dressed 7 days after transplanting, on dry matter and N partitioning in hybrid rice 518. They reported that higher N applications significantly increased dry matter partitioning of leaf at the vegetative stage. Partitioning of dry matter to leaves decreased as the N concentration in the leaves decreased. Leaf partitioning of absorbed N, compared to dry matter, was higher and varied little during early vegetative growth, but varied greatly from panicle initiation onwards, probably due to competition for N among leaves, stem and the developing panicle.

A field experiment was conducted by Geethadevi *et al*. (2000) in Karnataka, India to determine the effect of different N rates (0, 50, 100 and 150 kg N ha^{-1}) and spacing (15 cm x 10 cm or 20 cm x 10 cm) on the growth and yield of hybrid rice. Among N rates, treatment with 150 kg N ha^{-1} recorded the highest values for total dry matter per plant (57.08 g).

2.1.1.5 Crop growth rate:

A field experiment was conducted by Das and Panda (2004) in Bhubaneswar, Orissa, India, to study the effects of N (0, 60, 120 or 180 kg ha^{-1}) and K (0, 40, 80 or 120 kg ha^{-1}) on the growth rate of hybrid rice 6102. N (urea) was applied as a basal dressing (25%), and as a top dressing at 18 days after transplanting (DAT; 50%) and at the panicle initiation stage (25%). K (K_2O) was applied during transplanting. Irrespective of treatment difference, Crop growth rate (CGR) was greater at 40-60 DAT and lower at 20-40 DAT. The increase in the N rate increased CGR. The highest CGR (22.52 g m^{-2}) was obtained with 80 kg K_2O ha^{-1}.

2.1.2 Effect on yield contributing character

2.1.2.1 Effective tillers $hill^{-1}$

Awan *et al.* (2011) conducted an experiment to study the effect of different N levels (110, 133 and 156 kg N ha^{-1}) in combination with different row spacing (15 cm, 22.5 cm and 30 cm). They noted that maximum level of N (156 kg N ha^{-1}) produced maximum effective tillers irrespective of spacing.

A field experiment was conducted by Singh and Shivay (2003) at the Research Farm of the Indian Agricultural Research Institute, New Delhi, India to study the effect of coating prilled urea with eco-friendly neem formulations in improving the efficiency of N use in hybrid rice. Two rice cultivars, hybrid rice (NDHR-3) and Pusa Basmati-1, formed the main plots, with the levels of N (0, 60, 120 and 180 kg N ha^{-1}) and various forms of urea at 120 kg N ha^{-1} in the subplots. They found that increasing levels of N significantly increased the number of effective tillers $hill^{-1}$.

Meena *et al.* (2002) studied the response of hybrid rice to N (0, 100 and 200 kg ha^{-1}) and potassium application (0, 75 and 150 kg ha^{-1}) at the research farm of the IARI, New Delhi. They observed that application of N significantly increased the effective tillers.

Bayan and Kandasamy (2002) noticed that the application of recommended rates of N in four splits at 10 days after sowing, active tillering, and panicle initiation and at heading stages recorded significantly lower dry weight of weeds and increased crop growth viz. effective tillers m^{-2}.

2.1.2.2 Panicle length

Hasanuzzaman *et al.* (2009) conducted an experiment to study the economic and effective method of urea application in rice crop. They noted that urea supergranules produced longest panicle (22.3 cm).

Islam *et al*. (2008) conducted an experiment to study the effect of N and number of seedlings per hill on the yield and yield components of T. aman rice (BRRI dhan 33). They noted that panicle length, number of grain $panicle^{-1}$ increased with the application rate of N up to 100 kg ha^{-1} and then declined. Singh and Shivay (2003) found that increasing levels of N significantly increased the panicle length. Meena *et al*. (2002) observed that increase in N fertilizer application rate enhanced length and weight of panicles of hybrid rice. Ebaid and Ghanem (2000) indicated that increasing N levels up to 144 kg N ha-1 significantly increased panicle length of rice. El-Batal *et al*. (2004) showed that increasing N rate from 50 to 80 kg ha^{-1} significantly increased panicle length. Sarkar *et al*. (2001) conducted a field experiment during the kharif 1995 in West Bengal, India to evaluate the performance of 3 rice cultivars (IET 12199, IET 10664 and IET 15914) treated with 5 different N fertilizer levels (0, 40, 80, 120 and 160 kg ha^{-1}). IET 12199, treated with 80 kg N ha^{-1} gave the highest values for panicle length (25.77 cm); IET 10664 and IET 15914 also performed well.

Freitas *et al*. (2001) conducted a field experiment in Mococa, Sao, Paulo, Brazil during 1997-98 and 1998-99 to evaluate the response of three new rice cultivars (IAC- 10 1, IAC-102 and IAC 104) grown under irrigated conditions N fertilizer was applied as urea (at the rate of 0, 50, 100 and 150 kg ha^{-1}) 33% at seedling transplantation, and 33% at 20 and 40 days. They found that panicle length of three cultivars was significantly affected by N treatments.

2.1.2.3 Filled grains panicle^{-1} and unfilled grains panicle^{-1}

Masum *et al*. (2010) reported that placement of N fertilizer in the form of USG @ 58 kg N ha-1 produced the highest number of effective tillers hill^{-1}, filled grains panicle^{-1} which ultimately gave the higher grain yield than split application of

BRRI (2006) found that increasing level of N increased the number of spikelet panicle-1 of rice and the highest number of spikelet panicle^{-1} (82.2) was obtained with 120 kg ha^{-1} compared to 90 and 0 kg ha^{-1} urea respectively.

A field experiment was conducted by Edwin and Krishnarajan (2005) to study the effects of irrigation and N fertilizer treatments on the yield of rice hybrid variety CoRH2 in Coimbatore, Tamil Nadu, India. They suggested that N supplied at 7 DAT, 21 DAT, panicle initiation stage and first flowering stage gave the highest filled grains.

Lang *et al*. (2003) found that the increase in N fertilizer application rate enhanced grains per panicle, effective panicles per plant, and total florets per plant.

Subhendu *et al*. (2003) conducted an experiment to evaluate the effect of N split application (during transplanting, tillering and panicle initiation, transplanting, tillering, panicle initiation and 50% flowering and 10 days after transplanting, panicle initiation and botting) on the yield and yield components of rice cultivars BRT-5204, MTU-1010 and IR-64 in Rajendranagar, Hyderabad, Andhra Pradesh, India. They found that the application N (120 kg ha^{-1})as urea in equal splits during transplanting, tillering, panicle initiation and tillering flowering resulted in the highest number of grains panicle^{-1} (89.8) in MTU-1010.

Meena *et al*. (2002) noted that increase in N fertilizer application rate enhanced number of grains and filled grains of hybrid rice. Ehsanulla *et al*. (2001) pointed out that the N level of 125 kg ha^{-1} produced maximum number of grains panicle^{-1}.

2.1.2.4 1000 grain weight

Maitti *et al*. (2003) reported that the application of 140 kg N ha^{-1} resulted in the highest increase in grain yield (by 76.2%), number of panicles (by 109.00%), number of filled grains per panicle (by 26.2%), and 1000-grain weight (5.80%) over the control.

Meena *et al*. (2002) reported that increase in N fertilizer application rate increased 1000-grain weight of hybrid rice.

Hasan *et al*. (2002) determined the response of hybrid (Sonar Bangla-1 and Alok 6201) and inbred (BRRI dhan 34) rice varieties to the application methods of urea supergranules (USG) and prilled urea (PU) and reported that the effect of application method of USG and PU was not significant in respect of panicle length, number of unfilled grains panicle^{-1} and 1000-grains weight.

Ahmed *et al*. (2000) conducted a field experiment to study the effect of point placement of urea supergranules (USG) and broadcasting prilled urea (PU) as sources of N in T. aman rice. USG and PU were applied @ 40, 80, 120 or 160 Kg N ha^{-1}. They suggested that USG was more efficient than PU in producing panicle length, filled grains panicle^{-1} and 1000-grain weight.

2.1.3 Effect on grain yield and straw yield

BRRI (2009) conducted an experiment on study of N release pattern from USG and prilled urea under field condition and its effect on grain yield and N nutrition of rice with three doses of N namely 50, 100 and 150 kg N ha^{-1}from two types of urea e.g. prilled (PU) and urea super granules (USG) were tested as treatment.

Result showed that the highest grain yield was recorded when N applied @ 100 kg N ha-1 both from USG and PU and the highest straw yield was obtained in PU @ 150 kg N ha^{-1}.

Kabir *et al*. (2009) conducted an experiment to find out the effect of urea super granules (USG), prilled urea (PU) and poultry manure (PM) on the yield and yield contributes of transplant aman rice. They observed that the highest grain yield (5.17 t ha^{-1}), straw yield (6.13 t ha^{-1}) and harvest index (46.78%) were found from full dose of USG.

BRRI (2008b) conducted an experiment on the title of response of MVs and hybrid entries to added N in a rice cropping pattern. Six N doses 0, 40, 80, 120, 160 and 120 kg N ha^{-1} were tested and resulted that grain yield of hybrid responded up to 120 kg N ha^{-1}.

Lin *et al*. (2008) conducted an experiment to find out the effect of plant density and N fertilizer rates (120, 150, 180 and 210156 kg N ha^{-1}) on grain yield and N uptake of hybrid rice. They observed that there was a better response to N fertilization, as increasing N application from 120 to 180 kg N ha^{-1} (by 50%) raised yield by 17%. Raising the application rate to 210 kg N ha^{-1} (by 75%) boosted yield by 24.1%.

Field experiments were conducted by Wan *et al*. (2007) in China to study the effects of different N (N) fertilizer application regimes (basal and panicle applications) on the yield, quality and N use efficiency of super japonica hybrid rice cv. Changyou 1. They indicated that yield was significantly influenced by the different N fertilizer application regimes. The regime with the highest yield was at the basal to panicle application ratio of 58.34:41.66 and equal split panicle applications at the fourth and second leaf age from the top.

A study was conducted by Mubarak and Bhattacharya (2006) under the Gangetic alluvial soil of West Bengal, India, to investigate the response of hybrid rice cultivars to various levels of N and potassium. Significantly higher values for growth and grain yield were obtained with the application of 150:60:80 kg NPK ha^{-1}, which was at par with 150:60:40 kg NPK ha^{-1}.

A study was conducted by Ingale *et al*. (2005) to determine the effects of seedling ages at transplanting (25, 40 and 55 days), number of seedlings per hill (one or two) and N rates (50, 100 and 150 kg ha^{-1}) on the yields of Sahyadri rice hybrid. They found that the application of 150 and 100 kg N ha^{-1}resulted in significantly higher yields than treatment with 50 kg N ha^{-1}.

Saito *et al*. (2005) conducted an experiment to evaluate three traditional and three improved cultivars which were grown under four fertilizer treatments: no added fertilizer, N only (N; 90 kg N ha^{-1}), phosphate only (P; 50 kg P ha^{-1}), and N and P (NP) at three locations. The two improved cultivars, IR55423-01 and B6144-MR-6-0-0 out-yielded traditional cultivars in all locations and fertilizer treatments. N fertilizer application increased grain yields of the two improved cultivars from 3.1 to 4.0 t ha^{-1} while increasing those of traditional cultivars from 1.6 to 1.9 t ha-1.

A field experiment was conducted by Rakesh *et al*. (2005) at Research farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh, India, to determine the response of hybrid rice cv. MPH-501 to different N (40, 80, 120 and 160 kg N ha^{-1}) and potassium levels (30, 60, and 90 kg K_2O ha^{-1}). The application of 160 kg N and 60 kg K_2O ha^{-1}significantly influenced the growth and yield attributes of hybrid rice and produced higher grain and straw yield.

N fertilizer when applied as USG was reported to have increased grain yield by around 18% and saved around 32% N in wetland rice over prilled urea and appeared to be a good alternative N fertilizer management for rice production (Annon., 2004).

A field experiment was conducted by Upendra *et al*. (2004) at Pusa, Bihar, India to evaluate two newly developed rice hybrids (KHR2 and DRRH1) and one local control (Boro 5) growth under 10 different N-potassium (NK) fertilizer levels. Data were recorded for plant height, effective tillers m^{-2}, panicle length, test weight, grain yield, straw yield, harvest index and benefit: cost ratio. Both rice hybrids performed better than the local cultivar. Yield and related characters increased with increasing fertilizer levels up to 150 kg N ha^{-1} and 80 kg K ha^{-1}.

A study was conducted by Verma *et al*. (2004) in Madhya Pradesh, India to investigate the effect of planting date (20 July; and 5 and 20 August) and N rates (50, 100 and 150 kg ha^{-1}). They reveled that N at 100 and 150 kg ha^{-1} resulted in the highest yield.

Singh and Shivay (2003) found that increasing levels of N significantly increased the grain and straw yields.

Maitti *et al*. (2003) reported that the application of 140 kg N ha^{-1} resulted in the highest increase in grain yield.

A field experiment was conducted by Balasubramanian (2002) in Madurai, Tamil Nadu, India to study the effect of levels (0, 150, 200 and STCR-based N) and time of application (3 or 4 splits) of N on 'CoRH 1' hybrid rice. Hybrid rice recorded good response to N up to 256.7 kg ha^{-1} (STCR-based N). Higher levels of N improved the growth and yield of rice. The STCR-based N applied in 4 splits (basal, active tillering, panicle initiation and panicle emergence) registered the maximum grain yield, followed by 200 kg N ha^{-1} applied in 4 splits.

A field experiment was conducted by Devasenamma *et al*. (2001) in Andhra Pradesh, India to study the performance of rice hybrids (APHR-2, DRRH-1, MGR-1, TNRH-16 and NLR-33358) at various N fertilizer rates (0, 60, 120 and 180 kg ha^{-1}). The highest values for yield and yield components were obtained with 180 kg N ha^{-1}.

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.

2.2.1 Effect on weed population and weed control efficiency

Supplementing herbicide application with manual weeding in dry seeded rice fields can help to control weeds more effectively. To test this assumption, pre and post-emergence herbicides applied either alone or supplemented with manual weeding were evaluated in a field study. Pendimethalin at 1137 g a.i. per ha as pre-emergence (0 DAS), bispyribac sodium, penoxsulam, pyrazosulfuron ethyl and ethoxysulfuron ethyl at 30, 15, 30 and 30 g a.i. per ha, respectively, as early post emergence (15 DAS) were applied alone and supplemented with manual weeding (hoeing/pulling, 30 DAS). A weedy check and manual weeding thrice (15, 30 and 45 DAS) were included for comparison. Data on weed dynamics and crop attributes were recorded following standard procedures. Weed density and biomass was significantly reduced under sole application of herbicides; nonetheless supplementing herbicides with manual weeding further reduced both of these attributes to a much larger extent. Bispyribac sodium recoded higher weed suppression when it was followed by manual weeding. Positive efficiency indices of different weed management treatments were also observed in the study (Khaliq *et al.*, 2013).

Al-Mamun *et al.* (2011) carried out an experiment at the Agronomy Farm of Bangladesh Rice Research Institute, Gazipur, During December 2008 to June 2009 in winter season on Surjamoni and BRRI dhan29 and observed that *Paspalum distichum* was the dominating weed species in the experimental site.

Biswas *et al.* (2011) conducted a field experiment at Agronomy field of Sher-e-Bangla Agricultural University, Bangladesh during December 2010 to May 2011 including 16 popular inbred and hybrid rice varieties. They concluded that at 30 DAT, the significantly highest weed population of 119.00 and 117.00 m^{-2} was found in BRRI dhan29 and BRRI dhan45 respectively whereas BR3 and BRRI dhan50 resulted the lowest weed population of 31.00 and 38.00 m^{-2} respectively.

Similar lowest weed population i.e. 35.33 and 36.00 m^{-2} was also found in BRRI dhan50 and BRRI hybrid dhan1 respectively at 60 DAT.

Bhuiyan *et al.* (2010) conducted an experiment during *boro* 2006 at Gazipur and Comilla location for the control of mixed weed flora in transplanted rice (*Oryza sativa L.*) and reported that *Cynodon dactylon*,*Scirpus maritimus*, *Monochoria vaginalis*,*Cyperus difformis*, *Fimbristylis miliacea*, *Cyperus iria*, *Marsilea quadrifolia* and *Alternanthera philoxeroides* were the major weeds in the experimental plots.

Reza *et al.* (2010) carried out an experiment at the Agronomy Field Laboratory, Bangladesh Agricultural University (BAU), Mymensingh, during the period 9 from January to April 2008 and found eight weed species to infest the crop were *Echinochloa crusgalli, Scirpus mucronatus, Cyperus difformis, Panicum repens, Digitaria ischaemum, Monochoria vaginalis, Leersia hexandra* and *Marsilia quadrifolia.* Among the weed species, *E. crusgalli* was the dominant one. They reported that the higher weed dry matter accumulation per unit area (7.98 g m^{-2}) was obtained from shorter variety, BRRI dhan28 and the lower weed dry weight (5.51 g m^{-2}) from the taller variety, Pajam.

Salam *et al.* (2010) carried out a field experiment at the Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh, to evaluate the effect of herbicide on growth and yield in *boro* rice (Binadhan-5).Ten weed species belonging to four families namely Angta, Chechra, Arail, Joina, Durba, Panee kachu, Sabuj nakphul, Shusni shak, Holud mutha and Khudeshama were found to grow in the experimental plots.

Hasanuzzaman *et al.* (2007) reported that 16 different weed species were observed in transplanted *aman* rice field where *Sagittaria guyanensis* and *Sphenoclea zeylanica* were the most dominant species. Chandra and Pandey (2001) stated that weed competition was severe in scented paddy culture, in view of its early slow growth rates.

2.2.2. Effect on growth characters

2.2.2.1 Plant height

Khan and Tarique (2011) carried out an experiment during June to December 2006 and observed that the longest plant was observed in completely weed free condition throughout the crop growth period. On the other hand, plant height appeared next to the highest was found in two hand weeding treatment. However, lowest value was observed in no weeding treatment.

Hassan *et al*. (2010) carried out a field experiment on transplant aman rice cv. BRRI dhan41 and observed that highest plant height was recorded from the treatment combination of three hand weeding regimes with two seedlings hill^{-1} in most of the evaluated traits. The weakest treatment combination was the no weeding with five seedlings hill^{-1}.

Hasanuzzaman *et al*. (2008) stated that Ronstar 25EC @ 1.25 L ha-1 + IR5878 50 WP @ 120 g ha^{-1}was most efficient that influenced plant height according to the effectiveness of the treatments.

Hasanuzzaman *et al*. (2007) conducted an experiment on transplanted (T) ‘aman’ rice at the Sher-e-Bangla Agricultural University Farm, Dhaka, Bangladesh during July-November, 2006 and stated that plant height was significantly affected by different weeding treatments.

2.2.2.2 Tillering pattern

Khan and Tarique (2011) carried out an experiment and observed that highest total tillers plant^{-1} was observed in completely weed free condition throughout the crop growth period. On the other hand, total tillers plant^{-1} that appeared next to the highest was found in two hand weeding treatment. However, shorter plant was found in no weeding treatment.

Hassan *et al*. (2010) carried out a field experiment on transplant aman rice cv. BRRI dhan41 and recorded data on total effective tillers hill^{-1}. Highest value was recorded from the treatment combination of three hand weeding regimes with two seedlings hill^{-1} in most of the evaluated traits. The weakest treatment combination was the no weeding with five seedlings hill^{-1}.

2.2.2.3 Crop growth rate and relative growth rate

Salehian *et al*. (2012) conducted an experiment to determine the most important yield related traits and competition with weeds in rice cultivars by path analysis to study the relative characteristics with growth of weeds in four different rice cultivars and two treatments of competition. Results showed that between cultivars, mean crop growth rate of Fajr cultivar (CGR=7.39 g m^{-2} d^{-1}) in this experiment was more than Ghaem (CGR=7.39 g m^{-2} d^{-1}).

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 hand weeding at 15 and 40 days after transplanting (DAT), one weeding with BRRI push weeder at 15 DAT + one hand weeding at 40 DAT, pre-emergence application of M.Chlor 5G (Butachlor) at 5 DAT + one hand weeding at 40 DAT, pre-emergence application of Oxastar 25 EC (Oxadiazon) at 5 DAT + one hand weeding at 40 DAT, pre- emergence application of Rifit 500EC (Pretilachlor) at 5 DAT + one hand weeding at 40 DAT and three plant spacing’s viz. 20cm x 10cm, 25cm x 15cm and 30cm x 20cm. It was evident that among the weed control treatments, Pretilachlor + one hand weeding gave the highest crop growth rate (0.71 g hill^{-1}day^{-1}) at 45-60 DAT.

2.2.3.Effect on yield contributing character

2.2.3.1 Effective tillers hill^{-1}

Hassan *et al*. (2010) carried out a field experiment on transplant aman rice cv. BRRI dhan41 and found that highest number of effective tillers hill^{-1} was recorded from the treatment combination of three hand weeding regimes with two seedlings hill-1 in most of the evaluated traits. The weakest treatment combination was the no weeding with five seedlings hill^{-1}.

Hasanuzzaman *et al*. (2008) stated that Ronstar 25EC @ 1.25 L ha^{-1} + IR5878 50 WP @ 120 g ha^{-1} was the most efficient for the number of effective tillers hill^{-1} according to the effectiveness of the treatments.

2.2.3.2Effect on panicle length and grain

Khan and Tarique (2011) observed that the effects of weeding regimes were significant in respect of yield and most of the characters. The longest panicle and heavier 1000 grain weight were observed in completely weed free condition throughout the crop growth period. On the other hand, values that appeared next to the highest were found in two hand weeding treatment. However, panicle length and heavier 1000 grain weight were lowest in no weeding treatment.

Hassan *et al*. (2010) recorded the highest value of 1000 grain weight from the treatment combination of three hand weeding regimes with two seedlings hill^{-1} in most of the evaluated traits. The weakest treatment combination was the no weeding with five seedlings hill^{-1}.

Ashraf *et al*. (2006) conducted an experiment in Lahore, Pakistan, during 2004 and 2005 kharif seasons, for screening of herbicides for weed management in transplanted rice (cv. Basmati-2000) and observed that the highest number of grains panicle^{-1} (135.50) was obtained from hand weeding treatment.

2.2.3.3 Total dry matter production

Bhuiyan *et al*. (2011) conducted a field experiment to evaluate the performance of different weed management options regarding effective weed control, yield and yield contributing characters of three popular BRRI aman varieties having different growth duration (BRRI dhan39, BRRI dhan49 and BR11) found that total dry matter was significantly highest in plot of three hand weeding at 15, 30

& 45 DAT, 20.17 g m-2 and post-emergence herbicide + 1 hand weeding at 30 DAT, 22.2 g m^{-2}.

Reza *et al*. (2010) carried out an experiment at the Agronomy Field Laboratory, Bangladesh Agricultural University (BAU), Mymensingh, during the period from January to April 2008 and found that *Echinochloa crusgalli* was the major weed having the highest absolute density (12.70 m^{-2}), relative density (36.95 m^{-2}), dry matter accumulation (1.85 g m^{-2}) and intensity of weed infestation (0.46).

2.2.3.4. Effect on grain yield and straw yield

Supplementing herbicide application with manual weeding in dry seeded rice fields can help control weeds more effectively. To test this assumption, pre and post-emergence herbicides applied either alone or supplemented with manual weeding were evaluated in a field study. Pendimethalin at 1137 g a.i. per ha as pre-emergence (0 DAS), bispyribac sodium, penoxsulam, pyrazosulfuron ethyl and ethoxysulfuron ethyl at 30, 15, 30 and 30 g a.i. per ha, respectively, as early post emergence (15 DAS) were applied alone and supplemented with manual weeding (hoeing/pulling, 30 DAS). A weedy check and manual weeding thrice (15, 30 and 45 DAS) were included for comparison. Data on weed dynamics and crop attributes were recorded following standard procedures. Significant improvement in rice growth and grain yield was recorded when herbicides were followed by manual weeding. Bispyribac sodium and ethoxysulfuron ethyl followed by manual weeding recorded similar grain yields.

Rice growth and yield was negatively associated with weed density and biomass, and unrestricted weed growth incurred 75% yield loss in dry seed fine rice. Combination of bispyribac sodium and manual weeding was the best integrated weed management strategy to control weeds and enhance growth and yield of rice (Khaliq *et al.,* 2013).

Al-Mamun *et al*. (2011) carried out an experiment at the Agronomy Farm of Bangladesh Rice Research Institute, Gazipur, During December 2008 to June 2009 in winter season on Surjamoni and BRRI dhan29 and 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.

Bhuiyan *et al*. (2011) conducted a field experiment to evaluate the performance of different weed management options regarding effective weed control, yield and yield contributing characters of three popular BRRI aman varieties having different growth duration (BRRI dhan39, BRRI dhan49 and BR11) in 2008 and 2009 at Bangladesh Rice Research Institute, regional station, Rajshahi and found that, irrespective of weed management options, hand weeding and post-emergence herbicide with one supplement hand weeding produced significantly higher yield 4.89 and 4.80 t ha^{-1}, respectively while lowest yield was recorded in control (3.29 t ha^{-1}).

Khaliq *et al*. (2011) reported that manual weeding scored highest paddy yield of 4.17 t ha^{-1}. Bispyribac sodium with 3.51 t ha^{-1} paddy yield appeared superior to penoxsulam. Sorghum, sunflower and wheat residues resulted in statistically similar paddy yields of 2.85, 2.80 and 2.58 t ha-1, respectively. Bispyribac sodium exhibited maximum marginal rate of return of 23.76%. Chemical control proved to be a viable strategy with higher economic returns.

Khan and Tarique (2011) carried out an experiment during June to December 2006 and stated that the highest grain yield and straw yield were observed in completely weed free condition throughout the crop growth period. On the other hand, values that appeared next to the highest were found in two hand weeding treatment and lowest in no weeding treatment.

Mamun *et al*. (2011) conducted field experiments at Bangladesh Rice Research Institute (BRRI), Gazipur during boro, 2009 and aus, 2010 to evaluate the performance of Bensulfuron methyl + Pretilachlor 6.6% GR for weed suppression and its impacts on transplanted rice and observed that application of Bensulfuron methyl + Pretilachlor 6.6% GR @ 652 g a.i. ha^{-1} resulted in higher yield attributes and grain yield of transplanted rice that were comparable to the standard in both seasons.

Shultana *et al*. (2011) conducted an experiment at Bangladesh Rice Research Institute, Gazipur, during winter season 2009 to evaluate the weed control efficiency of some pre-emergence herbicides in transplanted rice and found that among the evaluated herbicides, Rigid 50 EC (pretilachlor) @ 1L, Alert 18WP (bensulfuron + acetachlor) @ 400 g, Kildor 5G (butachlor) @ 25 kg, Bigboss 500EC (pretilachlor) @ 1L, Rifit 500EC (pretilachlor) @ 1L, Ravchlor 5G (butachlor) @ 25 kg, Succour 50EC (pretilachlor) @ 1L and Topstar 80WP (oxadiazon) @ 75 g ha^{-1} showed grain yields above 4.00 t ha^{-1} which were comparable to the standard check; however, weed free plots gave the highest grain yield as anticipated.

Ali *et al*. (2010) conducted an experiment at the Agronomy farm, Sher-e-Bangla Agricultural University, Dhaka during the period July-December, 2006 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 hand weeding at 40 DAT performed best for controlling weeds which ultimately contributed to the highest grain yield (3.60 t ha^{-1}).

Effect of rice establishment methods and weed management practices on associated weeds and grain yield of rice was studied at BRRI farm Gazipur and BRRI farm Bhanga, Faridpur District during dry seasons of 2006 and 2007. Seven weed control treatments were imposed inside three planting methods in Split Plot under RCBD. Herbicide MCPA 500 @ 500g a.i. per ha showed some phytotoxicity in broadcasting and drum seeded system where other treatment combinations did not show any significant phytitoxicity on crops. Grass type weed were dominant in direct wet seeded rice whereas sedges and broad leafs were dominant in transplanting method of rice. Weed control efficiency varied from 80 to 85% during 2006 and 88-91% in 2007 against different weed control treatments. Weed number and weight was significantly higher in broadcast and drum seeded method resulting lower weed control efficiency than transplanting method. Different groups of herbicide + one hand weeding gave statistically similar yield compared with weed free treatments except MCPA500 @ 500g a.i. per ha + one hand weeded treatments. Higher panicles m^{-2} in broadcasting and drum seeded method led to higher grain yield than transplanting method. Interaction effect of ethoxysulfuron 150WG @ 15g a.i. per ha + one hand weeding in broadcasted method and pretilachlor 500EC @ 500g a.i. per ha + one hand weeding under drum seeding produced higher grain yield, whereas other combinations of treatments produced intermediate grain yield. Broadcasting and drum seeding method produced lower grain yield in unweeded condition as compared with transplanting method under the with same condition. It is thus, concluded that for realizing higher yields of rice drum and broadcast methods should be integrated with ethoxysulfuron and pretilachlor @150 and 500 g a.i. per ha, respectively in combination with one hand weeding (Ahmed and Bhuiyan, 2010).

Hassan *et al*. (2010) carried out a field experiment on transplant aman rice cv. BRRI dhan41 and found that highest straw yield was recorded from the treatment combination of three hand weeding regimes with two seedlings $hill^{-1}$ in most of the evaluated traits. The weakest treatment combination was the no weeding with five seedlings $hill^{-1}$.

Islam *et al*. (2010) revealed that pre-emergence herbicide Rifit 500 EC showed the best performance in achieving comparatively better grain yield. As a result net income was also increased. The highest grain yield (3.61 t ha^{-1}) was obtained from Rifit 500 EC. BRRI dhan41 gave the highest grain yield (4.43 t ha^{-1}) with Rifit 25 EC @ 1.0 L ha^{-1}.

Karim and Ferdous (2010) conducted an experiment at the net house of the Department of Agronomy, Bangladesh Agricultural University during the period from June to December 2008 and stated that the highest grain yield (15.09 g pot^{-1}) was found under weed free condition. Grain yield was reduced by 2.66%, 12.59%, 44.93% and 54.01% due to competition from 2, 4, 6 and 8 number of weeds of E.

indica, whereas the yield was reduced by 57.19%, 58.98%, 82.31% and 79.26%, respectively due to competition from 2, 4, 6 and 8 number of weeds of *E. crusgalli.*

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 reported that weed free condition produced the highest grain yield (4.35 t ha^{-1}) whereas no weeded condition produced the lowest grain yield (2.02 t ha^{-1}).

Salam *et al*. (2010) carried out a field experiment at the Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh, to evaluate the effect of herbicide on growth and yield in boro rice (Binadhan-5). The highest grain yield (7.15 t ha^{-1}) and straw yield (7.37 t ha^{-1}) were found due to application of Machete 5G @ 25 kg ha^{-1}.

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.

Kabir *et al*. (2008) stated that the highest grain yield (5.22 t ha^{-1}) was obtained under good water management in weed free treatment followed by Butachlor 5G @ 2 kg ha^{-1} and one hand weeding (4.96 t ha^{-1}) under same water management. Results revealed that Butachlor application along with one manual weeding accompanied by proper water management might be the best option to combat weed problems as well as to obtain satisfactory grain yield in transplanted aman rice.

Jacob and Syriac (2005) showed that adoption of 20 x 10 cm spacing and pre-emergence application of Anilofos+2, 4-D ethyl ester (0.40+0.53 kg a.i. ha^{-1}) at six days after transplanting supplemented with 2, 4-D Na salt (1.0 kg a.i. ha^{-1}) at 20 days after transplanting generally favored increased yield and net income.

Bijon (2004) observed that other than weed free condition, the highest grain yield (5.90 t ha^{-1}) was produced by BR11 under two hand weeding. It was further identified to reduce the weed seed bank status in rice soils and rice grains to the lowest extent in both farmer's field as well as experimental field.

Ferrero (2003) estimated that without weed control, at a yield level of 7.00 to 8.00 t ha^{-1}, yield loss can be as high as about 90%.

Moorthy *et al*. (2002) investigated the efficacy of pre and post-emergence herbicides in controlling weeds in rainfed upland direct sown rice. The application of Pretilachlor @ 625 g ha^{-1} and Butachlor 1600 @ g ha^{-1} on 2 days after sowing and the treatments gave effective weed control and produced highest grain yield compared with twice hand weeding on 20 and 40 DAT.

Tamilselvan and Budhar (2001) studied the effects of pre-emergence herbicides Pretilachlor 0.4 kg a.i. ha^{-1}, Pretilachlor 0.4 kg a.i. ha^{-1} on rice cv. ADT 43. The herbicides were applied 8 days after sowing.

The density and dry weight of weeds at 40 DAS were lower in herbicide treated plots than in unweeded and hand weeded plots. The weed control treatment had effect in increasing grain yield.

2.2.4 Effect of no weeding

Gogoi *et al*. (2000) from Assam reported that different weed control practices significantly reduced the dry matter accumulation of weed and increased the rice yield over the unweeded control in transplanted rice.

Singh and Kumar (1999) reported that maximum weed dry weight and the lowest a grain yield was observed in the unweeded control in the scented rice variety Pusa Basmati-1. Singh *et al*. (1999) studied the effect of various weed management practices on the weed growth and yield and N uptake in transplanted rice and weeds and reported that weed control until maturity removed significantly higher amount of N through weeds (12.97 kg ha^{-1}) and reduced the grain yield of rice by 49% compared to that of weed free crop up to 60 DAT.

Thomas *et al*. (1997) reported that rice weed competition for moisture was heavy during initial stages and yield losses from uncontrolled weeds might be as high as 74%. Kamalam and Bridgit (1993) reported that the average reduction in grain vield due to weed competition was 56 %.

2.2.5 Effect of hand weeding

Ashraf *et al*. (2006) conducted an experiment in Lahore, Pakistan, during 2004 and 2005 kharif seasons, for screening of herbicides for weed management in transplanted rice (cv. Basmati-2000). In the second year the maximum control of weeds was 94.67% in the case of hand weeding. Regarding the number of tillers $plant^{-1}$, hand weeding resulted in 20.8 weeding to 16.6 for the control in second year, whereas the highest number of grains $panicle^{-1}$ was 135.50 during the second year. In terms of paddy yield, hand weeding gave the highest grain yield but remained statistically at par with certain herbicides.

Baloch *et al*. (2006) made an experiment in NWFP, Pakistan 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 hand weeding, closely followed by Butachlor (Machete 60EC during both cropping seasons).

Manish *et al*. (2006) said that Alternanthera triandra, Echinochloa colorer, Fimhristylis miliacea and Xanthium strumarium were the dominant weeds associated with the transplanted rice crop. Results revealed that hand weeding at 15 and 30 DAT (days after transplanting) gave the highest grain yield, straw yield and harvest index. Maximum weed density and dry matter were recorded in the unweeded control, while the minimum values were obtained with hand weeding at 15 and 30 0 DAT. Other than weed free condition, the highest grain yield (5.9 t ha^{-1}) was produced by BR 11 under two hand weeding.

Chandra and Solanki (2003) studied the effect of herbicides on the yield characteristics of direct sown flooded rice. The treatments were two hand weeding, Butachlor 2.0 kg ha^{-1}1 and Oxadiazon 0.8 kg ha^{-1}. They found that two hand weeding produced the highest ear length (23.49 cm), number of grains ear^{-1}, grain yield (33.65 g ha^{-1}), straw yield (65.35 g ha^{-1}) and harvest index (33.97%).

Bhowmick (2002) said two hands weeding at 20 and 40 days after transplanting (DAT) in transplanted rice showed the highest control of weeds.

Bhowmick (2002) revealed that *Echinochloa crus-galli*, *Cyperus iria*, *Cyperus rotundus* were the dominant weeds in transplanted rice. He observed that two hand weeding at 20 and 40 days after transplanting were able to control almost all categories of weeds.

Chandra and Pandey (2001) showed that hand weeding was the most effective in mitigating the weed dry matter accumulation and also reported that higher grain and straw yield were obtained with hand weeding.

Hossain (2000) observed experiment oriented impact of different weeding approaches on rice like one hand weeding, two hand weeding, three hand weeding, Oxadiazon, Oxadiazon in combination with one hand weeding and observed that yield and yield contributing traits in rice production had upgraded by degrees with the higher frequency of hand weeding.

2.2.6 Effect of mechanical weeding

Singh (2005) conducted an experiment at Bihar, India, during the wet season to assess the effectiveness of Beushening (a kind of mechanical weed control) in controlling weeds under rainfed lowland conditions as well as to make a comparison between Beushening and chemical weed control (i.e. 2,4-D and Butachlor). It was found that common practice of Beushening alone was not effective in controlling weeds of rainfed lowland rice but standard practice of Beushening along with one hand weeding 40 days after sowing, (DAS) was better in controlling weeds than other chemical treatments with or without one hand weeding 40 DAS and both (common and standard) practices of Beushening as effective as two hand weedings (25 and 40 DAS) in terms of grain yield, net return and benefit cost ratio.

Ahmed *et al*. (2003) said that Cinosulfuron, Pretilachlor and the BRRI push weeder performed better than farmer existing weed control practices of hand weeding with reduced weeding cost.Sharma and Gogoi (1995) observed that the peg type dry land weeder and a twin wheel hoe gave best weed control which was comparable to that achieved with Butachor + hand weeding.

Moorthy and Das (1992) stated that the paddy wheel hoe use twice resulted in the greatest weed control (80%), higher grain yield (1.65 t ha^{-1}) and straw yields (3.54 t ha^{-1}) and the finger weeder used twice resulted in the greatest weed control (80%), highest grain yield (1.65 t ha^{-1}) and straw yields (3.54 t ha^{-1}) and the finger weeder used twice resulted in the greatest weed control (80.7%) and grain yield (2.81 t ha^{-1}) but the paddy wheel hoe used gave twice higher straw yield (4.68 t ha^{-1}).

Kulmi (1990) stated that plots receiving cultural control methods, manual or rotary weeding at 40 and 35 days after transplanting resulted in lower weed densities (8.9-9.7 plants m^{-2}) and higher grain yield (18.5-20.3% above the unweeded control value of 2.36 t ha^{-1}) than the plot treated with 0.75-2.0 kg ha^{-1} Oxadiazon as pre-emergence at 6 days after transplanting or with 0.75-2.0 kg ha^{-1}

Pretilachlor as post- emergence at 30 days after transplanting.Chandra and Mama (1990) observed that rotary weeder controlled weeds effectively and increased grain yield by 29.7% and hand weeding also controlled weed successfully and increased yields.

2.3 Combined effect of N and weed control

Latheef *et al.* (2011) conducted at Agricultural Research Station, Kampasagar, Nalgonda district of Andhra Pradesh during the kharif seasons of 2008 and 2009 to find out the effect of irrigation schedules, weed management practices and N levels on weed growth, nutrient depletion and yield of aerobic rice. The major weed flora observed in the experimental plot was *Echinochloa colona* L., *Cynodon dactylon Pers., Dactyloctenium aegyptium Beauv., Cyperus rotundus* L. (Monocots), *Eclipta alba Hassk., Trianthemaportulacastrum* L. and *Amaranthus viridis* L. (Dicots) during both the years. Irrigation scheduled at seven days interval during vegetative stage and four days interval during reproductive stage resulted in significantly higher weed density, weed dry matter production and NPK removal by weeds and higher panicle number and weight, filled spikelets per panicle grain yield and NPK uptake at harvest than that of irrigation scheduled once in two days. Pre-emergence application of pendimethalin @ 1 kg/ha fb cono weeding at 30 DAS and one HW at 45 DAS recorded significantly lower weed density, weed dry matter production and NPK uptake by weeds and significantly higher panicle number and weight, filled spikelets per panicle, NPK uptake at harvest and grain yield than that of pre-emergence application of pendimethalin @ 1 kg ha^{-1} fb 2, 4-D Na salt @ 1 kg/ha at 40 DAS and HW at 20 and 45 DAS. Among latter treatments, significantly lower values of above said weed parameters and significantly higher crop parameters were observed with pre-emergence application of pendimethalin @ 1 kg ha^{-1} fb 2, 4-D Na salt @ 1 kg ha^{-1} at 40 DAS as compared to HW at 20 and 45 DAS. Weed density, weed dry matter production and NPK removal by weeds and panicle number, length and weight, filled spikelets per panicle, grain yield and NPK uptake at harvest were significantly higher at 180 kg N ha^{-1} during both the years.

CHAPTER 3

MATERIALS AND METHODS

MATERIALS AND METHODS

Details of different materials used and methodologies followed in the experiment are presented in this chapter.

3.1 Description of the experimental site

3.1.1 Location

The field experiment was conducted at the Agronomy field laboratory, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from December, 2011 to May, 2012. The location of the site is $23^{0}74^{/}$N latitude and $90^{0}35^{/}$E longitude with an elevation of 8.2 meter from sea level (Appendix I).

3.1.2 Soil

The soil of the experimental area belonged to the Modhupur tract (AEZ No. 28). It was a medium high land with non-calcareous dark grey soil. The pH value of the soil was 5.6. The characteristics of the experimental soil have been shown in Appendix III.

3.1.3 Climate

The experimental area was under the subtropical climate and was characterized by high temperature, high humidity and heavy precipitation with occasional gusty winds during the period from April to September, but scanty rainfall associated with moderately low temperature prevailed during the period from October to March. The detailed meteorological data in respect of air temperature, relative humidity, rainfall and sunshine hour recorded by the Dhaka meteorology center, Dhaka for the period of experimentation have been presented in Appendix II**.**

3.2 Crop / planting material

Rice variety hybrid heera-4 was used as the test crop.

3.2.1 Description of rice cultivars

The variety is grown in *boro* season. The variety is recommended for cultivation in medium high lands and medium low lands where the maximum tidal depths not exclude to 50 cm. This cultivar matures at 140-145 days of planting. It attains a plant height 125-130 cm. The cultivar gives an average yield of 10-12 t ha^{-1}.

3.3 Treatment

The experiment consisted of two factors as mentioned below:

Factor A:

Nitrogen(N) level : 4

1) N_o = 0 kg N ha^{-1}
2) N_1 = Urea super granules(USG) (2.7 g) @ 75 kgN ha^{-1}
3) N_2 = 140 kg N ha^{-1}
4) N_3 = 180 kg N ha^{-1}

Factor B:

Weed control methods (W) : 4

1) W_0 =No weeding (Control)
2) W_1= One weeding (30 Days after transplanting)
3) W_2= Two weeding (30 DAT and 50 DAT)
4) W_3= Sunrice 150 WG at recommended dose (100g ha^{-1})
5) W_4=Topstar 80WG at the recommended dose (80g $ha^{-1)}$

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) One weeding: One hand weeding was done at 30 DAT.

3) Two weedings: First hand weeding was done at 30 DAT and second hand weeding was done at 50 DAT.

4) Sunrice 150 WG at the recommended dose: Sunrice 150 WG was applied at 100 g ha^{-1}at 7 DAT in 4-5 cm standing water in field.

5)Topstar 80WG at recommended dose : Topstar 80WG was applied at 80 g ha^{-1}at 3DAT in 4-5 cm standing water in field.

3.4 Description of herbicides

A short description of the herbicides used in the experiment given below:

Trade name	Common name	Mode of action	Selectivity	Time of application
Sunrice 150 WG	Ethoxysulfuran	Systemic	For rice	Post emergence
Topstar 80WG	Oxadiarzil	Systemic	For rice	Pre emergence

3.5 Description of the nitrogen

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

Prilled Urea (PU)

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

Urea supergranules (USG)

Urea supergranules 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% Nwhich is similar to that of PU average diameter of the granule is 11.5 mm. It is not a slow release fertilizer but can be considered as a slowly available N fertilizer. The supergranules 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.

3.6 Seed collection and sprouting

Seeds of hybrid rice variety heera-4 were collected from Supreme Seed Company Ltd. Healthy seeds were selected following standard method. Seeds were immersed in water in a bucket for 24 hrs. These were then taken out of water and kept in gunny bags. The seeds started sprouting after 48 hrs which were suitable for sowing in 72 hrs.

3.7 Raising of seedlings

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

3.8 Collection and preparation of initial soil sample

The initial soil samples were collected before land preparation from a 0-15 cm soil depth. The samples were collected by means of an auger from different location covering the whole experimental plot and mixed thoroughly to make a composite sample. After collection of soil samples, the plant roots, leaves etc. were picked up and removed. Then the sample was air-dried and sieved through a 10-mesh sieve and stored in a clean plastic container for physical and chemical analysis.

3.9 Preparation of experimental land

The experimental field was first opened on 17 December, 2011 with the help of a power tiller; later the land was irrigated and prepared by three successive ploughings and cross-ploughings. Each ploughing was followed by laddering to have a good puddled field. All kinds of weeds and residues of previous crop were removed from the field. The field layout was made on 26 December, 2011 according to design immediately after final land preparation. Individual plots were cleaned and finally leveled with the help of wooden plank.

3.10 Fertilizer management

The experimental plots were fertilized with P, K, Zn and S @ 140,134.7, 7.5, 60 kg ha^{-1} in the form of triple super phosphate (TSP), muriate of potash (MoP), zinc sulphate and gypsum, respectively (BRRI, 2010) as basal. 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 75 kg N ha^{-1}. Nitrogen in the form of USG and prilled urea (PU) was given following treatment levels. Split application of nitrogen was done only for PU at 10, 35 and 55 DAT.

3.11 Experimental design

The experiment was laid out in a split plot design with three replications having nitrogen levels in the main plots and weed control in the sub plots. There were 20 treatments combinations. The total numbers of unit plots were 60. The size of unit plot was 5 m x 2.5 m = 12.5 m^2. The distances between sub-plot, main plot and replication were 0.75, 0.75 and 1.5 m respectively.

3.12 Uprooting and transplanting of seedlings

Thirty days old seedlings were uprooted carefully and were kept in soft mud in shade. The seed beds were made wet by water application in previous day before uprooting the seedlings to minimize mechanical injury of roots. Seedlings were then transplanted as per experimental treatment on the well puddled plots on 28 December 2011.

3.13 Intercultural operations

3.13.1 Gap filling

After one week of transplanting, a minor gap filling was done where it was necessary using the seedling from the same source.

3.13.2 Weeding

Weeding operations were done as per treatment.

3.13.3 Application of irrigation water

Irrigation water was added to each plot according to the critical stage. Irrigation was done up to 5 cm. above ground.

3.13.4 Method of water application

The experimental plots were irrigated through irrigation channels. Centimeter marked sticks were installed in each plot which were used to measure depth of irrigation water.

3.13.5 Plant protection measures

Plants were infested with rice stem borer and leaf hopper to some extent which were successfully controlled by applying Diazinone 60 EC on 12 February and 13 March,2012 respectively. Crop was protected from birds during the grain filling stage.

3.14 General observation of the experimental field

The field was supervised time to time to detect visual difference among the treatment and any kind of infestation by weeds, insects and diseases to minimize considerable losses by pest should be minimized. The field views were quite good with normal green color plants. Incidence of stem borer, green leaf hopper, leaf roller was observed during tillering stage while bacterial and fungal disease was not observed. The variation in flowering was observed. Lodging did not occur during booting and heading stage even at occurance of heavy rainfall followed by gusty winds perhaps due to plant stature of the variety.

3.15 Harvesting and post-harvest operation

Maturity of crop was determined when 90% of the grains become golden yellow in color. The harvesting was done on 1, 4 and 7 May, 2012. An area of 3 m^2 was harvested from centre of each plot avoiding the border effect. Each plot was harvested separately, bundled, properly tagged and then brought to the threshing floor. Threshing was done using pedal thresher. The grains were cleaned and sun dried at moisture content of 12%. Straw was also sun dried properly. Finally grain and straw yields $plot^{-1}$ were recorded and converted to t ha^{-1}.

3.16 Experimental measurements

The necessary data on agronomic characters were recorded from randomly ten sampled hills from each plot in field and at harvest.

3.16.1 Number of weeds per square meter

Number of weeds m^{-2} was measured at 15, 30, 45 and 60days after transplantation. Number of weeds per m^{-2} was counted from each plot and then averaged.

3.16.2 Dry weight of weeds per square meter

Dry weight of weeds $m^{-2}$was measured at 15, 30, 45 and 60 days after transplantation.Weeds were collected from 1 m^2 in each plot and washed by tap water; oven dried for 24 hours at 70º C temperature and then weighed by electric balance.

3.16.3 Plant height (cm)

The height of the plant was determined by measuring the distance from the soil surface to the tip of the leaf before heading, and to the tip of panicle after heading.

3.16.4 Tillers hill^{-1} (No.)

Tillers hill^{-1} were counted and averaged as number hill^{-1}. Only those tillers having three or more leaves were considered for counting.

3.16.5 Leaf area index (LAI)

Leaf area index were estimated measuring the length and width of leaf and multiplying by a factor of 0.75 followed by Yoshida (1981).

3.16.6 Dry matter weight of plant

The sub-samples of 5 hills plot^{-1} uprooted from 2nd line were oven dried until a constant level from which the weight of total dry matter were recorded.

3.16.6 Crop growth rate (g hill^{-1} day^{-1})

Crop growth rate was calculated by using the following standard formula (Radford, 1967 and Hunt, 1978) as shown below:

$$CGR = \frac{1}{GA} \times \frac{W_2 - W_1}{T_2 - T_1} \text{ gm}^{-2}\text{day}^{-1}$$

Where,

W_1= Total dry matter production at previous sampling date

W_2= Total dry matter production at current sampling date

T_1= Date of previous sampling

T_2= Date of current sampling

GA= Ground area (m^2)

3.16.7 Effective tillers hill^{-1} (No.)

The panicles that had at least one grain was considered as an effective tiller. The effective tillers from ten hills were counted and averaged to calculate on hill^{-1}basis.

3.16.8 Panicle length

Measurement of panicle length was taken from basal node of the rachis to apex of each panicle. Each observation was an average of 10 panicles.

3.16.9 Number of filled grains panicle^{-1}

Spikelet was considered to be fertile if any kernel was present there in. The number of total fertile spikelets present on each panicle was recorded.

3.16.10 Number of unfilled grains panicle^{-1}

Sterile spikelet means the absence of any kernel inside in and such spikelets present on each panicle were counted.

3.16.11 Total grain panicle^{-1}

The number of fertile spikelets panicle^{-1} plus the number of sterile spikelets panicle^{-1} counted together was the total number of spikelets panicle^{-1}.

3.16.12 Weight of 1000-grain

One thousand cleaned dried seeds were counted randomly from each sample and weighed by using a digital electric balance at the stage the grain retained 12% moisture and the mean weight were expressed in gram.

3.16.13 Grain yield

Grain yield determined from the central 3 m^2 areas of each plot were sun dried, cleaned, weighed carefully and adjusted at 12% moisture level. Weight of grains of each plot was converted into t ha^{-1}. Grain moisture content was measured by using a digital moisture meter.

3.16.14 Straw yield

Straw yield was determined from the central 3 m^2 of the plot. After threshing, the sub-sample was sun dried, cleaned, weighed separately and finally converted to t ha^{-1}.

3.16.15 Biological yield

The biological yield was calculated with the following formula-

Biological yield= Grain yield + Straw yield

3.16.16 Harvest index (%)

It denotes the ratio of economic yield to biological yield and was calculated with following formula (Gardner *et al*., 1985).

$$\text{Harvest index (\%)} = \frac{\textbf{Grain yield}}{\textbf{Biological yield}} \times 100$$

3.17 Analysis of data

The collected data were compiled and analyzed statistically using the analysis of variance (ANOVA) technique with the help of a computer package program MSTAT-C and the mean differences among the treatments were compared by Duncan's Multiple Range Test (DMRT) (Gomez & Gomez, 1986).

CHAPTER 4

RESULTS AND DISCUSSION

RESULTS AND DISCUSSION

Result obtained from the present study have been presented and discussed in this chapter. The data have been presented in the form of different tables and figures. The results have been presented and discussed, and possible interpretations are presented under the following headings.

4.1 Weed species infestion in the experimental field

It was a general observation that conditions favourable for growing boro rice were also favourable for exuberant growth of numerous weeds that compete with crop plants. This competition of weeds tends to increase when the weed density increased. There were eight weed species belonging to four families were found to infest the experimental plot. Local name, scientific name, family, morphological type and life cycle of the weed species have been presented in Table 1. The density of weeds varied considerably in different weed control methods treatments and nitrogen doses. The most important weeds of the experimental plot were *Echinochloa colonum, Cyperus rotundus, Scirpus mucronatus, Spilanthes acmella*. Among the eight species six were grasses and two were sedge (Table 1).

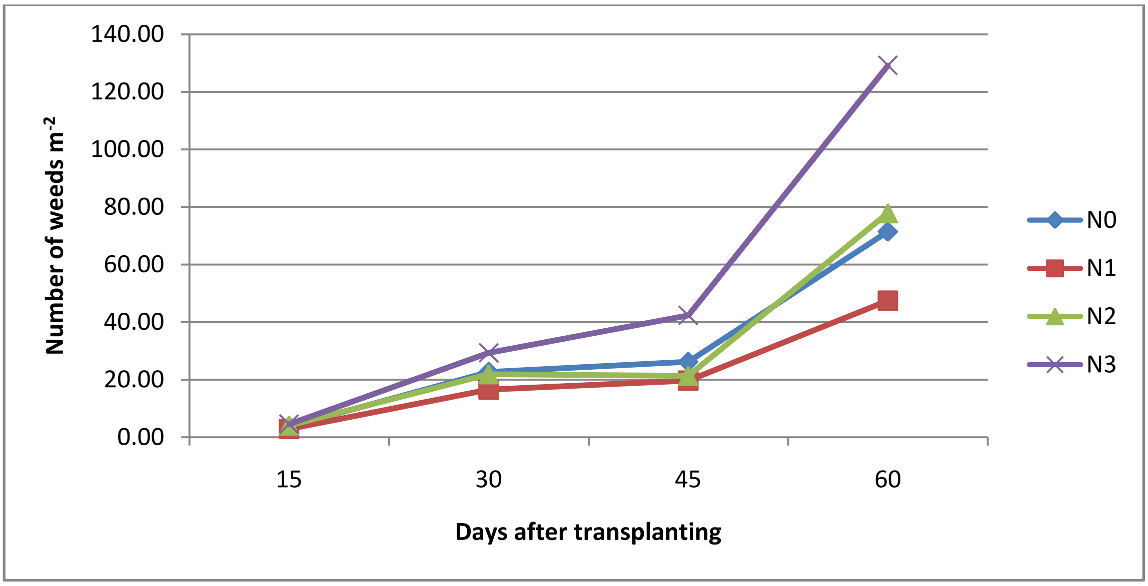
Table 1. Weed species found in the experimental plots in boro rice

Local name		Scientific name	Family	Lifecycle	Type
1	Khudeshama	*Echinochloa colonum*	Poaceae	Annual	Grass
2	Arail	*Leersia hexandra*	Poaceae	Perennial	Grass
3	Durba	*Cynodon dactylon*	Poaceae	Perennial	Grass
4	Mutha	*Cyperus rotundus*	Cyperaceae	Perennial	Sedge
5	Chechra	*Scirpus mucronatus*	Cyperaceae	Perennial	Sedge
6	Girakata	*Spilanthes acmella*	Asteraceae	Perennial	Grass
7	Helancha	*Enhydra fluctuans*	Asteraceae	Annual	Grass
8	Tripatrishak	*Desmodium trifolium*	fabaceae	Annual	Grass

4.2Number of weedsm^{-2}

4.2.1 Effect of nitrogen

There was no significant variation observed on weed density at 15 and 30 DAT for N variation but significant variation observed at 45 and 60 DAT (Figure 1 and Appendix IV). The highest weed population (4.53, 29.27, 42.27 and 129.10 at 15, 30, 45 and 60 DAT respectively) was recorded from 180 kg N ha^{-1}(N_3) and the lowest weed population (2.87, 16.53, 19.67and 47.40 at 15, 30, 45 and 60 DAT respectively) recorded from Urea super granules @ 75 kgN ha^{-1}(N_1) treatment.

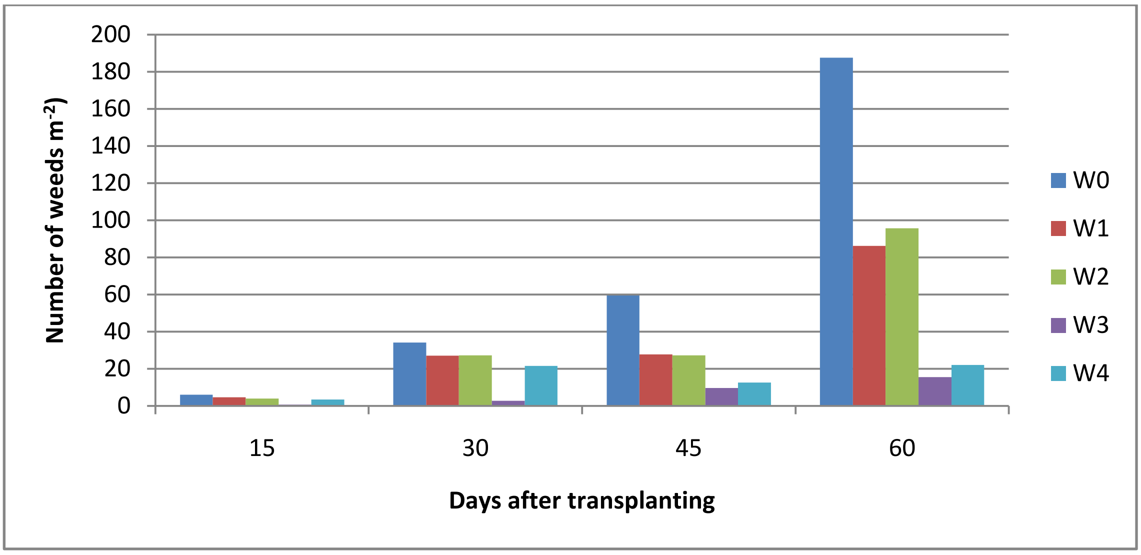


Note: N_o = 0 kg N ha^{-1}, N_1 = Urea super granules (2.7 g) @ 75 kgN ha^{-1} , N_2 = 140 kg N ha^{-1} , N_3 = 180 kg N ha^{-1}

Fig. 1. Effect of nitrogen on number of weeds m^{-2} of rice at different days After transplanting (SE value= 0.90, 3.90, 4.15 and 22.27 at 15, 30, 45, and 60 DAT respectively)

4.2.2 Effect of weed control methods

Significant variation was observed on weed density throughout the growing period for different weed control methods treatments (Figure 2 and Appendix IV). The highest weed population (6, 34.17, 59.42 and 187.6at 15, 30, 45 and 60 DAT respectively) was observed in control methods (W_0) throughout the growing period. The lowest number of weeds (0.67, 2.83, 9.58 and 15.50 at 15, 30, 45, and 60 DAT respectively) was observed in case of Sunrice150WG (W_3). Herbicidal treatments drastically reduced weed population. This result was supported by Bhuiyan *et al.* (2010) who reported that pre emergence application of Oxadiargyl 400SC @ 75 g a.i. ha^{-1} had minimum population than any other herbicide and doses. Similar results were also stated by Bhuiyan *et al.* (2011), Kalhirvelan and Vaiyapuri (2003), Mahajan *et al.* (2003), Gnanasambandan and Murthy (2001) and Islam *et al.* (2001).



Note: W_0 =No weeding (Control methods) ,W_1= One weeding (30 Days after transplanting),W_2= Two weedings (30 DAT and 50 DAT),W_3= Sunrice 150 WG at recommended dose (100g ha^{-1}),W_4=Topstar 80WG at the recommended dose(80g ha^{-1})

Fig. 2. Effect of weed control methods on number of weeds m^{-2} of rice at different days after transplanting (SE =1.00, 4.36, 4.64 and 24.89 at 15, 30, 45, and 60 DAT respectively)

4.2.3 Interaction effect of nitrogen and weed control methods

The effect of nitrogen and weed control methods on number of total weeds were statistically significant at different day after transplanting (Table 2 and appendix IV). The highest total number of weeds (9.33, 56.33, 117.3 and 317.30at 15, 30, 45, and 60 DAT respectively) was found from N_3W_0 (180 kg N ha^{-1}with control methods) and minimum number of weeds (0.00, 0.00, 2.67 and 8.33 at 15, 30, 45, and 60 DAT respectively) from Urea super granules @ 75 kgN ha^{-1} and Sunrice 150WG (N_1W_3).

Table 2.Interaction effect of nitrogen and weed control methods on total number of weed of hybrid rice at different days after transplanting

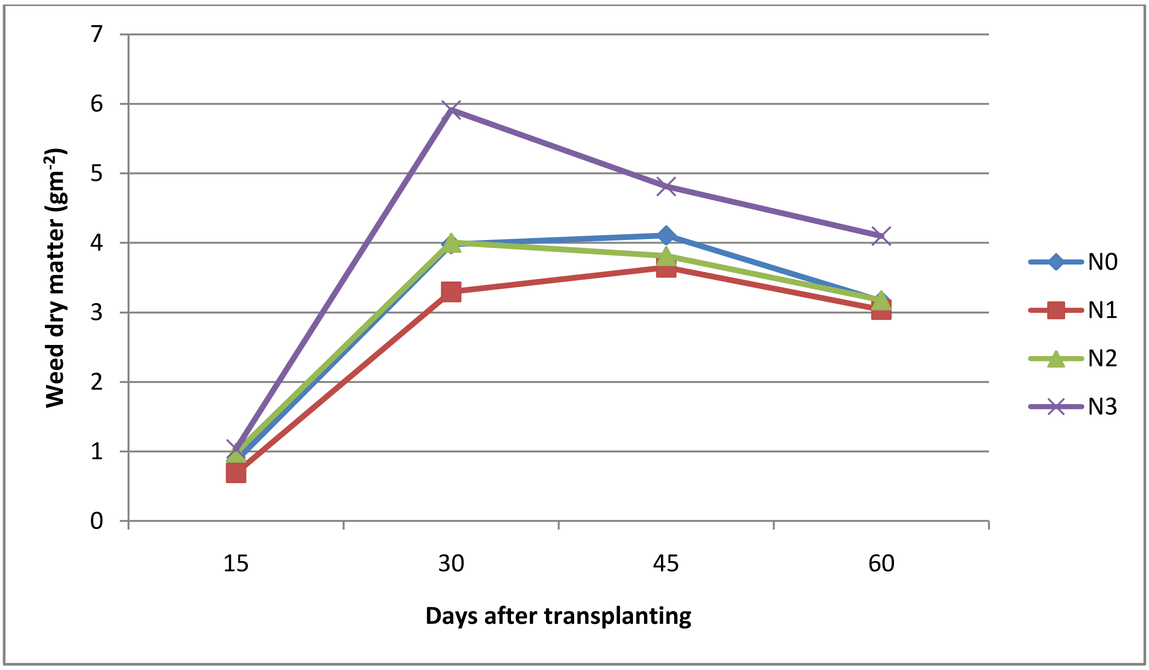
Treatment combinations	Total number of weeds m^{-2} at			
	15DAT	30DAT	45DAT	60DAT
N_0W_0	2.33 b	38.00 ab	63.33 b	159.00 bc
N_0W_1	5.33 ab	23.33 b-d	23.00 cd	93.33 bc
N_0W_2	4.67 ab	33.33 a-c	35.00 c	77.00 bc
N_0W_3	4.33 ab	13.33 b-d	5.67 cd	15.33 c
N_0W_4	1.33 b	5.00 cd	3.67 cd	12.33 c
N_1W_0	3.33 ab	21.00 b-d	30.33 cd	82.00 bc
N_1W_1	6.33 ab	26.00 b-d	35.00 c	59.00 bc
N_1W_2	4.00 ab	19.00 b-d	21.00 cd	66.67 bc
N_1W_3	0.00 b	0.00 d	2.67 d	8.33 c
N_1W_4	2.67 ab	0.33 d	9.33 cd	21.00 bc
N_2W_0	6.33 ab	31.00 a-c	26.67 cd	192.00 ab
N_2W_1	5.33 ab	36.00 ab	28.33 cd	77.67 bc
N_2W_2	5.33 ab	19.00 b-d	24.67 cd	77.33 bc
N_2W_3	3.00 ab	17.00 b-d	13.67 cd	25.33 bc
N_2W_4	0.33 b	6.00 cd	13.00 cd	16.67 c
N_3W_0	9.33 a	56.33 a	117.30 a	317.30 a
N_3W_1	1.67 b	23.00 b-d	25.00 cd	115.00 bc
N_3 W_2	4.67 ab	28.00 a-d	28.00 cd	162.00 bc
N_3W_3	4.00 ab	39.33 ab	9.67 cd	26.33 bc
N_3W_4	1.00 b	16.33 b-d	31.33 cd	24.67 bc
SE	2.01	8.72	9.28	49.78
CV (%)	12.33	16.91	8.83	5.91

Note: N_o = 0 kg N ha^{-1}, N_1 = Urea super granules (2.7 g) @ 75 kgN ha^{-1} , N_2 = 140 kg N ha^{-1} , N_3 = 180 kg N ha^{-1} ,W_0 =No weeding (Control methods) ,W_1= One weeding (30 Days after transplanting),W_2= Two weedings (30 DAT and 50 DAT),W_3= Sunrice 150 WG at recommended dose (100g ha^{-1}),W_4=Topstar 80WG at the recommended dose(80g ha^{-1})

4.3Weed dry matter m^{-2}

4.3.1 Effect of nitrogen

It was evident from Figure 3 that weed dry matter of rice significantly varied at 60 DAT (Fig. 3 and appendix V). It showed that N_3 significantly had the highest weed dry matter (1.04, 5.91, 4.81 and 4.10g at 15, 30, 45 and 60 DAT respectively). The lowest amount of weed dry matter (0.69, 3.30, 3.65 and 3.04 g at 15, 30, 45 and 60 DAT respectively) was found in N_1 treatment.

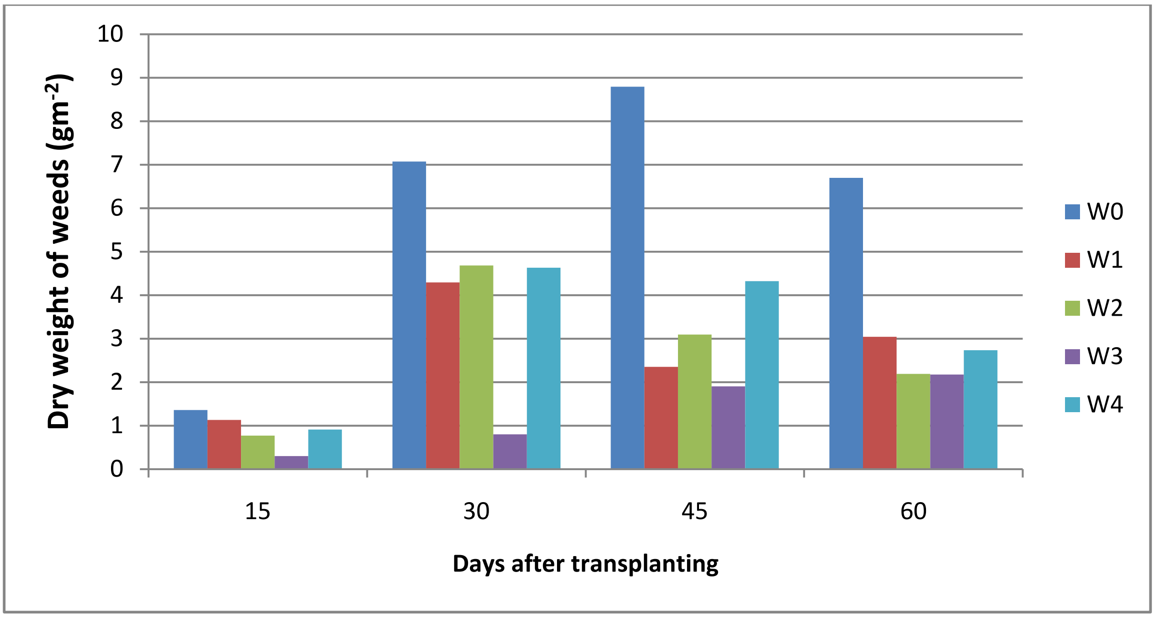


Note: N_o = 0 kg N ha^{-1}, N_1 = Urea super granules (2.7 g) @ 75 kgN ha^{-1}, N_2 = 140 kg N ha^{-1}, N_3 = 180 kg N ha^{-1}

Fig. 3. Effect of nitrogen on weed dry matter m^{-2} of rice at different days after transplanting (SE value= 0.17, 0.97, 0.81 and 0.34)

4.3.2 Effect of weed control methods

Different weed control methods showed statistically significant variation for weed dry matter at 30, 45and 60 DAT (Fig. 4 and Appendix V). The highest weed dry matter was recorded from W_0 (1.36, 7.07, 8.80 and 6.70 gm^{-2}at 15, 30, 45 and 60 DAT respectively) (control methods), whereas the lowest was observed from W_3 (0.30, 0.80, 1.91 and 2.18 gm^{-2} at 15, 30, 45 and 60 DAT respectively).



Note:W_0 =No weeding (Control methods) ,W_1= One weeding (30 Days after transplanting),W_2= Two weedings (30 DAT and 50 DAT),W_3= Sunrice 150 WG at recommended dose (100g ha^{-1}),W_4=Topstar 80WG at the recommended dose(80g ha^{-1})

Fig. 4. Effect of weed control methods on weed dry matter m^{-2} of rice at different days after transplanting (SE=0.09, 1.08, 0.91 and 0.38 at 15, 30, 45 and 60 DAT respectively)

4.3.3 Interaction effect of ntrogen and weed control methods

The effect of nitrogen and weed control methods on weed dry matter was statistically significant at different days after transplanting (Table 3 and Appendix V). The highest weed dry matter m^{-2} (2.26, 13.62, 9.59 and 7.45g at 15, 30, 45 and 60 DAT respectively) was found from N_3W_0 and minimum weed dry matter(0.00, 0.00, 0.33 and 1.08gm^{-2}at 15, 30, 45 and 60 DAT respectively) from N_1W_3 combinations.

Table 3.Interaction effect of nitrogen and weed control methods on dry weight of weed m^{-2} of hybrid rice at different days after transplanting

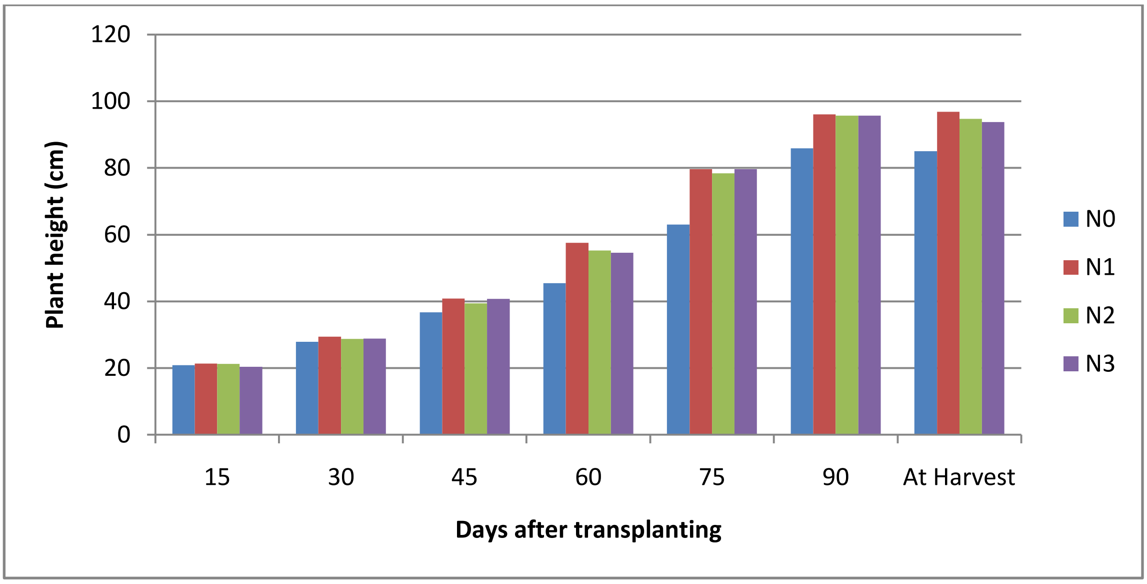
Treatment combinations	Total number of weed m^{-2} at			
	15 DAT	30 DAT	45 DAT	60 DAT
N_0W_0	0.59 b-d	5.82 bc	9.34 a	6.01 a-c
N_0W_1	0.89 b-d	3.90 bc	2.39 cd	1.26 g
N_0W_2	1.02 a-d	5.56 bc	3.16 b-d	1.53 g
N_0W_3	1.26 a-d	2.63 bc	1.74 cd	4.66 b-e
N_0W_4	0.57 b-d	1.99 bc	1.36 cd	1.74 fg
N_1W_0	0.90 b-d	4.25 bc	8.99 ab	6.87 ab
N_1W_1	1.84 ab	3.87 bc	3.54 a-d	2.78 d-g
N_1W_2	1.33 a-c	3.81 bc	4.07 a-d	2.27 e-g
N_1W_3	0.00 d	0.00 c	0.33 d	1.08 g
N_1W_4	0.53 cd	0.17 c	3.61 a-d	1.68 fg
N_2W_0	0.93 b-d	6.36 bc	7.26 a-c	6.48 a-c
N_2W_1	1.09 a-d	4.89 bc	1.47 cd	4.82 b-d
N_2W_2	0.68 b-d	2.31 bc	3.74 a-d	2.19 e-g
N_2W_3	0.83 b-d	3.64 bc	9.18 ab	1.33 g
N_2W_4	0.09 cd	1.05 bc	2.40 cd	2.22 e-g
N_3W_0	2.26 a	13.62 a	9.59 a	7.45 a
N_3W_1	0.71 b-d	4.52 bc	2.02 cd	3.32 d-g
N_3 W_2	0.84 b-d	5.33 bc	1.40 cd	2.77 d-g
N_3W_3	1.22 a-d	7.87 ab	2.77 cd	2.75 d-g
N_3W_4	0.34 cd	4.39 bc	3.53 a-d	4.20 c-f
SE	0.38	2.17	1.82	0.77
CV (%)	12.97	17.25	16.80	9.34

Note: N_o = 0 kg N ha^{-1}, N_1 = Urea super granules (2.7 g) @ 75 kgN ha^{-1} , N_2 = 140 kg N ha^{-1} , N_3 = 180 kg N ha^{-1} ,W_0 =No weeding (Control methods) ,W_1= One weeding (30 Days after transplanting),W_2= Two weedings (30 DAT and 50 DAT),W_3= Sunrice 150 WG at recommended dose (100g ha^{-1}),W_4=Topstar 80WG at the recommended dose(80g ha^{-1})

4.4 Plant height

4.4.1 Effect of nitrogen

Although there was no significant variation at 15 and 30DAT of sampling but significant variation was observed at 45, 60, 75, 90 DAT and also at harvest on plant height due to different form of nitrogen fertilizer application (Figure 5 and Appendix VI).The tallest plant (21.35, 29.43, 40.79, 57.54, 79.69, 95.91 and 96.89 cm at 15, 30, 45, 60, 75, 90 DAT and at harvest, respectively) was observed with N_1 (Urea super granules @ 75 kgN ha^{-1}) and the shortest plant (20.35, 27.87, 36.73, 45.46, 62.98, 85.87and 85.01cmat 15, 30, 45, 60, 75, 90 DAT and at harvest respectively) with N_0 (0 kg N ha^{-1}). It might be due to continuous availability of N from the deep placed USG that released N slowly and it enhanced growth to crop more than prilled urea. These results were in agreement with Singh and Singh (1986) who reported that USG produced taller plants than prilled urea when applied @ 27 to 87 kg N ha^{-1}. In case of rice.

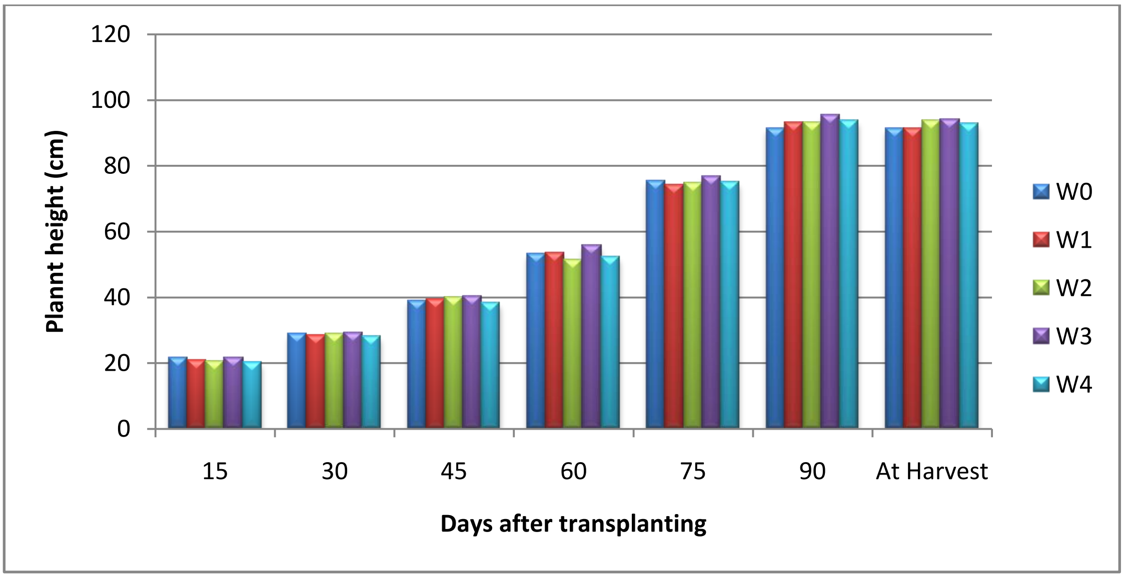


Note: N_o = 0 kg N ha^{-1}, N_1 = Urea super granules (2.7 g) @ 75 kgN ha^{-1} , N_2 = 140 kg N ha^{-1} , N_3 = 180 kg N ha^{-1}

Fig. 5. Effect of nitrogen on plant height of rice at different days after transplanting (SE= 0.98, 0.72, 1.01, 06.4, 0.69, 1.19 and 0.92 at 15, 30, 45, 60, 75, 90 DAT and at harvest respectively)

4.4.2 Effect of weed control methods

Although there was no significant variation observed at 15, 30 and 45 DAT of sampling but the results revealed that there was a significant effect at 60, 75, 90 DAT and also at harvest on plant height due to different weed control methods (Figure 6 and Appendix VI). Throughout the growing period, Sunrice 150WG (W_3) recorded the highest plant height (21.78, 29.16, 40.24, 55.67, 76.69, 95.39, and 93.97 cm at 15, 30, 45, 60, 75, 90 DAT and at harvest, respectively) and no weeding treatment (W_0) attained the lowest plant height (20.10, 28.08, 38.2, 52.18, 74.10, 91.43, and 91.32 cm at 15, 30, 45, 60, 75, 90 and at harvest, respectively). The results were in agreement with the findings of Khan and Tarique (2011) who found that the highest plant height was observed in completely weed free condition throughout the crop growth period with chemical weed control method and followed by two hand weeding treatment whereas the lowest value of it was observed in no weeding treatment. The results were in consistence with the findings of Hasanuzzaman *et al.* (2008), Hasanuzzaman *et al.* (2007).



Note:W_0 =No weeding (Control methods) ,W_1= One weeding (30 Days after transplanting),W_2= Two weedings (30 DAT and 50 DAT),W_3= Sunrice 150 WG at recommended dose (100g ha^{-1}),W_4=Topstar 80WG at the recommended dose(80g ha^{-1})

Fig. 6. Effect of weed control methods on plant height of rice at different days after transplanting (SE=1.09, 0.81, 1.12, 0.71, 0.78, 0.97, 0.47 at 15, 30, 45, 60, 75, 90 and at harvest, respectively)

4.4.3 Interaction effect of nitrogen and weed control methods

Plant height was significantly affected by the interaction of nitrogen and weed control methods in all the studied periods except 15 DAT (Table 4 and Appendix VI). The highest plant height (31.40, 44.93, 61.73, 84.33, 99.43 and 98.10 cm at 30, 45, 60, 75, 90 DAT and at harvest respectively) was recorded from the combination of Urea super granules @ 75 kgN ha^{-1} and Sunrice 150WG (N_1W_3) and the lowest (43.03, 58.13, 80.03 and 80.10 cm at 60, 75, 90 DAT and at harvest, respectively) was obtained from 0 kgN ha^{-1} and no weeding combination (N_0W_0) except at 15, 30, 45 DAT.

Table 4.Interaction effect of nitrogen and weed control methods on plant height of rice at different days after transplanting (DAT)

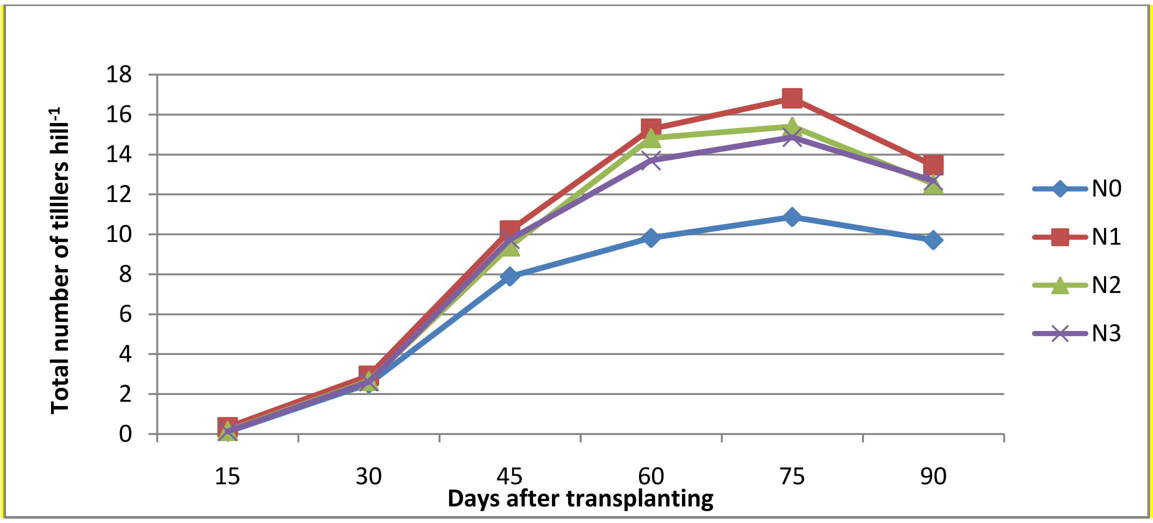
Treatment combinations	Plant height (cm)						
	15 DAT	30 DAT	45 DAT	60 DAT	75 DAT	90 DAT	At harvest
N_0W_0	19.87	27.07ab	35.80bc	43.03h	58.13g	80.03f	80.10f
N_0W_1	19.53	27.00ab	36.10bc	45.27gh	59.57g	84.60ef	82.03ef
N_0W_2	23.13	29.77ab	38.67a-c	44.63gh	64.83f	86.50de	86.43de
N_0W_3	21.07	25.97ab	34.30c	47.73fg	66.07f	90.97b-d	89.37b-d
N_0W_4	20.87	29.53ab	38.77a-c	46.63gh	66.30f	87.27c-e	87.13c-e
N_1W_0	22.40	29.43ab	39.87a-c	59.03ab	79.73a-c	95.17ab	96.17ab
N_1W_1	19.40	28.07ab	38.40a-c	56.97b-d	75.20c-e	95.60ab	95.47ab
N_1W_2	22.97	29.40ab	40.83a-c	53.00de	78.43b-e	92.60bc	97.40a
N_1W_3	23.20	31.40a	44.93a	61.73a	84.33a	99.43a	98.10a
N_1W_4	20.17	29.70ab	41.47a-c	56.93b-d	80.40ab	95.73ab	97.30a
N_2W_0	23.77	28.63ab	40.70a-c	57.43a-d	77.67b-e	96.50ab	96.03ab
N_2W_1	20.50	27.50ab	37.63a-c	53.43de	79.20ad	95.27ab	93.47a-c
N_2W_2	19.77	29.07ab	40.70a-c	54.73b-e	82.53ab	96.17ab	95.60ab
N_2W_3	20.87	30.07ab	43.40ab	56.83b-d	73.97e	95.43ab	94.50ab
N_2W_4	21.17	28.40ab	41.53a-c	53.73c-e	78.73b-e	95.20ab	93.83ab
N_3W_0	20.97	30.53a	39.60a-c	53.30de	81.10ab	94.03ab	93.13a-c
N_3W_1	21.83	30.57a	35.77bc	58.23a-c	82.43ab	97.30ab	94.30ab
$N_3 W_2$	21.27	28.40ab	40.53a-c	53.40de	80.97ab	96.90ab	95.43ab
N_3W_3	17.87	29.00ab	39.53a-c	56.40b-d	79.50a-d	95.73ab	93.90ab
N_3W_4	18.20	24.67b	39.20a-c	51.43ef	74.43de	96.23ab	92.07a-d
SE	ns	1.63	2.53	1.43	1.56	1.93	2.06
CV (%)	18.16	9.82	9.90	9.61	9.15	4.94	3.86

Note: N_o = 0 kg N ha^{-1}, N_1 = Urea super granules (2.7 g) @ 75 kgN ha^{-1} , N_2 = 140 kg N ha^{-1} , N_3 = 180 kg N ha^{-1} ,W_0 =No weeding (Control methods) ,W_1= One weeding (30 Days after transplanting),W_2= Two weeding (30 DAT and 50 DAT),W_3= Sunrice 150 WG at recommended dose (100g ha^{-1}),W_4=Topstar 80WG at the recommended dose(80g ha^{-1})

4.5. Total tillers hill^{-1}

4.5.1 Effect of nitrogen

Tiller number hill^{-1} was significantly influenced by the nitrogen levels at all growth stages (Figure 7 and Appendix VII). The maximum tiller number hill^{-1} (1.33, 2.91, 10.19, 15.28, 16.8 and 13.45 at 15, 30, 45, 60, 75 and 90 DAT respectively) was observed with USG @ 7 k5g N ha^{-1} (N_1) and minimum (1.11, 2.52, 7.89, 9.82, 10.87 and 9.71, at 15, 30, 45, 60, 75 and 90 DAT respectively) with control methods treatment. The improvement in the formation of tillers with N application in the present experiment might be due to increase of nitrogen availability which enhanced tillering. Increased number of tillers in USG than others might be due to uniform N supply through USG. Kabir *et al*. (2009) and Masum *et al*. (2008) reported that the highest number of tillers hill^{-1} was found from full doses of USG @ 58 kg N ha^{-1}. Hasanuzzaman *et al*. (2009) reported that deep placement of USG @ 75 kg N ha^{-1} showed the highest number of tillers might be due to little loss of N from soil and slow releasing process. Hamidullah *et al*. (2006) found that tiller number increased with increasing N at 120 and 160 kg N ha^{-1} produced statistically similar tillers hill^{-1}.

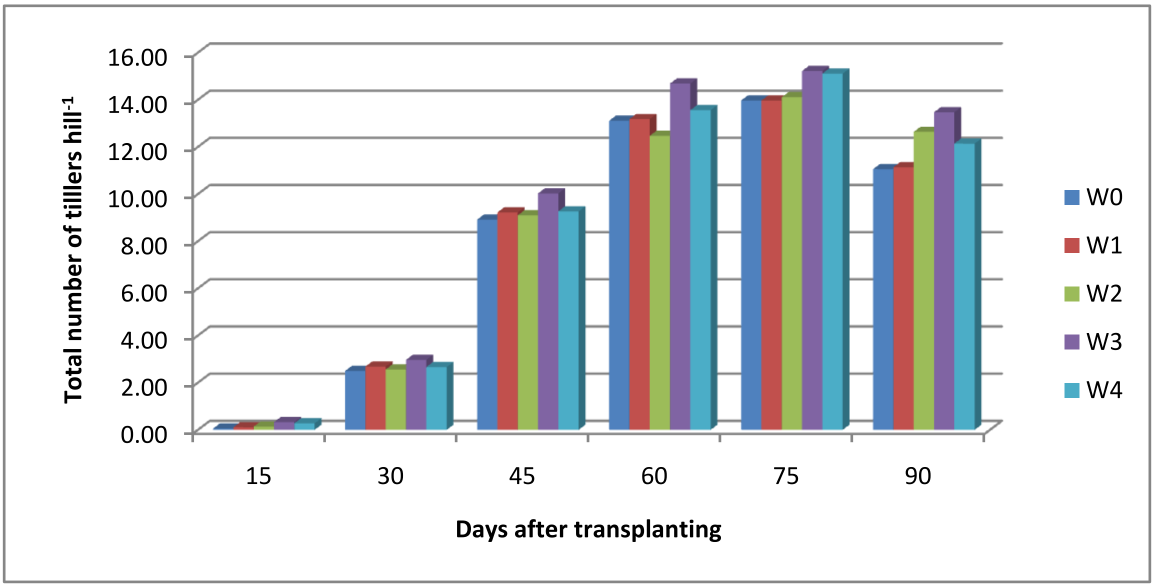


Note: N_o = 0 kg N ha^{-1}, N_1 = Urea super granules (2.7 g) @ 75 kgN ha^{-1} , N_2 = 140 kg N ha^{-1} , N_3 = 180 kg N ha^{-1}

Fig. 7. Effect of nitrogen on total number of tillers of rice at different days after transplanting (SE=0.05, 0.16, 0.46, 0.41, 0.56 and 0.52 at 15, 30, 45, 60, 75 and 90 DAT respectively)

4.5.2 Effect of weed control methods

Different weed control methods treatments affected tiller production significantly throughout the growing period. Tillers hill^{-1} increased gradually up to 75 DAT and then decreased in all the weed control methods due to mortality of ineffective tillers at later stages (Figure 8 and Appendix VII). All weed control methods treatments contributed to significantly higher number of tillers hill^{-1} than unweeded and that trend continued throughout the growing period. The highest number of tillers hill^{-1} (1.33, 2.97, 10.03, 14.69, 15.22 and 13.47 at 15, 30, 45, 60, 75 and 90 DAT respectively) was found in W_3 (Sunrice 150WG) treatment and the lowest number of tillers hill^{-1} (1.06, 2.50, 8.92, 13.11, 13.97 and 11.06 at 15, 30, 45, 60, 75 and 90 DAT respectively) was found in W_0 (Control methods) treatment. Similar findings were reported by Khan and Tarique (2011) who observed that the highest number of tillers plant^{-1} was observed in completely weed free condition throughout the crop growth period.



Note:W_0 =No weeding (Control methods) ,W_1= One weeding (30 Days after transplanting),W_2= Two weedings (30 DAT and 50 DAT),W_3= Sunrice 150 WG at recommended dose (100g ha^{-1}),W_4=Topstar 80WG at the recommended dose(80g ha^{-1})

Fig. 8. Effect of weed control methods on total number of tillers of rice at different days after transplanting (SE=0.06, 0.18, 0.52, 0.46, 0.64 and 0.58 at 15, 30, 45, 60, 75 and 90 DAT respectively)

4.5.3 Interaction effect of nitrogen and weed control methods

The interaction effect of nitrogen and weed control methods showed significant variation on the tiller dynamic of the hybrid rice (Table 5 and Appendix VII). The highest tiller hill^{-1} (1.67, 3.99, 12.22, 17.63, 19.00 and 15.67 at 15, 30, 45, 60, 75 and 90 DAT respectively) was recorded by N_1W_3 (USG @ 75 kg N ha^{-1}and Sunrice 150WG) treatment combination. The minimum tiller (1.00, 1.89, 6.67, 8.33, 8.56 and 7.67 at 15, 30, 45, 60, 75 and 90 DAT respectively) was found with N_0W_0 (0 kg N ha^{-1} and no weed control methods).

Table 5.Interaction effect of nitrogen and weed control methods on total number of tiller of rice at different days after transplanting (DAT)

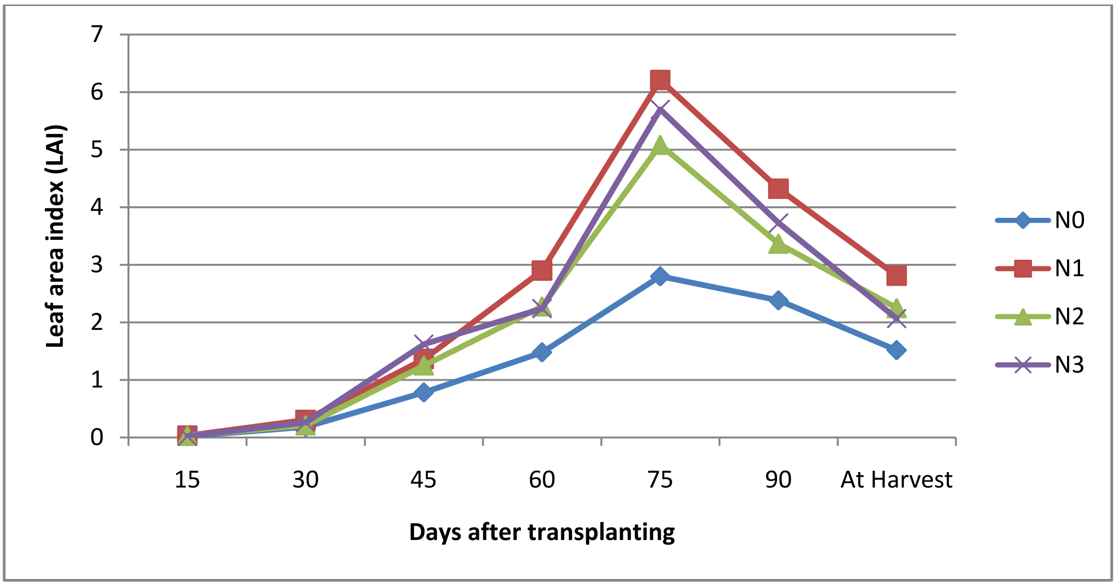
Treatment combinations	Total number of tiller											
	15 DAT		30 DAT		45 DAT		60 DAT		75 DAT		90 DAT	
N_0W_0	1.00	c	1.89	c	6.67	d	8.33	j	8.56	g	7.67	g
N_0W_1	1.11	c	2.78	bc	7.78	cd	10.11	h-j	10.22	fg	9.00	fg
N_0W_2	1.11	c	2.92	a-c	10.00	a-d	11.00	g-j	11.44	e-g	9.89	e-g
N_0W_3	1.22	bc	2.44	bc	8.22	cd	9.89	ij	11.89	d-g	11.11	b-g
N_0W_4	1.22	bc	2.22	bc	6.78	d	9.78	ij	12.22	d-g	10.89	b-g
N_1W_0	1.11	c	2.52	bc	8.89	a-d	14.55	a-f	16.11	a-d	12.22	a-f
N_1W_1	1.11	c	2.44	bc	8.67	bcd	13.11	d-h	15.78	a-d	12.55	a-f
N_1W_2	1.33	a-c	3.11	a-c	10.00	a-d	17.33	ab	17.45	ab	14.78	ab
N_1W_3	1.67	a	3.99	a	12.22	a	17.63	a	19.00	a	15.67	a
N_1W_4	1.22	bc	2.56	bc	9.78	a-d	15.40	a-e	15.67	a-e	13.11	a-e
N_2W_0	1.11	c	2.70	bc	10.84	a-c	15.29	a-e	17.11	ab	12.44	a-f
N_2W_1	1.22	bc	2.33	bc	8.33	cd	12.66	e-i	12.22	d-g	10.11	e-g
N_2W_2	1.17	c	3.07	a-c	10.66	a-c	16.67	a-c	17.00	ab	14.67	ab
N_2W_3	1.11	c	2.45	bc	8.89	a-d	11.89	f-i	14.11	b-f	10.33	d-g
N_2W_4	1.56	ab	2.67	bc	9.67	a-d	16.00	a-d	16.56	a-c	14.11	a-d
N_3W_0	1.00	c	2.78	bc	9.89	a-d	14.56	b-f	14.11	b-f	11.89	a-f
N_3W_1	1.00	c	3.18	ab	12.11	ab	16.55	a-c	17.67	ab	12.89	a-f
$N_3 W_2$	1.22	bc	2.78	bc	9.44	a-d	13.78	c-g	15.00	a-e	13.78	a-e
N_3W_3	1.22	bc	2.45	bc	8.89	a-d	12.11	f-i	14.78	a-e	14.33	a-c
N_3W_4	1.11	c	2.23	bc	8.40	cd	11.44	g-i	12.67	c-g	10.44	c-g
SE	0.12		1.04		1.03		0.93		1.27		1.17	
CV (%)	14.93		8.42		19.24		11.95		15.21		16.70	

Note: N_o = 0 kg N ha^{-1}, N_1 = Urea super granules (2.7 g) @ 75 kgN ha^{-1} , N_2 = 140 kg N ha^{-1} , N_3 = 180 kg N ha^{-1} ,W_0 =No weeding (Control methods) ,W_1= One weeding (30 Days after transplanting),W_2= Two weedings (30 DAT and 50 DAT),W_3= Sunrice 150 WG at recommended dose (100g ha^{-1}),W_4=Topstar 80WG at the recommended dose(80g ha^{-1})

4.6 Leaf Area Index (LAI)

4.6.1 Effect of nitrogen

Leaf area index (LAI) or the surface area of green leaves produced by rice plants unit area^{-1} of land was taken as an index of leaf area. The leaf area of plant is one of the major determinants of its growth. LAI was significantly affected by nitrogen treatments observed at 30, 45, 60, 75, 90 DAT and at harvest. There was no statistical difference in the values of LAI observed at 15 DAT (Figure 9 and Appendix VIII). Maximum LAI (0.03, 0.30, 1.36, 2.90, 6.21, 4.32and2.81 at 15, 30, 45, 60, 75, 90 DAT and at harvest, respectively)LAI was found due to the effect of USG @ 75 kg N ha^{-1}and minimum (0.02, 0.18, 0.78, 1.48, 2.80, 2.38and 1.52 at 15, 30, 45, 60, 75, 90 DAT and at harvest, respectively) with control methods. Masum *et al.* (2008) reported that LAI was significantly higher in USG receiving plants than prilled urea. Gorgy *et al*. (2009) observed higher LAI (7.09) with application of 165 kg N ha^{-1} as three equal splits and Hamidullah *et al.* (2006) found maximum LAI with 160 kg N ha^{-1}. Ali (2005) and Miah *et al.* (2004) reported that LAI was significantly higher in USG receiving plants than prilled urea.

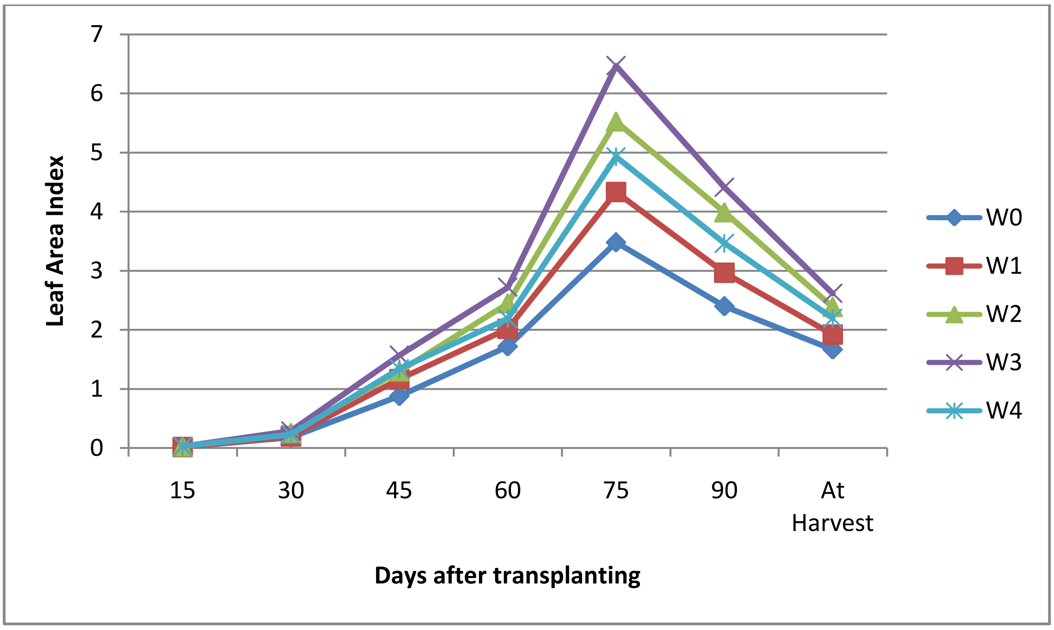


Note: N_o = 0 kg N ha^{-1}, N_1 = Urea super granules (2.7 g) @ 75 kgN ha^{-1}, N_2 = 140 kg N ha^{-1} , N_3 = 180 kg N ha^{-1}

Fig. 9. Effect of nitrogen on leaf area index of rice at different days after transplanting (SE=0.02, 0.01, 0.05, 0.09, 0.13, 0.09 and 0.07 at 15, 30, 45, 60, 75, 90 DAT and at harvest respectively)

4.6.2 Effect of weed control methods

Different weed control methods affected LAI significantly throughout the growing period except at 15 DAT (Figure 10 and Appendix VIII). The highest LAI (0.29, 1.57, 2.72, 6.47, 4.41and 2.62 at 30, 45, 60, 75, 90 DAT and at harvest, respectively) was found in W_3 (Sunrice 150WG) treatment and the lowest LAI (0.18, 0.88, 1.72, 3.48, 2.40, and 1.67 at 30, 45, 60, 75, 90 DAT and at harvest, respectively) was found in W_0 (Control treatment).



Note:W_0 =No weeding (Control methods) ,W_1= One weeding (30 Days after transplanting),W_2= Two weedings (30 DAT and 50 DAT),W_3= Sunrice 150 WG at recommended dose (100g ha^{-1}),W_4=Topstar 80WG at the recommended dose(80g ha^{-1})

Fig. 10. Effect of weed control methods on leaf area index of rice at different days after transplanting (SE=0.01, 0.01, 0.18, 0.10, 0.14, 0.29and 0.08 at 15, 30, 45, 60, 75, 90 DAT and at harvest respectively)

4.6.3 Interaction effect of nitrogen and weed control methods

The interaction effect of nitrogen and weed control methods showed significant influence on the LAI of the hybrid rice except at 15 DAT (Table 6 and Appendix VIII). The highest LAI (0.36, 3.65, 7.79, 5.57 and 3.54 at 30, 60, 75, 90 DAT and at harvest, respectively) was achieved by N_1W_3 (USG @ 75 kg N $ha^{-1}$and Sunrice 150WG) treatment combination except at 45 DAT. The minimum LAI (0.13, 0.53, 1.19, 1.87, 1.65 and 1.19 at 30, 45, 60, 75, 90 DAT and at harvest, respectively) was found with N_0W_0 (0 kg N ha^{-1} and no weed control methods).

Table 6.Interaction effect of nitrogen and weed control methods on leaf area index of hybrid heera 4 at different days after transplanting (DAT)

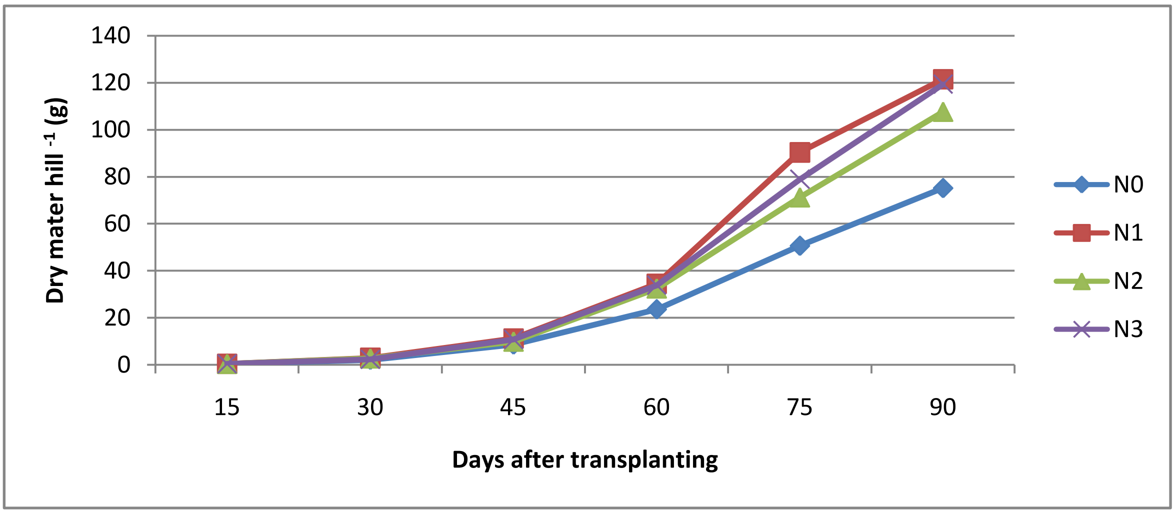
Treatment combinations	Leaf Area Index						
	15 DAT	30 DAT	45 DAT	60 DAT	75 DAT	90 DAT	At harvest
N_0W_0	0.02	0.16ij	0.53j	1.19j	1.87 i	1.65 i	1.19 j
N_0W_1	0.02	0.13j	0.69ij	1.48h-j	2.43 hi	2.22 hi	1.32 ij
N_0W_2	0.03	0.23e-i	0.85h-j	1.58h-j	2.87 gh	2.55 f-h	1.69 g-i
N_0W_3	0.02	0.21f-j	0.97g-i	1.75f-j	3.71 d-g	3.05 d-g	1.79 f-i
N_0W_4	0.02	0.19g-j	0.86h-j	1.39ij	3.12 f-h	2.43 gh	1.59 h-j
N_1W_0	0.02	0.23d-i	0.94g-i	2.27c-g	4.42 d	2.98 e-g	2.22 d-f
N_1W_1	0.02	0.27b-g	1.13e-h	2.47c-e	5.37 c	3.66 cd	2.35 d
N_1W_2	0.03	0.31a-d	1.39c-f	3.36ab	6.60 b	5.20 a	2.94 bc
N_1W_3	0.03	0.36a	1.79a-c	3.65a	7.79 a	5.57 a	3.54 a
N_1W_4	0.03	0.32a-c	1.57b-d	2.74cd	6.88 b	4.19 bc	3.00 b
N_2W_0	0.03	0.18hj	0.97g-i	1.74f-j	3.38 e-g	2.40 gh	1.69 g-i
N_2W_1	0.02	0.19g-j	1.03f-i	2.11d-h	3.97 d-f	2.82 f-h	1.87 e-h
N_2W_2	0.03	0.23d-i	1.32d-g	2.49c-e	6.16 bc	3.86 bc	2.61 b-d
N_2W_3	0.03	0.29a-f	1.51b-e	2.67c-e	6.61 b	4.07 bc	2.64 b-d
N_2W_4	0.03	0.17h-j	1.38d-f	2.36c-f	5.30 c	3.69 cd	2.43 d
N_3W_0	0.02	0.16ij	1.08f-i	1.69g-j	4.25 de	2.57 f-h	1.58 h-j
N_3W_1	0.03	0.24c-i	1.81ab	2.02e-i	5.57 c	3.17 d-f	2.15 d-g
N_3 W_2	0.03	0.30a-e	1.61b-d	2.37c-f	6.48 b	4.35 b	2.32 de
N_3W_3	0.02	0.33ab	2.04a	2.82bc	7.78 a	4.96 a	2.50 cd
N_3W_4	0.02	0.26b-h	1.53b-d	2.27c-g	4.40 d	3.56 c-e	1.77 f-i
SE	0.02	0.02	0.12	0.2	0.28	0.20	0.43
CV (%)	22.95	18.23	17.05	15.68	9.97	10.2	12.2

Note: N_o = 0 kg N ha^{-1}, N_1 = Urea super granules (2.7 g) @ 75 kgN ha^{-1} , N_2 = 140 kg N ha^{-1} , N_3 = 180 kg N ha^{-1} ,W_0 =No weeding (Control methods) ,W_1= One weeding (30 Days after transplanting),W_2= Two weeding (30 DAT and 50 DAT),W_3= Sunrice 150 WG at recommended dose (100g ha^{-1}),W_4=Topstar 80WG at the recommended dose(80g ha^{-1})

4.7 Dry matter hill $^{-1}$

4.7.1 Effect of nitrogen

Dry matter is the material which was dried to a constant weight. Total dry matter (TDM) production indicates the production potential of a crop. A high TDM production is the first prerequisit for high yield. TDM of roots, leaves, leaf sheath + stem and or panicles of plants data were measured at 15, 30, 45, 60, 75 and 90 DAT. It was evident from Figure 11 and Appendix IX that significant variation was found in the total dry matter accumulation at different growth stages except at 15 DAT. The highest total dry matter (2.98, 11.19, 34.49, 90.33 and 121.4 g hill^{-1} at 30, 45, 60, 75 and90 DAT respectively) was found with N_1 (USG @ 75 kg N ha^{-1}) and lowest (2.11, 8.60, 23.59, 50.60 and 75.15 g hill^{-1} at 30, 45, 60, 75 and 90 DAT respectively) with N_0(0 kg N ha^{-1}). Masum *et al.* (2008) revealed that USG applied plants gave higher TDM compared to prilled urea. Geethadevi *et al*. (2000) concluded that application of 150 kg N ha^{-1} gave the highest total dry matter per hill. Rambabu *et al*. (1983) and Rao *et al.* (1986) concluded that USG was the most effective in increasing TDM than split application of urea.

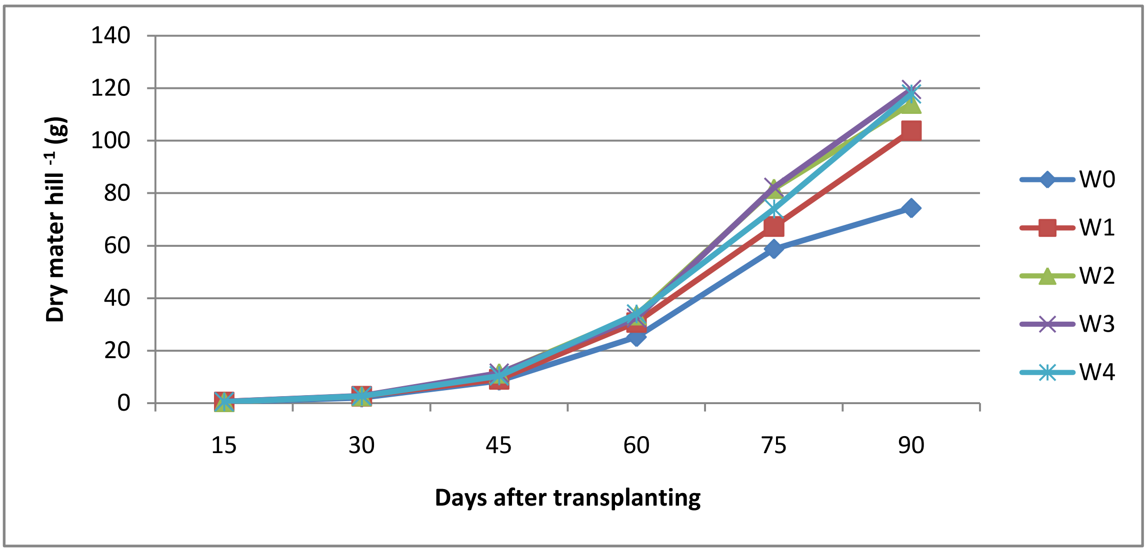


Note: N_o = 0 kg N ha^{-1}, N_1 = Urea super granules (2.7 g) @ 75 kgN ha^{-1} , N_2 = 140 kg N ha^{-1} , N_3 = 180 kg N ha^{-1}

Fig. 11. Effect of nitrogen on total dry mater of rice at different days after transplanting (SE= 0.05, 0.16, 0.46, 0.41, 0.57 and 0.52 at 15, 30, 45, 60, 75 and90 DAT respectively)

4.7.2 Effect of weed control methods

Total dry matter (TDM) increased exponentially with time. TDM was significantly affected by different weed control methods (Figure 12 and Appendix IX). From the early stages distinct differences were visible among the weed control methods treatments in TDM production. The lowest TDM throughout the growing period was observed in unweeded treatment (W_0). Among all the weed control methods Sunrice 150WG (W_3) achieved the highest TDM throughout the growing period. Similar results were observed by Bhuiyan *et al.* (2011).



Note: W_0 =No weeding (Control methods) , W_1= One weeding (30 Days after transplanting), W_2= Two weedings (30 DAT and 50 DAT), W_3= Sunrice 150 WG at recommended dose (100g ha^{-1}), W_4=Topstar 80WG at the recommended dose(80g ha^{-1})

Fig. 12. Effect of weed control methods on total dry mater of rice at different days after transplanting (SE= 0.04, 0.12, 1.34, 2.13, 2.94 and 10.31 at 15, 30, 45, 60, 75 and 90 DAT respectively)

4.7.3 Interaction effect of nitrogen and weed control methods

The interaction of nitrogen and weed control methods treatments had significant effect on TDM production throughout the growing period (Table 7 and Appendix IX). The treatment combination of USG @ 75 kg N ha^{-1} and Sunrice 150WG (N_1W_3) recorded the highest TDM (0.68, 3.80, 13.50, 41.90, 100.2 and 149.30 g at 15, 30, 45, 60, 75 and 90 DAT respectively). The lowest TDM (0.26, 1.54, 6.96, 20.03, 39.57 and 54.20 g $hill^{-1}$ at 15, 30, 45, 60, 75, 90 DAT respectively) was found in control combination.

Table 7.Interaction effect of nitrogen and weed control methods on dry mater hill^{-1} of rice at different days after transplanting (DAT)

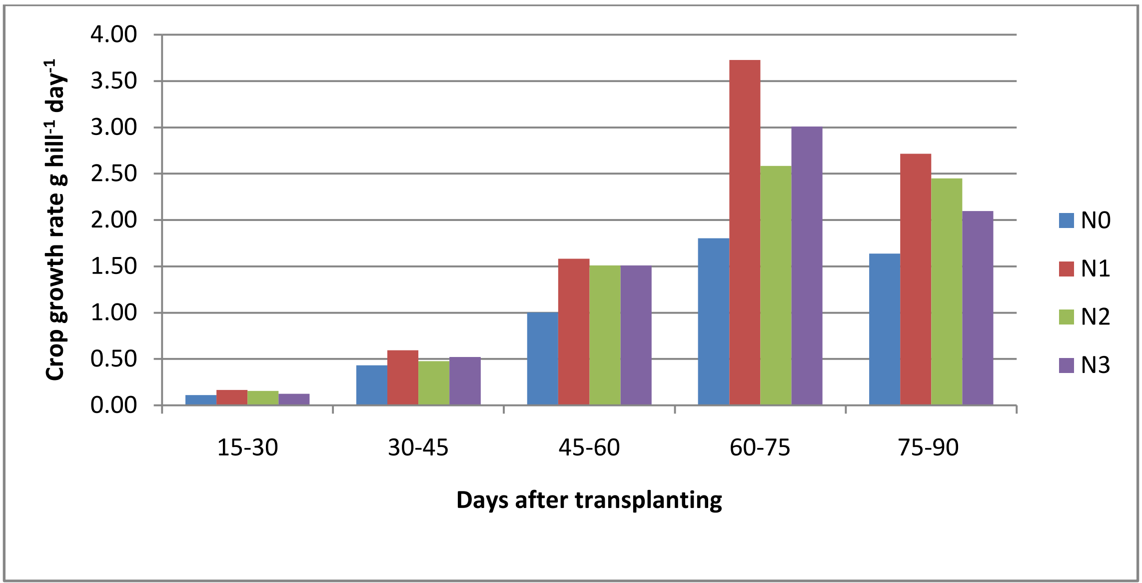
Treatment Combinations	Dry mater hill^{-1} (g)					
	15 DAT	30 DAT	45 DAT	60 DAT	75 DAT	90 DAT
N_0W_0	0.26 c	1.54 c	6.96 e	20.03 i	39.57 g	54.20 i
N_0W_1	0.44 a-c	2.43 bc	8.07 e	22.67 hi	39.73 g	66.43 hi
N_0W_2	0.42 a-c	2.20 bc	9.50 b-e	24.73 gh	59.40 ef	86.17 f-h
N_0W_3	0.42 a-c	1.95 bc	9.17 c-e	23.43 g-i	64.07 d-f	85.57 f-h
N_0W_4	0.40 a-c	2.04 bc	9.31 b-e	27.07 e-h	50.23 fg	83.40 gh
N_1W_0	0.54 a-c	2.20 bc	9.34 b-e	26.30 f-h	68.13 c-f	78.33 h
N_1W_1	0.37 bc	3.16 ab	8.73 de	32.67 cd	85.87 a-c	107.00 d-f
N_1W_2	0.35 bc	2.79 a-c	12.40 ab	38.47 ab	98.93 a	125.70 b-e
N_1W_3	0.68 a	3.80 a	13.50 a	41.90 a	100.20 a	149.30 a
N_1W_4	0.43 a-c	2.96 ab	11.34 a-d	33.13 cd	98.50 a	146.70 ab
N_2W_0	0.60 ab	2.77 a-c	8.89 de	27.80 e-g	61.37 ef	77.20 h
N_2W_1	0.37 bc	2.93 ab	9.68 b-e	30.73 d-f	64.83 d-f	103.60 e-g
N_2W_2	0.51 a-c	2.26 bc	10.15 b-e	38.07 ab	81.37 a-d	121.70 c-e
N_2W_3	0.48 a-c	3.12 ab	11.43 a-d	34.17 b-d	77.70 b-e	114.70 c-e
N_2W_4	0.40 a-c	2.65 a-c	9.30 b-e	31.67 de	70.83 b-e	120.70 c-e
N_3W_0	0.40 abc	1.92 bc	8.97 de	26.63 f-h	65.77 d-f	87.43 f-h
N_3W_1	0.65 ab	2.00 bc	9.86 b-e	36.63 bc	78.70 b-e	137.60 a-c
N_3 W_2	0.39 abc	3.24 ab	12.23 a-c	34.23 b-d	87.77 ab	120.70 c-e
N_3W_3	0.36 bc	2.40 bc	12.37 a-c	38.53 ab	86.00 a-c	130.30 a-d
N_3W_4	0.39 abc	2.31 bc	11.28 a-d	33.17 cd	76.40 b-e	120.30 c-e
SE	0.09	1.15	0.94	4.27	16.84	20.61
CV (%)	14.13	17.44	16.06	13.12	14.00	17.81

Note: N_o = 0 kg N ha^{-1}, N_1 = Urea super granules (2.7 g) @ 75 kgN ha^{-1} , N_2 = 140 kg N ha^{-1} , N_3 = 180 kg N ha^{-1} ,W_0 =No weeding (Control methods) ,W_1= One weeding (30 Days after transplanting),W_2= Two weedings (30 DAT and 50 DAT),W_3= Sunrice 150 WG at recommended dose (100g ha^{-1}),W_4=Topstar 80WG at the recommended dose(80g ha^{-1})

4.8. Crop growth rate (CGR)

4.8.1 Effect of nitrogen

Crop growth rate is a measure of the increase in size, mass or number of crops over a period of time. This increase can be plotted as a logarithmic or exponential curve in many cases. It varied significantly due to nitrogen shown in Figure 13 and Appendix X. The highest CGR (0.17, 0.59, 1.58, 3.73 and2.72g hill^{-1} day^{-1} at15-30, 30-45, 45-60, 60-75 and 75-90 DAT respectively) was produced inN_1(USG @ 75 kg N ha$^{-1)}$.The lowest CGR (0.11, 0.43, 1.00, 1.80 and 1.64 g hill^{-1} day^{-1}at 15-30, 30-45, 45-60, 60-75 and 75-90 DAT respectively) was observed from control treatment (N_0).



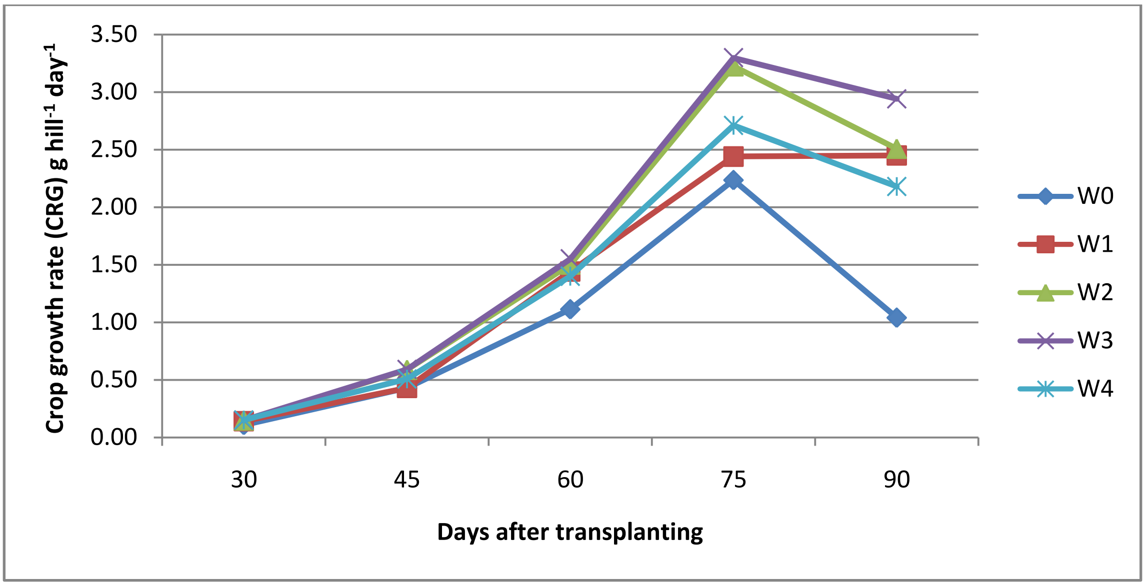
Note: N_o = 0 kg N ha^{-1}, N_1 = Urea super granules (2.7 g) @ 75 kgN ha^{-1} , N_2 = 140 kg N ha^{-1} , N_3 = 180 kg N ha^{-1}

Fig. 13. Effect of nitrogen on crop growth rate(CGR) of rice at different days after transplanting (SE = 0.01, 0.03, 0.07, 0.58 and 0.23 at 15-30, 30-45, 45-60, 60-75 and 75-90 DAT respectively)

4.8.2 Effect of weed control methods

The growth rate of rice crop was significantly influenced by different weed control methods (Figure 14 and Appendix X). Unweeded treatment (W_0) showed the lowest CGR throughout the growing period. It revealed that severe weed infestation might hamper the growth and development of rice plants drastically

(Figure 14). The treatment W_3 (Sunrice 150WG) gave the highest CGR (0.15, 0.59, 1.55, 3.30 and 2.94g $hill^{-1}$ day^{-1}at 15-30, 30-45, 45-60, 60-75 and 75-90 DAT respectively). The lowest CGR (0.11, 0.43, 1.11, 2.23 and 1.04 g $hill^{-1}$ day^{-1} at 15-30, 30-45, 45-60, 60-75 and 75-90 DAT respectively) was produced in control treatment (W_0).



Note:W_0 =No weeding (Control methods) ,W_1= One weeding (30 Days after transplanting),W_2= Two weedings (30 DAT and 50 DAT),W_3= Sunrice 150 WG at recommended dose (100g ha^{-1}),W_4=Topstar 80WG at the recommended dose(80g ha^{-1})

Fig. 14. Effect of weed control methods on crop growth rate (CGR) of rice at different days after transplanting (SE = 0.01, 0.03, 0.22, 0.23 and0.26 at 15-30, 30-45, 45-60, 60-75 and 75-90 DAT respectively)

4.8.3 Interaction effect of nitrogen and weed control methods

The interaction of nitrogen and weed control methods treatments significantly influenced the CGR throughout the growing period (Table 8 and Appendix X). The highest CGR (0.22, 0.69, 2.04, 4.39 and 3.95g $hill^{-1}$ day^{-1}at 15-30, 30-45, 45-60, 60-75 and 75-90 DAT respectively) was produced in N_1W_3 treatment. The lowest CGR was obtained from control treatment.

Table 8. Interaction effect of nitrogen and weed control methods on crop growth rate of hybrid heera 4 at different days after transplanting

Treatment combinations	Crop growth rate (g $hill^{-1}$ day^{-1}) at different days after transplanting				
	15 DAT	30 DAT	45 DAT	60 DAT	75 DAT
N_0W_0	0.08 d	0.34 f	0.88 h	1.14 g	0.68 e
N_0W_1	0.13 b-d	0.38 ef	0.98 f-h	1.30 fg	1.78 b-e
N_0W_2	0.12 b-d	0.49 a-f	1.02 e-h	2.32 c-g	1.78 b-e
N_0W_3	0.10 cd	0.48 b-f	0.95 gh	2.71 b-f	1.43 c-e
N_0W_4	0.11 b-d	0.48 a-f	1.19 d-h	1.55 e-g	2.21 a-e
N_1W_0	0.11 b-d	0.47 b-f	1.13 d-h	2.79 b-f	0.97 de
N_1W_1	0.17 a-c	0.37 ef	1.60 a-d	3.55 a-d	1.44 c-e
N_1W_2	0.16 a-d	0.64 a-c	1.74 a-c	4.12 ab	3.31 ab
N_1W_3	0.22 a	0.69 a	2.04 a	4.39 a	3.95 a
N_1W_4	0.17 a-c	0.51 a-f	1.40 b-h	3.80 a-c	3.23 ab
N_2W_0	0.14 a-d	0.41 def	1.26 c-h	2.24 d-g	1.06 de
N_2W_1	0.17 a-c	0.45 c-f	1.41 b-h	2.27 c-g	2.62 a-d
N_2W_2	0.11 b-d	0.53 a-f	1.86 ab	2.89 b-e	2.72 a-d
N_2W_3	0.19 ab	0.55 a-e	1.52 b-e	2.90 b-e	2.50 a-d
N_2W_4	0.15 a-d	0.44 c-f	1.49 b-f	2.61 b-g	3.35 ab
N_3W_0	0.10 cd	0.50 a-f	1.18 d-h	2.61 b-g	1.44 c-e
N_3W_1	0.09 cd	0.52 a-f	1.79 a-c	2.80 b-f	1.81 b-e
N_3 W_2	0.19 ab	0.62 a-c	1.38 b-h	3.57 a-d	2.22 a-e
N_3W_3	0.13 b-d	0.67 ab	1.75 a-c	3.18 a-d	2.98 a-c
N_3W_4	0.13 b-d	0.60 a-d	1.46 b-g	2.88 b-e	2.98 a-c
SE	0.07	0.06	0.16	1.29	1.50
CV (%)	13.53	21.03	19.38	18.13	10.66

Note: N_o = 0 kg N ha^{-1}, N_1 = Urea super granules (2.7 g) @ 75 kgN ha^{-1} , N_2 = 140 kg N ha^{-1} , N_3 = 180 kg N ha^{-1} ,W_0 =No weeding (Control methods) ,W_1= One weeding (30 Days after transplanting),W_2= Two weedings (30 DAT and 50 DAT),W_3= Sunrice 150 WG at recommended dose (100g ha^{-1}),W_4=Topstar 80WG at the recommended dose(80g ha^{-1})

4.9Effective tillers $hill^{-1}$

4.9.1Effect of nitrogen

The number of effective tillers $hill^{-1}$ was significantly influenced by nitrogen (Table 9 and Appendix XI). The highest number of effective tiller $hill^{-1}$ (13.40) was observed from N_1 (Urea super granules @ 75 kgN ha^{-1}) that similar to N_2 and N_3. The lowest number of effective tiller (9.82) production was observed in N_0 (control methods) treatment. It was in agreement with Rama *et a1*. (1989), who reported that USG produced higher numbers of panicle m^{-2} than splits application of urea. Adequacy of nitrogen and uniform supply through USG probably favoured the cellular activities during panicle formation and development which laded to increase number of effective tillers hill^{-1}. Thakur (1991b) and Gosh *et al.*(1991) also agreed to this view.

4.9.2 Effect of weed control methods

Weed control methods by Sunrice (W_3) gave the highest effective tiller (11.61) that similar to two weedings (10.58) (Table 9 and Appendix XI). No weeding (W_0) gave the lowest effective tillers hill^{-1} (9.14). These results were in similar to the findings of Hasanuzzaman *et al.* (2008) and Raju *et al.* (2003) who stated that use of weedicide (Ronstar 25 EC, Safener and Butachlor) gave the highest effective tiller.

4.9.3Interaction effect of nitrogen and weed control methods

The effect of interaction between N levels and weed control methods was found to be significant in respect of number of effective tillers hill^{-1} (Table 9 and Appendix XI). The highest number of effective tiller hill^{-1} (12.67) was found from N_1W_3(Urea super granules (2.7 g) @ 75 kgN ha^{-1}with Sunrice 150 WG at recommended dose) (100g ha^{-1}) that similar to N_2W_2 (12.67), N_1W_2 (11.89), N_2W_4 (11.89), N_3W_2 (11.89), N_3W_1 (11.11), N_3W_3 (11.11), N_1W_1 (10.89), N_1W_4 (10.89), N_2W_0 (10.89), N_0W_3 (10.78), N_3W_0 (10.45) and the lowest number of effective tiller hill^{-1} (6.33) was recorded from N_0W_0 (control treatment combination) that similar to N_0W_1 (6.89), N_3W_4 (8.01), N_0W_2 (8.22), N_0W_4 (8.56), N_2W_3 (8.56), N_1W_0 (8.89), N_2W_1 (8.89).

4.10Panicle length

4.10.1Effect of nitrogen

Panicle length was statistically significant by forms of nitrogen (Table 9 and Appendix XI).The longest (24.17 cm) panicle was produced due to application of USG @ 75 kg N ha^{-1}. The shortest (23.01 cm) was produced in control methods.

A similar finding was reported by Hasan *et al.*(2002). Sen and Pandey (1990) also found similar panicle length by applying 38.32 kg N ha^{-1} either in the form of USG or prilled urea.

4.10.2 Effect of weed control methods

The panicle length varied significantly due to weed control methods shown in Table 9 and Appendix XI. It was observed that the longest panicle (24.29 cm) was observed from the treatment W_3 (Sunrice 150WG), which was statistically similar with W_1, W_2 and W_4. The shortest (22.55 cm) panicle length was observed from control methods (W_0). This confirms the report of Khan and Tarique (2011) and Hasanuzzaman *et al.* (2008) who observed that panicle length was varied due to different weed control methods treatments.

4.10.3 Interaction effect of nitrogen fertilizer and weed control methods

Panicle length was statistically influenced by the interaction of nitrogen fertilizer and weed control methods (Table 9and Appendix XI). The highest panicle length (25.23 cm) was observed from N_1W_3 (Urea super granules (2.7 g) @ 75 kgN ha^{-1} with Sunrice 150 WG at recommended dose (100g ha^{-1}) and the lowest (21.73 cm) panicle length was produced form N_0W_0 treatment.

4.11Number of filled grains panicle^{-1}

4.11.1Effect of nitrogen

From the table 9 it was observed that there was a statistical variation in number of filled grains panicle^{-1} due to N fertilizer. Results showed that the highest number of filled grains panicle^{-1}(176.50) was obtained with USG @ 75 kg N ha^{-1}that similar to N_3 .The lowest (130.00) was produced in control methods (W_0). Rama *et al.* (1989) found significantly higher filled grains panicle^{-1} with 40, 80 or 120 kg N ha^{-1} applied as USG over split application of urea. The present results supported those results.

4.11.2 Effect of weed control methods

Significant variation was found in filled grains panicle^{-1} due to the effect of weed control methods (Table 9 and Appendix XI). The highest filled grains (173.00) was obtained from the effect of Sunrice 150WG (W_3) which was statistically similar with the effect of Topstar 80 WG (W_4) and W_2 (Two weedings). The lowest filled grain (137.70) was obtained from no weeding treated plot (W_0). This result supports the findings of Hasanuzzaman *et al.* (2008) and Salam *et al.* (2010) who showed that application of herbicide contributed mainly increasing the number of grains panicle^{-1}. But similar findings were stated by Karim and Ferdous (2010) who revealed that the number of filled grains panicle^{-1}was negatively related to weed density.

4.11.3 Interaction effect of nitrogen fertilizer and weed control methods

Interaction effect of N fertilizer and weed control methods was found significant on filled grains panicle^{-1} (Table 9 and Appendix XI). From the results of Table 9 it was observed that the highest (205.70) filled grains panicle^{-1}was found from the combination of Urea super granules (2.7 g) @ 75 kgN ha^{-1} with Sunrice 150 WG (N_1W_3). The lowest filled grains panicle^{-1} (108.80) was obtained in combination of control treatment (N_0W_0).

4.12Number of unfilled grains panicle^{-1}

4.12.1Effect of nitrogen

Number of unfilled grains panicle^{-1} was statistically influenced from the N fertilizer (Table 9 and Appendix XI). The lowest unfilled grains panicle^{-1}(11.17) was obtained from the application of USG (N_1).The highest unfilled grains panicle^{-1} (18.67) was obtained from control methods (N_0). Hasan *et al.* (2002) also observed that unfilled grains panicle^{-1} was differed by the application of USG and PU.

4.12.2 Effect of weed control methods

Effect of weeding showed significant variation in unfilled grains (Table 9 and Appendix XI). No weeding (W_0) gave the highest unfilled grain panicle^{-1} (18.63). The lowest unfilled grains panicle^{-1} (12.48) was obtained from Sunrice 150WG (W_3).

4.12.3Interaction effect of nitrogen fertilizer and weed control methods

Interaction of nitrogen fertilizer and weed control methods showed significant response on unfilled grains panicle^{-1} (Table 9 and Appendix XI). The lowest (8.93) unfilled grains panicle^{-1} was observed from N_1W_3treatment and the highest (28.47) unfilled grains panicle^{-1} from N_0W_0 treatment.

4.13Total grains panicle^{-1}

4.13.1Effect of nitrogen

The total grain panicle^{-1}was significantly affected by the source of N(Table 9 and Appendix XI).The highest total grains panicle^{-1} (187.67) was observed from N_1 treatment that was similar to N_3 treatment. Whereas the lowest total grains panicle^{-1} (148.67) was observed from N_0 treatment.

4.13.2 Effect of weed control methods

Significant variation was observed on total grain panicle^{-1} due to different weed control methods (Table 9 and Appendix XI). All the weed control methods treatments performed better than the unweeded treatment (W_0). Among the weed control methods treatments, the highest total grains panicle^{-1}(185.48) was recorded from Sunrice 150WG (W_3). The lowest total grain panicle^{-1}(156.33) was recorded from no weeding (W_0) treatment.

4.13.3 Interaction effect of nitrogen fertilizer and weed control methods

Significant effect was observed in total grain panicle^{-1} from the interaction of N fertilizer and weed control methods (Table 9 and Appendix XI). The highest total grains panicle^{-1} (214.63) was obtained by the interaction of Urea super granules with Sunrice 150 WG and the lowest total grains panicle^{-1}(137.27) was found from the control (N_0W_0) treatment.

4.141000-grain weight

4.14.1Effect of nitrogen

There was significant variation in 1000-grain weight due to different forms of N fertilizer (Table 9 and Appendix XI). The highest 1000-grain weight (29.20g) was obtained form N_1 treatment. The lowest 1000-grain weight (28.22 g) was observed from N_0 treatment. The 1000-grain weight of rice is more or less a stable genetic character (Yoshida, 1981) and N management strategy could not increase the grain weight in this case. Hasan *et al.* (2002) also reported that the effect of application method of USG and PU was not significant in respect of 1000-grain weight.

4.14.2 Effect of weed control methods

Effect of weeding showed significant variation in 1000 grain weight (Table 9 and Appendix XI). Sunrice 150WG (W_3) gave the highest 1000 grain weight (30.36 g) which was statistically similar with Topstar 80WG (W_4) and two hand weeding (W_2). The lowest 1000 grain weight (27.67 g) was found from no weeding (W_0). This finding was in agreement with Khan and Tarique (2011), Hassan *et al.* (2010) and Raju *et al.* (2003) who showed that weeding regime had significant effect on 1000 grain weight. But this result was dissimilar with the findings of Nahar *et al.* (2010) and Karim and Ferdous (2010) who observed that 1000 grain weight was negatively related to weed density.

4.14.3 Interaction effect of nitrogen fertilizer and weed control methods

Interaction of different forms of N fertilizer and weed control methods was showed significant variation on 1000-grain weight of rice (Table 9 and Appendix XI). The highest (31.77) 1000-grain weight was observed from N_1W_3 treatment and the lowest (26.70) 1000-grain weight from N_0W_0 treatment.

Table 9. Effect of nitrogen and weed control methods and their interaction on yield contributing characters of hybrid rice

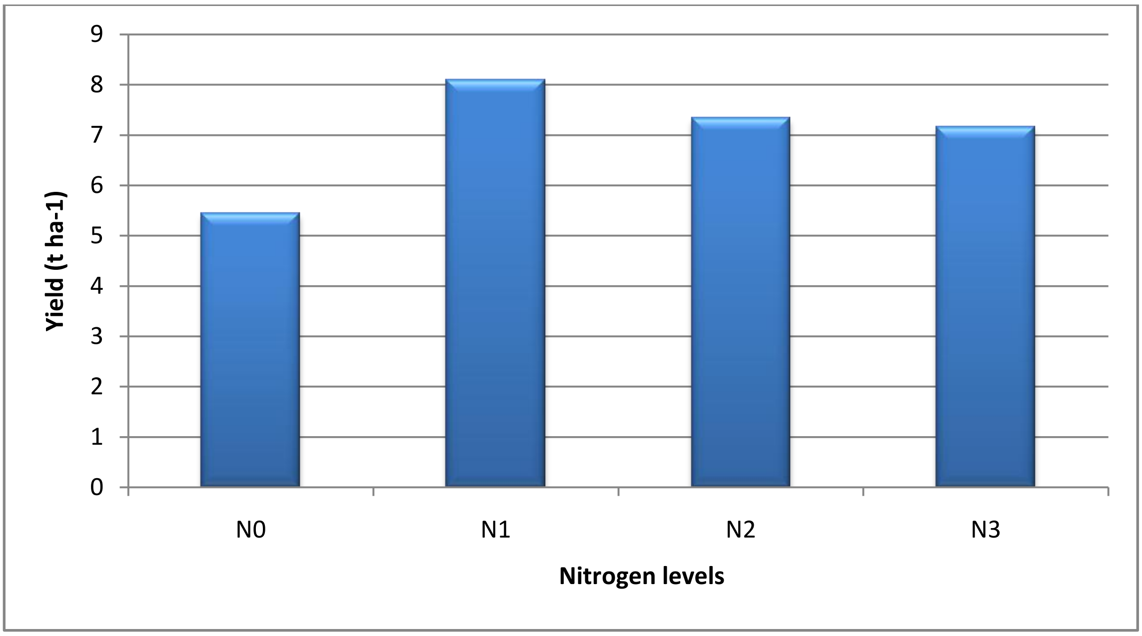
Treatment combinations	Effective tillers hill^{-1}	Panicle length (cm)	Filled grains panicle^{-1}	Unfiilled grains panicle^{-1}	Total grain penicle^{-1}	1000 grain weight (g)
Nitrogen						
N_0	9.82b	23.01c	130.00c	18.67a	148.67c	28.22
N_1	13.40a	24.17a	176.50a	11.17c	187.67a	29.20
N_2	12.84a	23.58b	156.50b	15.11b	171.61b	28.73
N_3	12.67a	24.10ab	169.10a	13.38b	182.48ab	28.66
SE	0.42	0.19	4.27	0.66	4.24	ns
CV(%)	16.84	3.21	10.47	17.63	9.53	3.85
Weed control methods						
W_0	9.14b	22.55b	137.70c	18.63a	156.33c	27.67b
W_1	9.44b	23.81a	151.60b	15.10b	166.7bc	28.46b
W_2	10.58ab	23.74a	161.20ab	13.10bc	173.68ab	29.48a
W_3	11.61a	24.29a	173.00a	12.48c	185.48a	30.36a
W_4	9.84b	24.19a	166.70a	13.62bc	180.32ab	30.03a
SE	0.49	0.22	4.78	0.74	4.74	0.32
CV(%)	16.84	3.21	10.47	17.63	9.53	3.85
Interaction effect of nitrogen and Weed control methods						
N_0W_0	6.33d	21.73f	108.80h	28.47a	137.27h	26.70h
N_0W_1	6.89d	22.53d-f	126.30gh	21.07b	147.37e-h	28.03e-h
N_0W_2	8.22cd	23.23c-e	130.30f-h	14.37c-g	144.67f-h	28.80d-h
N_0W_3	10.78a-c	23.97a-e	149.30d-g	17.30b-e	166.60c-h	28.50d-h
N_0W_4	8.56b-d	23.60b-e	135.00e-h	12.17e-h	147.17e-h	29.07c-g
N_1W_0	8.89b-d	23.07c-f	159.30c-f	11.50f-h	170.80b-g	29.77c-e
N_1W_1	10.89a-c	23.73b-e	183.70a-c	10.60gh	194.3a-c	29.50c-f
N_1W_2	11.89ab	24.13a-c	181.70a-c	11.80f-h	193.50a-c	30.07bc
N_1W_3	12.67a	25.23a	205.70a	8.93h	214.63a	31.77a
N_1W_4	10.89a-c	24.33a-c	191.70ab	11.27f-h	202.97ab	30.90b
N_2W_0	10.89a-c	22.53ef	125.70gh	16.87b-e	142.57gh	27.30f-h
N_2W_1	8.89b-d	23.73b-e	136.30e-h	12.67d-h	148.97d-h	28.00e-h
N_2W_2	12.67a	23.70b-e	154.30c-g	14.40c-g	168.70c-g	29.00c-g
N_2W_3	8.56b-d	24.03a-d	166.00b-f	15.47c-g	176.7b-e	28.97c-g
N_2W_4	11.89ab	23.90a-e	160.30b-f	16.17c-f	176.17b-e	30.37b-d
N_3W_0	10.45a-c	22.87c-f	156.70c-g	17.67bc	174.37b-f	26.93gh
N_3W_1	11.11a-c	25.20a	160.00b-f	16.07c-f	176.07b-e	28.30d-h
N_3 W_2	11.89ab	23.90a-e	178.30a-d	9.36h	187.60bc	29.07c-g
N_3W_3	11.11a-c	24.83ab	171.00b-d	10.7.gh	179.93b-d	30.20b-e
N_3W_4	8.01cd	24.03a-d	179.70a-d	14.87c-g	194.57a-c	28.80d-h
SE	0.98	0.44	9.55	1.48	9.49	0.65
CV (%)	16.84	3.21	10.47	17.63	9.53	3.89

Note: N_o = 0 kg N ha^{-1}, N_1 = Urea super granules (2.7 g) @ 75 kgN ha^{-1} , N_2 = 140 kg N ha^{-1} , N_3 = 180 kg N ha^{-1} ,W_0 =No weeding (Control methods) ,W_1= One weeding (30 Days after transplanting),W_2= Two weedings (30 DAT and 50 DAT),W_3= Sunrice 150 WG at recommended dose (100g ha^{-1}),W_4=Topstar 80WG at the recommended dose(80g ha^{-1})

4.15 Grain yield

4.15.1Effect of nitrogen

Grain yield affected significantly due to the forms of N-fertilizer (Fig. 15 and Appendix XII). The highest grain yield (8.10 tha^{-1}) was obtained from Urea super granules (N_1) which was 32.84% higher than control plot having the lowest grain. Placement of nitrogen fertilizer in the form of Urea super granules (2.7 g) @ 75 kgN ha^{-1}in the present experiment produced the highest number of effective tillers $hill^{-1}$, filled grains $panicle^{-1}$which ultimately gave higher grain yield than split application of urea. This result was in agreement with those of BRRI (2000) where USG gave 18% yield increase over the recommended prilled urea. In the present experiment it 12.2% higher grain yield was found in USG over urea. Similar results were reported by Mishra *et al.* (2000)and Raju *et al.* (1987) who observed that among all the forms of N, urea supergranules recorded the highest grain yield and proved significantly superior to other sources.

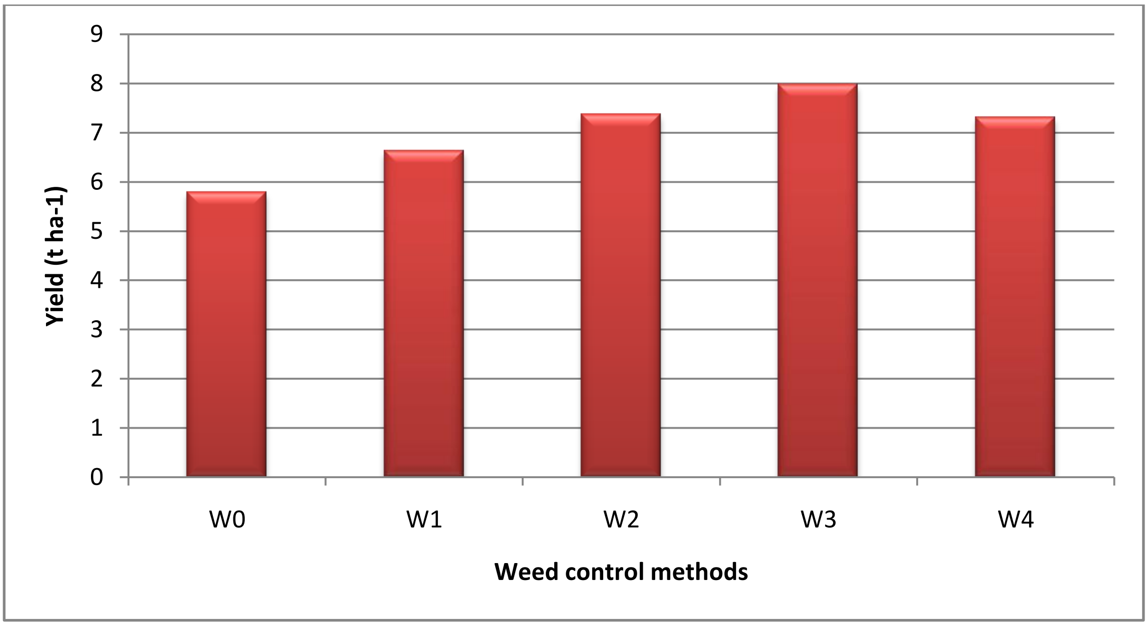


Note: N_o = 0 kg N ha^{-1}, N_1 = Urea super granules (2.7 g) @ 75 kgN ha^{-1} , N_2 = 140 kg N ha^{-1} , N_3 = 180 kg N ha^{-1}

Fig. 15. Effect of nitrogen levels on yield of rice (SE=0.09**)**

4.15.2 Effect of weed control methods

Significant variation was observed for grain yield due to different weed control methods (fig. 16 and Appendix XII). The highest yield (7.97 t ha^{-1}) was recorded from Sunrice 150WG (W_3) which was 27.35% higher than control plot having the lowest grain. Similar findings were reported by Al-Mamun *et al.* (2011), Bhuiyan *et al.* (2011), Khan and Tarique (2011), Mamun *et al.* (2011), Shultana *et al.*(2011), Ali *et al.* (2010), Bhuiyan *et al.* (2010), Gnanavel and Anbhazhagan (2010), Islam *et al.* (2010), Nahar *et al.* (2010), Salam *et al.* (2010) and Pacanoski and Glatkova (2009) who observed that application of chemical herbicides significantly increases grain yield of rice.



Note:W_0 =No weeding (Control methods) ,W_1= One weeding (30 Days after transplanting),W_2= Two weeding (30 DAT and 50 DAT),W_3= Sunrice 150 WG at recommended dose (100g ha^{-1}),W_4=Topstar 80WG at the recommended dose(80g $ha^{-1)}$

Fig. 16. Effect of weed control methods on yield of rice (SE = 0.10)

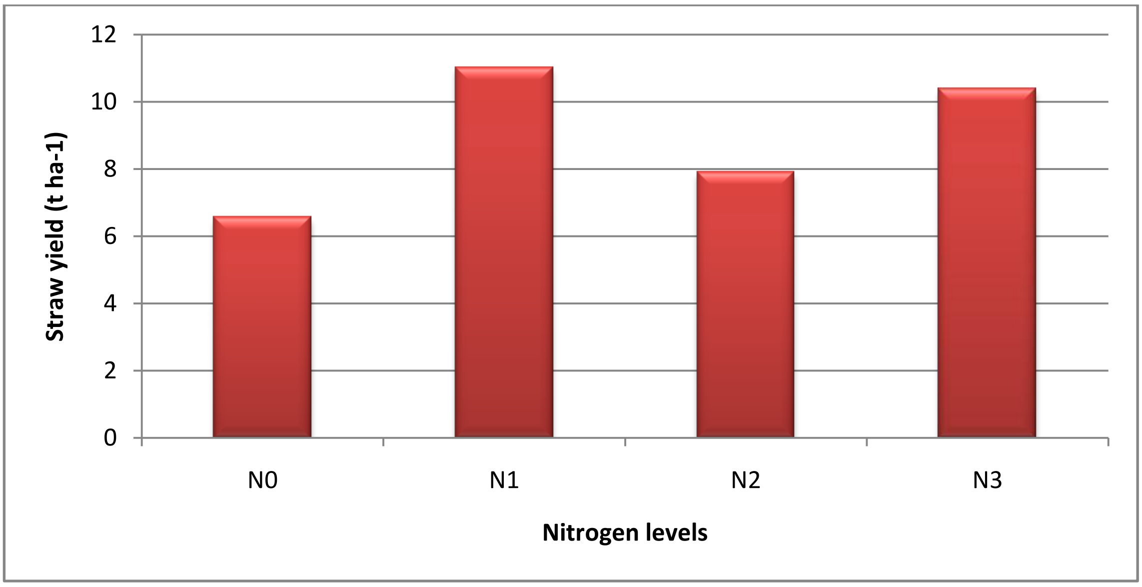
4.15.3 Interaction effect of nitrogen fertilizer and weed control methods

Interaction of N fertilizer and weed control methods significantly affected the grain yield (Table 10 and Appendix XII). Significantly the highest grain yield(9.48 t ha^{-1}) was found from the combination of USG with Sunrice 150 WG (N_1W_3) and the lowest (4.66 t ha^{-1}) obtained from control (N_0W_0) combination.

4.16 Straw yield

4.16.1 Effect of nitrogen

From Fig. 17 and Appendix XII, it was revealed that straw yield was significantly affected due to the application of nitrogen. The highest straw yield of 11.03 t ha^{-1} was obtained from N_1 (USG @ 75 kg N ha^{-1}). Whereas the lowest straw yield (6.55 t ha^{-1}) was observed in N_0 (0 kg N ha^{-1}). BRRI (2009) reported that application of 150 kg N ha^{-1} gave the highest yield. Hasanuzzaman *et al*. (2009) reported application of 200 kg N ha^{-1} and USG @ 75 kg N ha^{-1} gave the highest straw yield. Awan *et al*. (2011) also observed application of 156 kg N ha^{-1} gave the highest straw yield in their trail.



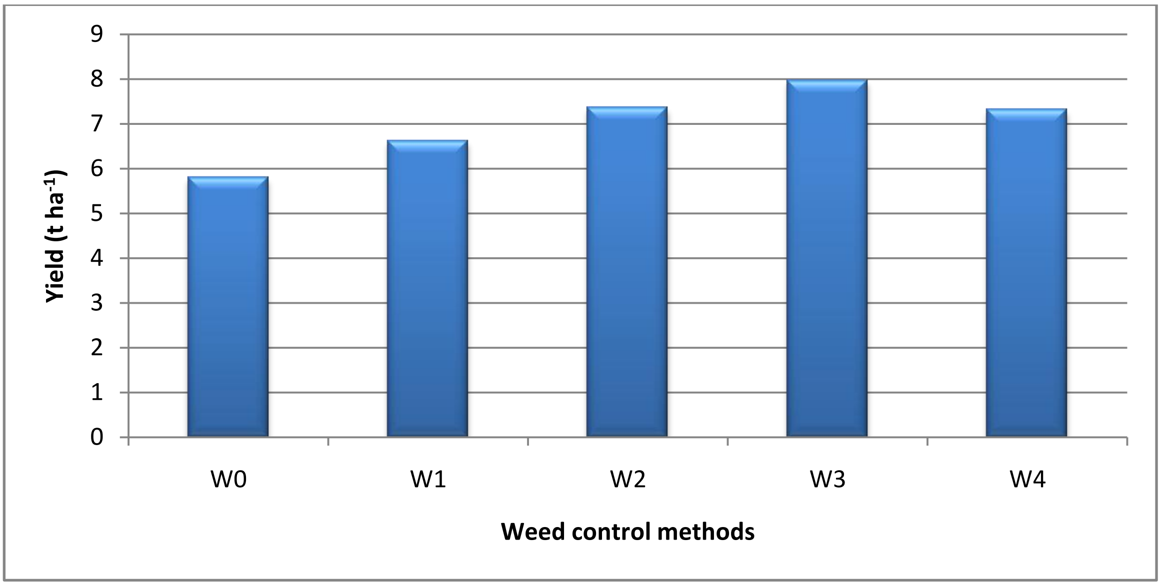
Note: N_o = 0 kg N ha^{-1}, N_1 = Urea super granules (2.7 g) @ 75 kgN ha^{-1}, N_2 = 140 kg N ha^{-1}, N_3 = 180 kg N ha^{-1}

Fig. 17. Effect of nitrogen on straw yield of rice (SE=0.29)

4.16.2 Effect of weed control methods

Significant variation was observed due to different weed control methods (Fig. 18 and Appendix XII). The highest straw yield (10.68 t ha^{-1}) was recorded from Sunrice 150WG (W_3) and the lowest (7.03 t ha^{-1}) was recorded from no weeding (W_0) treatment. This result was in agreement with the findings of Khan and Tarique (2011), Salam *et al.* (2010), Manish *et al.* (2006) and Chandra and

Solanki (2003) who revealed that weeding had significant variation on straw yield of rice.



Note: W_0 =No weeding (Control methods) , W_1= One weeding (30 Days after transplanting), W_2= Two weeding (30 DAT and 50 DAT), W_3= Sunrice 150 WG at recommended dose (100g ha^{-1}), W_4=Topstar 80WG at the recommended dose(80g ha^{-1})

Fig. 18. Effect of weed control methods on straw yield of rice (SE = 0.32)

4.16.3 Interaction effect on form of nitrogenous fertilizer and weed control methods

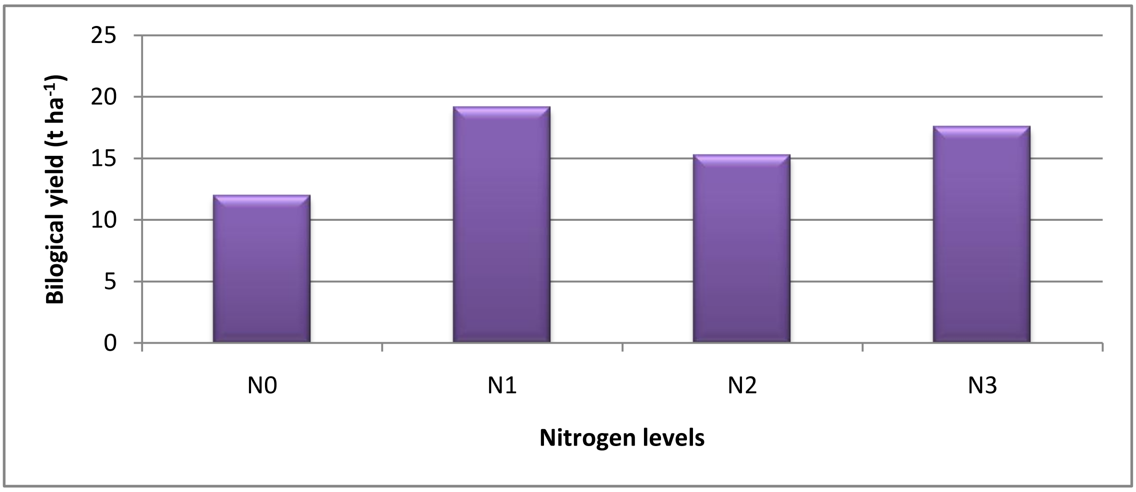
Interaction effect of nitrogen and weed control methods was observed significant on straw yield (Table 10 and Appendix XII). The highest (13.60 t ha^{-1}) straw yield was found from the combination of N_3W_3 (180 kg N ha^{-1} and Sunrice 150 WG), which was statistically similar with N_3W_3. The lowest straw yield (5.57 t ha^{-1}) was found with the combination of N_0W_0.

4.17 Biological yield

4.17.1 Effect of nitrogen

The biological yield was significantly affected by the nitrogen (fig. 19 and Appendix XII). The highest (19.13 t ha^{-1}) biological yield was measured from the N_1 (USG @) 75 kg N ha^{-1}) treated plots. The lowest biological yield (11.95 t ha^{-1})

was produced from N_0 (0 kg N ha^{-1}) treatment. The result agreed with the findings of Ahmed *et al.* (2005) who observed the effect of nitrogen dose on biological yield (t ha^{-1}) of rice.

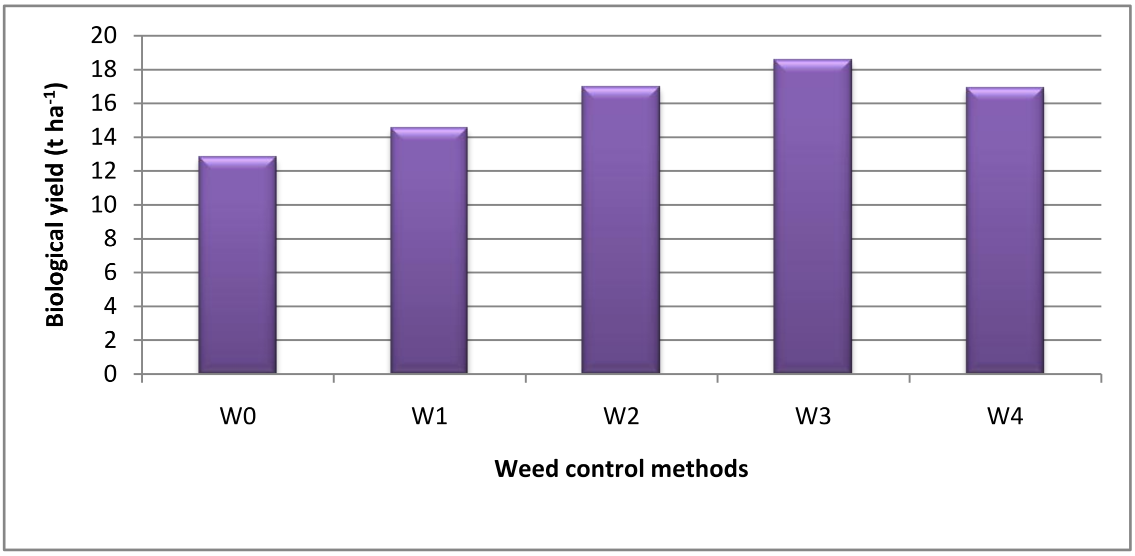


Note: N_o = 0 kg N ha^{-1}, N_1 = Urea super granules (2.7 g) @ 75 kgN ha^{-1}, N_2 = 140 kg N ha^{-1}, N_3 = 180 kg N ha^{-1}

Fig. 19. Effect of nitrogen on biological yield of rice (SE=0.33)

4.17.2 Effect of weed control methods

The biological yield varied significantly due to different weed control methods treatments shown in fig. 20 and Appendix XII. Weeds control methods led by Sunrice 150WG (W_3) gave the highest biological yield (18.55 t ha^{-1}) and no weeding (W_0) treatment gave the lowest biological yield (12.85 t ha^{-1}).



Note: W_0 =No weeding (Control methods) ,W_1= One weeding (30 Days after transplanting),W_2= Two weeding (30 DAT and 50 DAT),W_3= Sunrice 150 WG at recommended dose (100g ha^{-1}),W_4= Topstar 80WG at the recommended dose(80g ha^{-1})

Fig. 20. Effect of weed control methods on biological yield of rice (SE = 0.37)

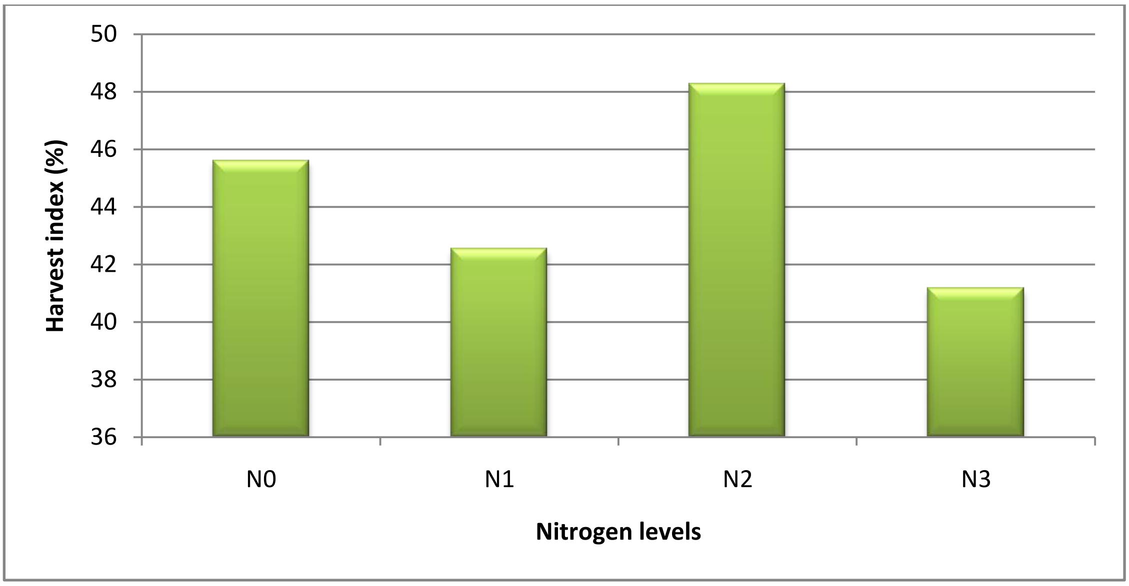
4.17.3 Interaction effect of nitrogen and weed control methods

Interaction effect of nitrogen and weed control methods was found significant on biological yield (Table 10 and Appendix XII). The highest biological yield (22.25 t ha^{-1}) was found from the combination of N_1W_3 (USG @ 75 kg N ha^{-1} and Sunrice 150WG) which was statistically similar with N_1W_2 and N_3W_3 and more than two times of control (N_0W_0) recorded 10.23 t ha^{-1}.

4.18 Harvest index

4.18.1 Effect of nitrogen

Effect of nitrogen doses exerted significant variation on harvest index (Fig. 21 and Appendix XII). Harvest index was the highest (48.27%) in N_2 (140 kg N ha^{-1}) and the lowest harvest index (41.16%) was observed in N_3 (180 kg N ha^{-1}). Awan *et al*. (2011) reported that highest harvest index was found with 156 kg N ha^{-1}.Ali (2005) reported that N management strategy did not influenced the HI. On the other hand Miah *et al.* (2004) reported that forms of nitrogen fertilizer had exerted very little variation on harvest index.

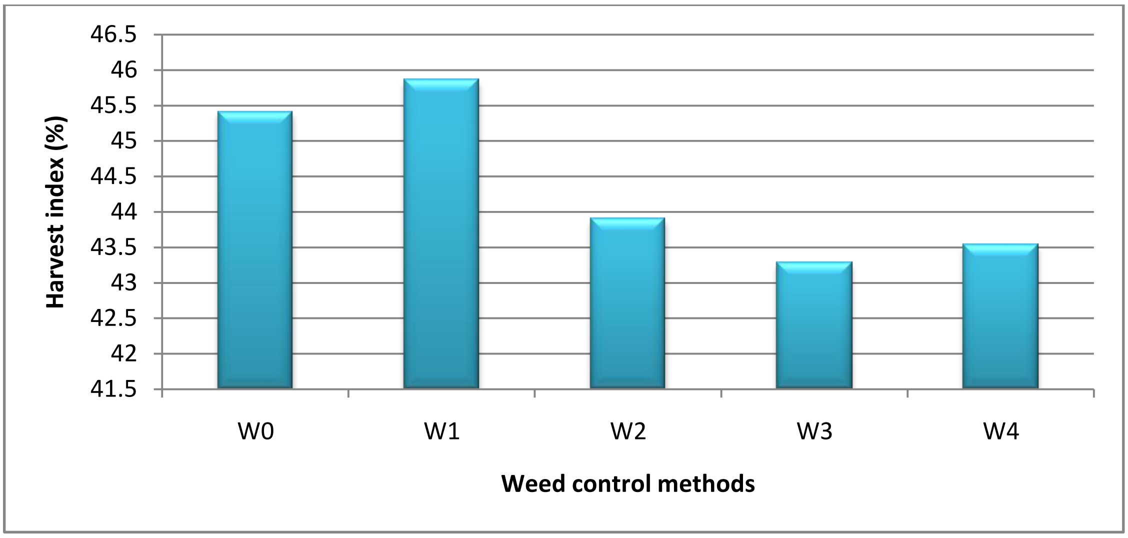


Note: N_o = 0 kg N ha^{-1}, N_1 = Urea super granules (2.7 g) @ 75 kgN ha^{-1}, N_2 = 140 kg N ha^{-1} , N_3 = 180 kg N ha^{-1}

Fig. 21. Effect of nitrogen on harvest index of rice (SE=0.75)

4.18.2 Effect of weed control methods

Significant variation was observed in harvest index due to the effect of weeding (fig. 22 and Appendix XII). The highest harvest index (45.86%) was found due to the effect of one weeding (W_3). Sunrice 150 WG (W_0) gave the lowest harvest index (43.28%).



Note:W_0 =No weeding (Control methods) ,W_1= One weeding (30 Days after transplanting),W_2= Two weedings (30 DAT and 50 DAT),W_3= Sunrice 150 WG at recommended dose (100g ha^{-1}),W_4=Topstar 80WG at the recommended dose(80g $ha^{-1)}$

Fig. 22. Effect of weed control methods on harvest index of rice (SE = 0.84)

4.18.3 Interaction of nitrogen and weed control methods

The interaction effect of nitrogen and weed control methods had significant effect on harvest index on hybrid boro rice (Table 10 and Appendix XII). Among the treatment combinations N_2W_1 produced the highest harvest index (49.97%) and the lowest harvest index (37.63%) was obtained from the treatment combinations of $N_3W_{3.}$

Table10: Interaction effect of nitrogen and weed control methods on grain yield, straw yield, biological yield and harvest index of rice

Treatment combinations	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
N_0W_0	4.66h	5.57j	10.23k	45.87ad
N_0W_1	5.05h	6.03ij	11.08j-k	46.00a-d
N_0W_2	5.66g	6.76g-j	12.42i-k	45.70a-e
N_0W_3	6.06g	7.19f-j	13.25g-j	45.93a-d
N_0W_4	5.78g	7.20f-j	12.98h-j	44.57a-e
N_1W_0	6.70f	8.40e-h	15.10e-h	44.37a-e
N_1W_1	7.57c-e	9.35d-f	16.92c-e	44.77a-e
N_1W_2	8.63b	12.63ab	21.26a	40.57d-f
N_1W_3	9.48a	12.77ab	22.25a	42.50b-f
N_1W_4	8.10b	11.98a-c	20.08ab	40.47d-f
N_2W_0	5.91g	6.36h-j	12.27i-k	48.17ab
N_2W_1	7.12ef	7.14f-j	14.26f-i	49.97a
N_2W_2	7.67c-e	7.94f-i	15.61d-g	49.20a
N_2W_3	8.12b-d	9.18d-g	17.30c-e	47.03a-c
N_2W_4	7.85bd	8.90e-g	16.75c-e	46.97a-c
N_3W_0	5.89g	7.77f-j	13.66f-i	43.23b-e
N_3W_1	6.75f	9.10d-f	15.85d-f	42.70b-f
N_3 W_2	7.48de	11.12b-d	18.60bc	40.13ef
N_3W_3	8.21bc	13.60a	21.81a	37.63f
N_3W_4	7.5de	10.31cd	17.81cd	42.10c-f
SE	0.20	0.67	0.75	1.67
CV (%)	5.04	12.34	8.14	6.53

Note: N_o = 0 kg N ha^{-1}, N_1 = Urea super granules (2.7 g) @ 75 kgN ha^{-1} , N_2 = 140 kg N ha^{-1} , N_3 = 180 kg N ha^{-1} ,W_0 =No weeding (Control methods) ,W_1= One weeding (30 Days after transplanting),W_2= Two weedings (30 DAT and 50 DAT),W_3= Sunrice® 150 WG at recommended dose (100g ha^{-1}),W_4=Topstar 80WG at the recommended dose(80g ha^{-1})

CHAPTER 5

SUMMARY AND CONCLUSION

SUMMARY AND CONCLUSION

The experiment was conducted at the Agronomy field of Sher-e-Bangla Agricultural University, Dhaka during the period from December, 2011 to May, 2012 to study the efficacy of different levels of nitrogen and methods of weeding on the growth and yield of hybrid boro rice (Heera 4). The treatment consisted of four nitrogen level viz., N_o = 0 kg N ha^{-1}, N_1 = Urea super granules (USG) (2.7 g) @ 75 kgN ha^{-1}, N_2 = 140 kg N ha^{-1}, N_3 = 180 kg N ha^{-1} and five different weed control method viz.**,** W_0 =No weeding (Control), W_1= One weeding (30 Days after transplanting), W_2= Two weedings (30 DAT and 50 DAT), W_3= Sunrice 150 WG at recommended dose (100g ha^{-1}), W_4=Topstar 80WG at the recommended dose (80g ha^{-1}). The experiment was laid out in a split plot design with three replications having urea application in the main plots, weed control in the sub plots. Necessary intercultural operations were done as and when necessary.

There was significant variation observed on all parameter due to nitrogen fertilizer. The highest weed population (4.53, 29.27, 42.27and129.10, at 15, 30, 45and60 DAT, respectively) was recorded from 180 kg N ha^{-1} (N_3) and lowest umber of weed (2.87, 16.53, 19.67and47.40, at 15, 30, 45and60 DAT respectively) recorded from Urea super granules @ 75 kgN ha^{-1} (N_1) treatment. The N_3 observed significantly highest amount of dry weight of weeds (1.04, 5.91, 4.81and 4.10 g at 15, 30, 45and60 DAT respectively). The lowest amount of dry weight of weeds (0.69, 3.30, 3.65and3.04 g at 15, 30, 45and60 DAT respectively) was producted in N_1 treatment. The tallest plant (21.35, 29.43, 40.79, 57.54, 79.69, 95.91 and 96.89 cm at 15, 30, 45, 60, 75, 90 DAT and at harvest respectively) was observed with N_1 (Urea super granules @ 75 kgN ha^{-1}). The maximum tiller number $hill^{-1}$ (.33, 2.91, 10.19, 15.28, 16.8 and 13.45 at 15, 30, 45, 60, 75 and 90 DAT respectively) was observed with USG @ 75 kg N ha^{-1} (N_1). Maximum (0.03, 0.30, 1.36, 2.90, 6.21, 4.32 and 2.81 67 at 15, 30, 45, 60, 75, 90 DAT and at harvest respectively) LAI was found due to the effect of USG @ 75 kg N ha^{-1}. The higher total dry matter (0.48, 2.98, 11.19, 34.49, 90.33 and 121.4 g at 15, 30, 45, 60, 75 and 90 DAT respectively) was found with N_1 (USG

@ 75 kg N ha^{-1}). The highest CGR (0.17, 0.59, 1.58, 3.73 and 2.72 g hill^{-1} day^{-1} at 15-30, 30-45, 45-60, 60-75 and 75-90 DAT respectively) was produced in N_1. The maximum effective tiller hill^{-1} (13.40) was observed from N_1 (Urea super granules @ 75 kgN ha^{-1}). The longest (24.17 cm) panicle length was produced due to application of USG. The highest number of filled grains panicle^{-1} was obtained with USG (176.50). The minimum (11.17) unfilled grains panicle^{-1} was obtained from the application of USG (N_1). The highest total grains panicle^{-1} (187.67) was observed from N_1 treatment. The maximum 1000-grain weight (31.20g) was obtained form N_1 treatment. The highest grain yield (8.10 t ha^{-1}) was obtained from Urea super granules (N_1). The lowest grain yield (5.44 t ha^{-1}) was observed in control (N_0). The highest straw yield was of 11.03 t ha^{-1} was obtained from N_1 (USG @ 75 kg N ha^{-1}). The lowest straw yield (6.55 t ha^{-1}) was observed in N_0 (0 kg N ha^{-1}). Maximum (19.13 t ha^{-1}) biological yield was measured from the N_1 (USG @) 75 kg N ha^{-1}) treated plots. Harvest index was the highest (48.27%) in N_2 (140 kg N ha^{-1}).

The effect of weed control on all parameters were statistically significant at different days after transplanting. The lowest weed population (0.67, 2.83, 9.58, 15.50 at 15, 30, 45, 60 DAT, respectively) and dry weight of weeds (0.30, 0.80, 1.91, 2.18 g at 15, 30, 45, 60 DAT respectively) was observed in case of Sunrice 150WG (W_3). Sunrice 150WG (W_3) scored the highest plant height (21.78, 29.16, 40.24, 55.67, 76.69, 95.39, and 93.97 cm at 15, 30, 45, 60, 75, 90 DAT and at harvest respectively). The highest number of tillers hill^{-1} (0.33, 2.97, 10.03, 14.69, 15.22 and 13.47 at 15, 30, 45, 60, 75 and 90 DAT respectively), LAI (0.03, 0.29, 1.57, 2.72, 6.47, 4.41 and 2.62 at 15, 30, 45, 60, 75, 90 DAT and at harvest respectively), CGR (0.15, 0.59, 1.55, 3.30 and 2.94 g hill^{-1} day^{-1} at 15-30, 30-45, 45-60, 60-75 and 75-90 DAT respectively), effective tiller (11.61), panicle length (24.29 cm), filled grains panicle^{-1} (173.00) were found in W_3 (Sunrice 150WG). The lowest unfilled grains panicle^{-1} (12.48) were obtained from Sunrice 150WG (W_3). The highest total grains panicle^{-1} (185.48), 1000 grain weight (30.36 g) were recorded from Sunrice 150WG (W_3). The highest yield (7.97 t ha^{-1}) was recorded from Sunrice 150WG (W_3) and the lowest yield (5.79 t ha^{-1}) was obtained from no weeding treatment (W_0). The highest straw yield (10.68 t ha^{-1}), biological yield (18.55 t ha^{-1}), harvest index (45.86%) were recorded from Sunrice 150WG (W_3).

The effect of nitrogen and weed control on all parameters were statistically significant at different day after transplanting. The minimum number of total weeds (0.00, 0.00, 2.67, 8.33 at 15, 30, 45, 60 DAT respectively) and dry weight of weeds (0.00, 0.00, 0.33, 1.08, g at 15, 30, 45, 60 DAT respectively) was observed from Urea super granules @ 75 kgN ha^{-1} and Sunrice 150WG (N_1W_3). The highest plant height (23.77, 31.40, 44.93, 61.73, 84.33, 99.43 and 98.10 cm at 15, 30, 45, 60, 75, 90 DAT and at harvest respectively), tillers $hill^{-1}$ (0.67, 3.99, 12.22, 17.63, 19.00 at 15, 30, 45, 60, 75, 90 DAT respectively), LAI (0.03, 0.36, 2.04, 3.65, 7.79, 5.57 and 3.54 at 15, 30, 45, 60, 75, 90 DAT and at harvest respectively), TDM (0.68, 3.80, 13.50, 41.90, 100.2 and 149.30 g at 15, 30, 45, 60, 75, 90 DAT respectively), CGR (0.22, 0.69, 2.04, 4.39 and 3.95.g $hill^{-1}$ day^{-1} at 30, 45, 60, 75 and 90 DAT respectively), number of effective tillers $hill^{-1}$ (12.67), panicle length (25.23 cm) and filled grains $panicle^{-1}$ (205.70) were recorded from the combination of Urea super granules @ 75 kg N ha^{-1} and Sunrice 150WG (N_1W_3). The minimum (8.93) unfilled grains $panicle^{-1}$ was observed from N_1W_3 treatment. The maximum (33.77) 1000-grain weight was obtained by the interaction of Urea super granules with Sunrice 150 WG. Significantly the highest grain yield (9.48 t ha^{-1}) was found from the combination of USG with Sunrice 150 WG (N_1W_3) and the lowest (4.66 t ha^{-1}) from combination of control (N_0W_0). The highest biological yield (22.25 t ha^{-1}) was found from the combination of USG with Sunrice 150 WG, the highest straw yield (13.60 t ha^{-1}) was found from the combination of N_3W_3 (180 kg N ha^{-1} and Sunrice 150 WG). N_2W_1 produced the highest harvest index (49.97%)

Based on the results of the present experiment, the following conclusion can be drawn:

1. Weed control method played a vital role for the growth and yield of hybrid rice.

2. Urea super granules produced the highest grain yield, straw yield and biological yield due to the highest dry matter production throughout the growing season and comparatively higher weed control efficiency.

3. Among the weed control methods, Sunrice 150WG was found the best for controlling weeds.

4. Urea super granules along with Sunrice 150WG gave the highest grain yield, straw and biological yield due to the highest dry matter production throughout the growing period.

However, to reach a specific recommendation, more research work on hybrid Heera4 rice with N and Sunrice 150WG should be done over different Agro-ecological zones of Bangladesh.

REFERENCES

REFERENCES

Ahmed, G. J. U., Mridha, A. J., Bhuiyan, M. K. A., Riches, C. R. and Mortimer, M. (2003). Effect of different weed management systems on weed control, plant growth and grain yield of lowland rice. In: Proceedings of Nineteenth Asian Pacific Weed Sci. Soc. Conf. 17-March, 2003. Philippines. No. 1: 84-92.

Ahmed, G.J.U., and Bhuiyan, M.K.A., (2010). Performance of weed management practices for different establishment methods of rice (Oryza sativa L.) in dry season. *Pak. J. Weed Sci. Res*. **16**(4): 393-402.

Ahmed, M. H., Islam, M. A., Kader, M. A. and Anwar, M. P. (2000). Evaluation of urea supergranules as a source of nitrogen in T. aman rice. *Pak. J. Biol. Sci.* **2**(5): 735-737.

Ahmed, M., Islam, M. and Paul, S.K. (2005). Effect of nitrogen on yield and other plant characters of local T. Aman rice, *Var. Jatai. Res. J. Agric. Biol. Sci.* **1**(2): 158- 161.

AIS (Agricultural Information Service). (2013). Krishi Diary (In Bangla). Agril. Inform. Ser. Khamarbari, Farmgate, Dhaka, Bangladesh. p.16.

Ali, A. M., Alam, R. M. and Miah, M.S.H. (2005). Crop productivity as affected by fertilizer management options in boro-T. aman cropping pattern at farmers' field. *Bangladesh J. Agril. Res*. **35**(2): 287-296.

Ali, M., Sardar, M. S. A. and Biswas, P. K. (2010). Weed control and yield of transplanted aman rice as affected by integrated weed management and spacing. *Bangladesh J. Weed Sci.* **1**(1):33-40.

Ali, M., Sardar, M. S. A., Biswas, P. K. and Sahed Bin Mannan, A. K. M. (2008). Effect of integrated weed management and spacing on the weed flora and on the growth of transplanted aman rice. *Intl. J. Sustain. Crop Prod.* **3**(5):55-64.

Al-Mamun, M. A., Shultana, R., Bhuiyan, M. K. A., Mridha, A. J. and Mazid, A. (2011). Economic weed management options in winter rice. *Pak. J. Weed sci. Res.* **17**(4):323-331.

Anonymous. (2004). Adaption and adoption USG technology for resource poor farmers in the tidal submergence area. Annual Internal Review Report for 2003-2004. Bangladesh Rice Research Institute. Gazipur. p. 4.

Ashraf, M. M., Awan, T. H., Manzoor, Z., Ahmad, M. and Safdar, M. E. (2006). Screening of herbicides for weed management in transplanted rice. *J. Animal Plant Sci.* **16** (3/4): 89-92.

Awan, T.H., Ali, R.I., Manzoor, Z., Ahmed, M. and Akhtar, M. (2011). Effect of different nitrogen levels and row spacing on the performance of newly evolted medium grain rice variety, KSK-133. *J. Animal Plant Sci.* **21**(2): 231-234.

Balasubramanian, R. (2002). Response of hybrid rice (Oryza sativa) to levels and time of application of nitrogen. *Indian J. Agron.* **47**(2): 203-206.

Baloch, M.S., Awan, L.U., Gul H. and Khakwani, A.A. (2006). Effect of establishment methods and weed management practices on some growth attributes of rice. *Rice Sci.* **13**(2): 131-140

Bayan, H.C. and Kandasamy, O.S. (2002). Effect of weed control methods and split application of nitrogen on weed and crop in direct seeded puddle rice. *Crop Res. Hisar.* **24**(2): 266-272.

BBS (Bangladesh Bureau of Statistics). (2013). Agriculture crop cutting. Estimation of rice production,2012-2013 . Government of the People's Republic of Bangladesh. Web site: http://www. bbs. gov.bd.

Bhowmick, M.K. (2002). Optimization of Pretilachlor dose for weed management in transplanted rice. *Annals Plant Protec. Sci.* **10**(1): 131 - 133.

Bhuiyan, M. K. A., Mridha, A. J., Ahmed, G. J. U., Begum, J. A. and Sultana, R. (2011). Performance of chemical weed control in direct wet seeded rice culture under two agro-ecological conditions of Bangladesh. *Bangladesh J. Weed Sci.* **1**(1):1-7.

Bhuiyan, M. K. A., Ahmed, G. J. U., Mridha, A. J., Ali, M. G., Begum, J. A. and Hossain, S. T. (2010). Performance of Oxadiargyl 400SC for weed control in transplanted rice. *Bangladesh J. Weed Sci*. **1**(1):55-61.

Bijon, K. M. (2004). Effect of variety and weed control on weed seed bank, weed dynamics and the performance of transplanted aman rice. M. S. Thesis. Dept. Agron.Bangabandu Sheikh Mujibar Rahman Agril. Univ.,Salna, Gazipur.,Bangladesh.

Biswas, P. K., Touhiduzzaman and Roy, T. S. (2011). Allelopathic effects of rice varieties transplanted in SRI (System of rice Intensification) to control weeds. The 6th World Congress on Allelopathy, December 15-19, Guangzhou, Chaina. p.17.

BRRI (Bangladesh Rice Research Institute). (2011). Adhunik Dhaner Chash (in bengali). Bangladesh Rice Research Institute, Joydebpur, Gazipur. p. 5.

BRRI (Bangladesh Rice Research Institute). (2010). Adhunik Dhaner Chash (In Bangla) Bangladesh Rice Research Institute, Joydebpur, Gazipur.

BRRI (Bangladesh Rice Research Institute). (2009). BRRI Annual Internal Review 2007-2008. Soil Science Division. Bangladesh Rice Research Institute, Gazipur-1701.

BRRI (Bangladesh Rice Research Institute). (2008a). BRRI Annual Internal Review 2006-2007. Soil Science Division. Bangladesh Rice Research Institute, Gazipur-1701.

BRRI (Bangladesh Rice Research Institute). (2008b). Annual Report for 2007-2008. Bangladesh Rice Research Institute, Gazipur-1701.

BRRI (Bangladesh Rice Research Institute). (2006a). Annual Report for 2005-2006. Bangladesh Rice Res. Inst., Joydebpur, Gazipur, Bangladesh. p. 63-67.

BRRI (Bangladesh Rice Research Institute). (2006b). Web site: http://www. knowledge-brri.org.

BRRI (Bangladesh Rice Research Institute). (2000). Annual Report for 1999-2000. Bangladesh Rice Research Institute, Joydebpur, Gazipur. P. 138.

Chandra, S. and Solanki, O.S. (2003). Herbicidal effect on yield attributing characters of rice in direct seeded puddled rice. *Agril. Sci. Digest Karmal.* **23**(1):75-76.

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

Chandra, D. and Mama, G. B. (1990). Weed management in transplanted rice grown under shallow submerged condition. *Indian J. Agron.* **27**(4): 465-467.

Chaturvedi I. (2006). Effect of nitrogen fertilizers on growth, yield and quality of hybrid rice *(Oryza sativa* L.). *J. Central Eur. Agric.* **6**(4): 611-618.

Craswell, E. T. and De Datta, S. K. (1980). Recent developments in research on nitrogen fertilizers for rice. Indian J. Agron. **3**(4): 387-389.

Das, L. K. and Panda, S. C. (2004). Effect of varied doses of nitrogen and potassium on crop growth rate of hybrid rice at different growth stages. *Environ. Ecol.* **22**(Spl-3): 540-542.

Devasenamma,V. Reddy, M. R.and Soundararajan, M. S. (2001). Effect of varying levels of nitrogen on yield and yield components of hybrid rice. *J. Res. ANGRAU.* **29**(1): 1-3.

Ebaid, R.A. and Ghanem, S.A. (2000). Productivity of Giza 177 rice variety grown after different winter crops and fertilized with different nitrogen levels. *Egyptian J. Agril. Res.* **87**(2): 717-731.

Edwin, L. and Krishnarajan, J. (2005). Influence of irrigation and nitrogen management practices on yield of hybrid rice. *Agric. Sci. Digest.* **25**(4): 309-310.

Ehsanullah, A., Cheema, M.S. and Usman, M. (2001a). Rice Basmati-385 response to single and split application of nitrogen at different growth stages. *Pakistan J. Agril. Sci.* **38**(1-2): 84-86.

Ehsanullah, Nawaz, H.M.A., Muhammad-Usman and Cheema, M.S. (2001b). Effect of various levels and methods of nitrogen application on nitrogen use efficiency m rice supper Basmati. *Intl. J. Agril. Bio.* **3**(1): 61-6-3).

El-Batal, M.A., Abd El-Gawad, M.F., Fatina, A. Abdo and El-Set A., El-Aziz, Abd. (2004). Uniconazole application as antilodging for rice plants fertilized with high nitrogen rate. *Zagazig J. Agric. Res.* **31**: 473-490.

FAO. (2008). FAO Production Yearbook, Food and Agriculture Organization, Rome, Italy. 59-78.

Ferrero, A. (2003). Weedy rice, biological features and control. In: Labrada R. (ed.): Weed management for developing countries. Addendum 1. FAO Plant Production and Protection Paper, No. 120:89–107.

Freitas, J.G., Azzini, L.E., Cantarrella, H., Bastos, C.R., Castro-LHSM-de, Gallo, P.B., Felicio, J.C., de-Freitas, J.G. and de-Castro, L.H.S.M. (2001). Response of irrigated rice cultivars to Nitrogen. *Scientia Agricola.* **58**(3): 573-579.

Fu, Q. L., Yu, J. Y. and Chen, Y. X. (2000). Effect of nitrogen applications on dry matter and nitrogen partitioning in rice and nitrogen fertilizer requirements for rice production. *J. Zhejiang Univ. Agril. Life Sci.* **26**(4): 399-403.

Ganga, D.M., Tirumala R.S., Sumatin, V., Pratima, T. and John, K. (2012). Nitrogen management to improve the nutrient uptake, yield and quality parameters of scented rice aerobic culture. *Int J Appl Biol Pharma Technol* **3**(1):340-344.

Gardner, Y. P. 1985 Gill, P.S. and Shahi, H.N. (1985). Effect of Nitrogen levels in relation of age of seedlings and time of transplanting oil growth yield and milling characteristics of rice. *Indian J. Agric. Sei.* **57**(9): 6310-614.

Geethadevi, T., Andani, G., Krishnappa, M. and Babu, B. T. R. (2000). Effect of nitrogen and spacing on growth and yield of hybrid rice. *Current Res. Univ. Agril. Sci. Bangalore.* **29**(5& 6): 73-75.

Gnanavel, I. and Anbhazhagan, R. (2010). Bio-efficacy of pre and post emergence herbicides in transplanted aromatic basmati rice. *Res. J. Agric. Sci.* **1**(4):315-317.

Gnanasambandan, S. and Murthy, P. B. (2001). Effect of tillage practices and pre-emergence herbicides application for weed control in wet seeded rice. *Madras Agril. J.* **88**(10-12): 590-593.

Gogoi, A. K., Rajkhowa, D. J. and Kandali, R. (2000). Effect of varieties and weed control practices on rice productivity and weed growth. *Indian J. Agron.* **45**(3): 580-585.

Gomez, K. A. and Gomez, A. A. (1986). Statistical Procedure for Agricultural Research (2nd edn.). Int. Rice Res. Inst., A Willey Int. Sci., Pub., pp.28-192.

Gorgy, R. N., Zayed, B. A., Abou, A.A.B. (2009). Effect of split application of nitrogen and potassium to SK2047 hybrid rice. *J. Agric. Sci. Mansoura Univ.* **34**(11):10631-10642.

Gosh, B.C., Raghavian, C.V. and Jana, M. K. (1991). Effect of seed rate and nitrogen on growth and yield of direct sown sown rice (*Oryza sativa*) under intermediate deep water condition. *Indian J. Agron.* **36**: 227-228.

Hamidullah, A. T. M., Rahman, M. S., Miah, M. N. M. and Miah, M. A. K. (2006). Growth and yield performance of BINA dhan 5 in boro season as affected by nitrogen rate. *Bangladesh J. Nuclear Agric.* **22**: 93-98.

Hasan, M. S., Hossain, S. M. A., Salim, M., Anwar, M. P. and Azad, A. K. M. (2002). Response of hybrid and inbred rice varieties to the application methods of urea supergranules and prilled urea. *Pakistan J. Bio. Sci.* **5**(7): 746-748.

Hasanuzzaman, M. Nahar, K. Alam, M.M., Hossain, M.Z. and Islam, M.R. (2009). Response of transplanted rice to different application methods of urea fertilizer. *Intl. J. Sustain. Agric.* **1**(1):1-5.

Hasanuzzaman, M., Islam, M. O. and Bapari, M. S. (2008). Efficacy of different herbicides over manual weeding in controlling weeds in transplanted rice. *Australian J. Crop Sci.* **2**(1):18-24.

Hasanuzzaman, M., Nahar, K. and Karim, M. R. (2007). Effectiveness of different weed control methods on the performance of transplanted rice. *Pak. J. Weed Sci. Res.* **13**(1-2):17-25.

Hassan, M. N., Ahmed, S., Uddin, M. J. and Hasan, M. M. (2010). Effect of weeding regime and planting density on morphology and yield attributes of transplant aman rice cv. BRRI dhan41. Pak. J. Weed Sci. Res. 16(4):363-377.

Hossain, M. (2000). Auto-ecology of Echinochloa crusgalli and its control in direct seeded aus rice. M. S. Thesis. Dept. Agron., Bangladesh Agril. Univ., Mymensingh. pp. 57-62.

Hunt, R. (1978). Plant growth analysis. The institute of Biology's studies in Biology No. 96. Edward Arnold (Publishers) Limited, London, UK.

Idris, M. and Matin, M.A. (1990). Response of four exotic strains of aman rice to urea. *Bangladesh J. Agril. Sci.* **17**(2): 271 -275.

Ingale, B.V., Jadhav, S. N.; Waghmode, B. D. and Kadam, S. R.(2005). Effect of age of seedling, number of seedling hill-1 and level of nitrogen on performance of rice hybrid, Sahyadri. *J. Maharashtra Agril.Univ.* **30**(2): 172-174.

Islam, S. S., Amin, M. H. A., Parvin, S., Amanullah, A. S. M. and Ahsanullah, A. S. M. (2010). Effect of pre and post-emergence herbicides on the yield of transplant aman rice. *Bangladesh res. Public. J.* **3**(4):1242-1252.

Islam M. S., Howlader M. I. A., Rafiquzzaman S., Bashar H. M. K. and Al-Mamun M. H. (2008). Yield Response of Chili and T. Aman Rice to NPK Fertilizers in Ganges Tidal Floodplain. *J. Soil. Nature.* **2**(1): 07-13.

Islam, T., Bhowmick, M. K., Ghosh, R. K. and Sounda, G. (2001). Effect of Pretilachlor on weed control and yield of transplanted rice. *Environ. Ecol.* **19**(2): 265-268.

Jacob, D. and Syriac, E. K. (2005). Relative efficacy of different spacings and weed control methods in scented rice. *Oryza.* **42**(1):75-77.

Kabir, M. H., Sarkar, M. A. R., and Chowdhury, A. K. M. S. H. (2009). Effect of urea super granules, prilled urea and poultry manure on the yield of transplant aman rice varieties. *J. Bangladesh Agril. Univ.* **7**(2): 259-263.

Kabir, M. H., Bari, M. N., Haque, M. M., Ahmed, G. J. U. and Islam, A. J. M. S. (2008). Effect of water management and weed control treatments on the performance of transplanted aman rice. *Bangladesh J. Agril. Res.* **33**(3):399-408.

Kalhirvelan, P. and Vaiyapuri. V. (2003). Relative efficacy of herbicides in transplanted rice. *Indian J. Weed Sci*. **35**(3-4): 257-258.

Kamalam, J. and Bridgit, T. K. (1993). Effect of chemical and integrated weed management in upland rice. *J. Tropic. Agric*. **31**: 77-80.

Karim, S. M. R. and Ferdous, M. N. (2010). Density effects of grass weeds on the plant characters and grain yields of transplanted aus rice. *Bangladesh J. Weed Sci.* **1**(1):49-54.

Khaliq, A., Matloob, A., Ihsan, M.Z., Abbas, R.N.; Aslam, Z.; Rasool, F. (2013). Supplementing herbicides with manual weeding improves weed control efficiency, growth and yield of direct seeded rice. *Intl. J. Agril. Biol. (Pakistan).* **15**(2): 191-199.

Khaliq, A., Riaz, M. Y. and Matloob, A. (2011). Bio-economic assessment of chemical and non-chemical weed management strategies in dry seeded fine rice (Oryza sativa L.). *J. Plant Breed. Crop Sci.* **3**(12):302-310.

Khan, T. A. and Tarique, M. H. (2011). Effects of weeding regime on the yield and yield contributing characters of transplant aman rice. *Intl. J. Sci. Advan. Technol.***11**:11-14.

Kulmi, G. S. (1990). Cultural and chemical weed control in transplanted rice (*Oryza sativa*). *Crop Res. Hisar*. **3**(2): 151-154.

Kumar, R. M. and Subbaiah, S. V. (2001). Influence of different sources of nitrogen on growth and grain yield of rice hybrid vs. HYV (high yielding variety) of rice. *J. Res. ANGRAU.* **29**(1): 4-8.

Lang, N., Xu, S. H., Liang, R. J.and Chen, G. S. (2003). Effect of different fertilizer application rates on no-tillage and seedling-throwing rice. *Hybrid-Rice*. **18**(2): 52.

Latheef, P. M., Reddy, M.D., Reddy, M.G. and Devi, M.Uma. (2011). Effect of irrigation schedule, weed management and nitrogen levels on weed growth in rice (Oryza sativa) under aerobic conditions. *Indian J. Weed Sci. (India)*. 43(1-2):54-60.

Lawal, M.I. and Lawal, A.B. (2002). Influence of nitrogen rate and placement method on growth and yield of rice (*Oryza sativa* L.) at Kadawa, Nigeria. *Crop Res. Hisar.* **23**(3): 403-411.

Lin, X. Q., Zhu, D. F., Chen, H. Z., Cheng, S. H and Uphoff, N. (2008). Effect of plant density and nitrogen rates on grain yield and nitrogrh uptake of hybrid rice (Oryza sativa L.). *J. Agric. Biote. Sustain. Develop.* **1**(2): 44-53.

Mahajan, G., Boparai, B. S., Bra, L. S. and Sardana, V. (2003). Effect of Pretilachlor on weeds in direct seeded puddled rice. *Indian J. Weed Sci*. **35** (1-2): 128-130.

Maiti, S., Naleshwar, N. and Pal, S. (2003). Response of high yielding and hybrid rice to varied levels of nitrogen nutrition. *Environ. Ecol*. **21**(2): 296-300.

Mamun, M. A. A., Shultana, R., Islam, S. A., Badshah, M. A., Bhuiyan, M. K. A. and Mridha, A. J. (2011). Bio-efficacy of bensulfuron methyl + pretilachlor 6.6% GR against weed suppression in transplanted rice. *Bangladesh J. Weed Sci.* **1**(1):8-11.

Mamun, A. A. (1990). Weeds and their control: A Review of Weed Research in Bangladesh. JSARD, Japan Intl. Co-operation Agency. Dhaka, Bangladesh. pp. 45-72.

Manish C., Khajanji, S.N., Sawi, R.M. and Dewangan, Y.K. (2006). Effect of halosulfuron- methyl on weed control in direct seeded drilled rice under puddled condition of Chhattisgarh plains. *Plant Archives.* **6** (2): 685-687.

Masum, S. M., Ali, M. H., and Ullah, M. J. (2008). Growth and yield of two T. aman rice varieties as affected by seedling number hill^{-1} and urea supergranules. *J. agric. Educ. Technol.* **11**(1 & 2): 51-58.

Masum, S. M., Ali, M. H., and Ullah, M. J. (2010). Performance of seedling rate and urea supergranules on the yield of T. aman rice varieties. *J. Sher-e-Bangla Agric . Univ.* **4**(1):1-5.

Meena, S.L., Sundera, S., and Shivay, Y.S. (2003). Response to hybrid rice (Oryza sativa) to nitrogen and potassium application in sandy clay-loam soils. *Indian J. Agril. Sci.* **73**(1) 9-11.

Meena, S. L., Surendra, S. and Shivay, Y. S. (2002). Response of hybrid rice (Oryza sativa) to nitrogen and potassium application. *Indian J. Agron.* **47**(2): 207-211.

Miah, M. N. H., Talukder, S., Sarkar, M. A. R. and Ansari, T. H. (2004). Effect of number of seedling hill-1 and urea supergranules on growth and yield of the rice cv. BINA dhan 4. *J. Biol. Sci.* **4**(2): 122-129.

Mishra, B.K., Mishra, S., Das, A.K. and Jena, D. (2000). Effect of time for urea super granule placement of low land rice. *Annual Agric. Res.* **20**(4): 443-447.

Moorthy, B. T. S., Saha, S. and Saha, S. (2002). Evaluation of pre and post emergence herbicides for their effects on weeds and upland direct seeded rice. *Indian J. Weed Sci.* **34**(3-4):197-200.

Moorthy, B. T. S. and Das, F. C. (1992). Performance evaluation of tow manuallly operated weeders in upland rice. *Orissa J. Agril. Res*. **5**(1-2): 36-41.

Mubarak, T. and Bhattacharya, B. (2006). Response of hybrid rice cultivars to various levels of nitrogen and potassium grown on gangetic alluvial soil in summer season. *Environ. Ecol.* **24**(3): 515-517.

Munnujan, K., Hamid, A., Hashem, A., Hirota, O. and Khanam, M. (2001). Effects of Nitrogen fertilizer levels and planting density on growth and yield of long grain rice. *Bangladesh Agric. Sci.* **9**(2): 19-20.

Nahar, S., Islam, M. A. and Sarkar, M. A. R. (2010). Effect of spacing and weed regime on the performance of transplant aman rice. *Bangladesh J. Weed Sci.* **1**(1):89-93.

Pacanoski, Z. and Glatkova, G. (2009). The use of herbicides for weed control in direct wet-seeded rice (*Oryza sativa* L.) in rice production regions in the Republic of Macedonia. *Plant Protect. Sci.* **45**(3):113–118.

Parthipan, T.V., Ravi, E. and Subramanian. (2013). Weed Management Strategies for Lowland Drum Seeded Rice (*Oryza Sativa* L.). *Intl. J. Innov. Res. Stud.* **2**(4):206-214

Phuhong, L. T., Denich, M., Vlek, P. L. G. and Balasubramanian, V. (2005). Suppressing weeds in direct seeded lowland rice: effects of methods and rates of seeding. *J. Agron. Crop Sci.* **191**:185-194.

Radford, P. J. (1967). Growth analysis formulae. Their use and abuse. *Crop Sci*. 7: 171-175.

Rakesh, K., Rajesh, K. and Sanjeev, K. (2005). Effect of nitrogen and potassium levels on growth and yield of hybrid rice. *J. Applied Biol.* **15**(1): 31-34.

Raju, A., Pandian, B. J., Thukkaiyannan, P. and Thavaprakash, N. (2003). Effect of weed management practices on the yield attributes and yield of wet seeded rice. Acta. Agron. Hungarica. **51**(4):461-464.

Raju, R. A., Hossain, M. M. and Nageeswariq, R. M. (1987). Relative efficiency of modified urea materials for low land rice. *Indian J. Agron.* **32**(4): 460-462.

Rambabu, P., Pillai, K. G. and Reddy, S. N. (1983). Effect of modified ureas materials and their methods of application on dry matter production, grain yield and nitrogen uptake in rice. *Oryza*. **20**: 86-90.

Rao, C. M., Ramaish, N. V., Reddy, S. N. and Reddy, G. V. (1986). Effect of urea and urea supergranules on dry matter accumulation yield and nutrient uptake in rice (*Oryza sativa*). *J. Res.* **14**:1-3.

Rama, S., Reddy, G. and Reddy, K. (1989). Effect of levels and sources of nitrogen on rice. *Indian J. Agron.* **34**(3): 364-366.

Ravisankar, N., Nair, A.K., Pramallik, S.C., Dinesh, R. and Choudhuri, S.G. (2003). Effect of controlled release nitrogen on growth, yield, economic and energetics of medium. duration 'Mansarovar' rice (*Oryza sativa*) under lowland condition. *Indian J. Agril. Sci.* **73**(5): 289-290.

Reza, M. S. U. A., Karim, S. M. R.and Begum, M. (2010). Effect of nitrogen doses on the weed infestation and yield of boro rice. *Bangladesh J. Weed Sci.* **1**(1):7-13.

Roder, W. (2001). Slash-and-burn rice systems in the hills of northern Lao PDR.In: Description, challenges and Opportunities, IRRI, Los Banos, Philippines, p. 201.

Saito, K., Linquist, B., Atlin, G.N., Planthaboon, K., Shiraiwa, T. and Horie, T. (2005). Response of traditional and improved upland rice cultivars to N and P fertilizer in northern Laos. *Field Crops Res.* **30**: 30-35.

Salam, M. A., Islam, M. M., Islam, M. S. and Rahman, M. H. (2010). Effects of herbicides on weed control and yield performance of Binadhan-5 grown in boro season. *Bangladesh J. Weed Sci.* **1**(1):15-22.

Salehian, H., Ghasemy, M. H. G. and Jamshidi, M. (2012). Determination the most important yield related traits and competition with weeds in rice cultivars by path analysis. *Intl. J. Agri. Crop Sci.* **4**(19):1426-1432.

Salem, A.K.M. (2006). Effect of nitrogen levels, plant spacing and time of farmyard manure application on the productivity of rice. *J. Appl. Sci. Res.* **2**(11): 980-987.

Sarkar, S., Pat, S., Mandla, N.N. and Maiti, S. (2001). Response of rice cultivars to different levels of nitrogen. *Environ. Ecol.* **19**(1): 118-120.

Sathiya, K. and Ramesh, T. (2009). Effect of split application of nitrogen on growth and yield aerobic rice. *Asian J. Expt. Sci.* **23**(1): 303-306.

Sen, A. and Pandey, B. K. (1990). Effect on rice of placement depth of urea supergranules. *Intl. Rice Res. Newsl.* **15**(4): 18, 51.

Shakouri, M.J., Vajargah, A.V., Gavabar, M.G., Mafakheri, S. and Zargar, M. (2012). Rice vegetative response to different biological and chemical fertilizer. *Adv. Environ. Biol.* **6**(2):859-863.

Sharma, A. and Gogoi, A. K. (1995). Mechanical weed control in upland rice. *World Weed*. **2**(2): 137-143.

Shultana, R., Al-Mamun, M. A., Rezvi, S. A. and Zahan, M. S. (2011). Performance of some pre emergence herbicides against weeds in winter rice. *Pak. J. Weed Sci. Res.* **17**(4):365-372.

Singh, B. K., and Modgal, S.C. (2005). Pattern of dry mattern accumulation and nitrogen concentration and uptake as influenced by levels and methods of nitrogen application in rainfed upland rice. *J. Plant Sci.* **52**(1): 9-17.

Singh, C.S. and Singh, U.N. (2002). Effect of nitrogen and sulphur nutrition on growth and yield of rice (*Oryza sativa* L.) cultivars. *Res.Crops.* **3**(3): 643-646.

Singh, R.S. (2005). Study of Beushening in controlling weeds under rainfed lowland rice in Chotanagpur Region. *J. Appl. Biol.* **15**(1): 22-24.

Singh, S. P. and Kumar, R. M. (1999). Efficacy of single and sequential application of herbicides on weed control in transplanted rice. *Indian J. Weed Sci.* **31**(3-4): 222-224.

Singh, B. K. and Singh, R. P. (1986). Effect of modified urea materials on rainfed low land transplanted rice and their residual effect on successding wheat crop. *Indian J. Agron*. **31**: 198-200.

Singh, S.and Shivay, Y. S. (2003). Coating of prilled urea with eco-friendly neem (Azadirachta indica A. Juss.) formulations for efficient nitrogen use in hybrid rice. *Acta Agronomica Hungarica.* **51**(1): 53-59.

Subhendu. M., Swamy, S.N. and Mandal, S. (2003). Effect of time of nitrogen application on yield and yield attributes of rice (*Oryza sativa* L.) cultivars. *Environ. Ecol.* **21**(2): 411-413.

Tamilselvan, N. and Budhar, M. N. (2001). Weed control in direct seeded puddled rice. *Madras. Agril. J.* **88**(10-12):745-746.

Tang, Q. Y., Zou,Y. B., Mi, X. C., Wang, H. and Zhou, M. L. (2003). Grain yield formation and N fertilizer efficiency of super hybrid rice under different N applications. *Hybrid Rice.* **18**(1): 44-48.

Thakur, R. B. (1991a). Relative efficiency of prilled urea and modified urea fertilizer on rainfed low land rice under late transplanting. *Indian J. Agron.* **36**(1): 87-90.

Thakur, R. B. (1991b). Effect of levels and forms of urea on low land rice under late transplanting. *Indian J. Agron.* **36**: 281-282.

Thomas, C. G., Abraham, C. T. and Sreedevi, P. (1997). Weed flora and their relative dominance in semi dry rice culture. *J. Tropic. Agric*. **35**: 51-53.

Upendra, R., Dayanand, P. and Choudhary, S. K. (2004). Evaluation of newly developed hybrid rice under different levels of nitrogen and potassium on calcitharants of North Bihar. *J. Appl. Biol.* **14**(1): 42-43

Verma, A. K., Pandey, N. and Tripathi, R. S. (2004).Leaf growth, chlorophyll, nitrogen content and grain yield of hybrid rice as influenced by planting times and N levels. *Ann. Agril. Res.* **25**(3): 456-458.

Wan, L. J., Zhang, H. C., Huo, Z.Y., Lin, Z. C.; Dai, Q. G., Xu, K. and Zhang, J. (2007). Effects of nitrogen application regimes on yield, quality, and nitrogen use efficiency of super japonica hybrid rice. *Acta Agron. Sin.* **33**(2): 175-182.

Wang, L. and Schjoerring, K.J. (2012). Seasonal variation in nitrogen pools and 15N/13C natural abundances in different tissues of grassland plant's. *Biogeosci.* **9**:1583-1595.

Wang, R. L., Hua, C. and Wei, J. C. (2002). Effect of nitrogen levels on photosynthetic characteristics of rice variety (combination) Shanyou 64 and Kinmaze. *Chinese J. Rice Sci.* **16**(4): 331-334.

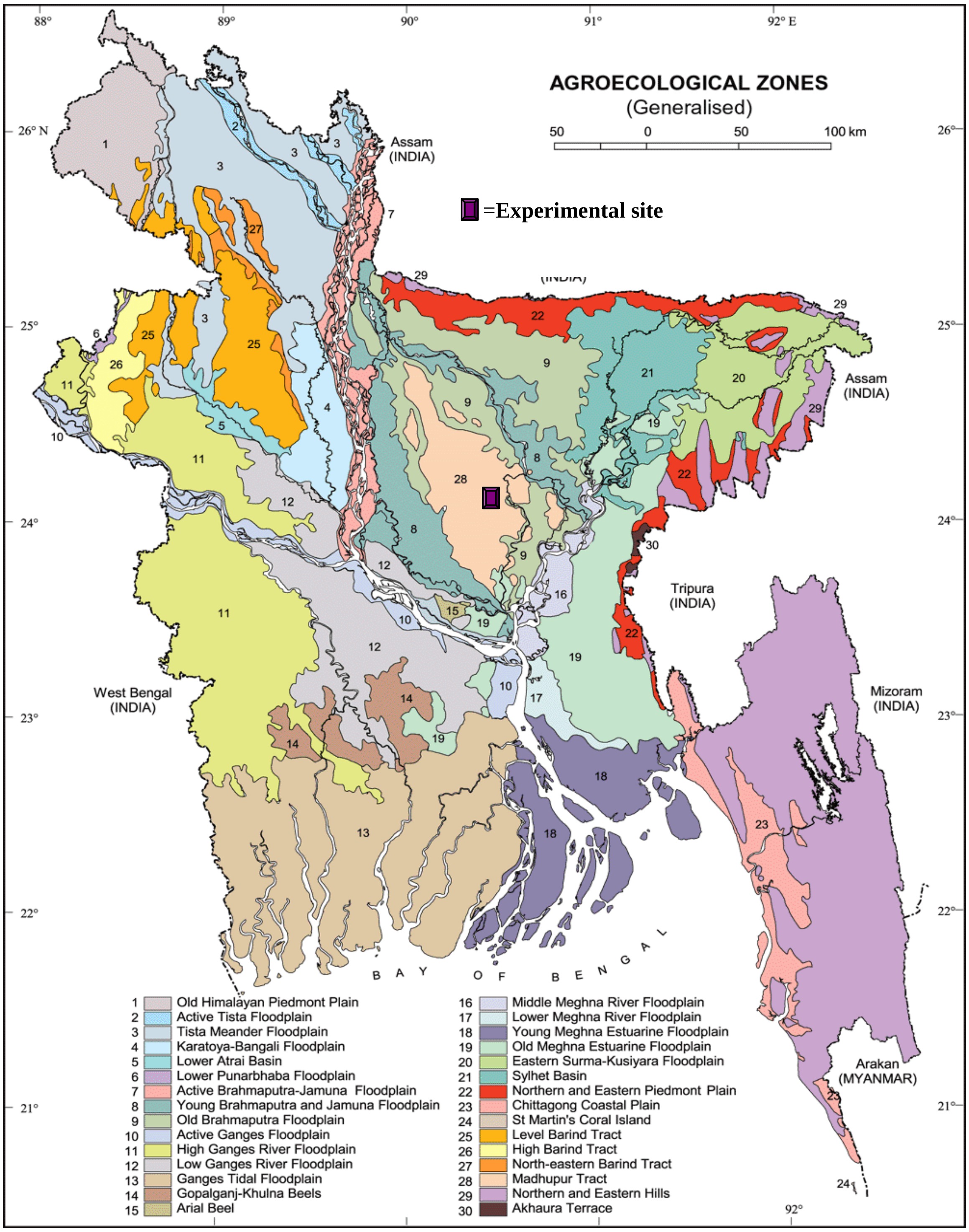
Xia, W., Wang, W. and Zhang, Q. (2007). Potential production simulation and optimal nutrient management of two hybrid rice varieties in Jinhua, Zhejiang Proviance. *J. Zhejiang Univ. Sci.* **8**(7): 486-492.

Yoshida, S. (1981). Physiological analysis of rice yield. In: Fundamental of Rice Crop Science. IRRI, Los Banos, Philippines. pp. 91-98, 269.

APPENDICES

LIST OF APPENDICES

Appendix I. Experimental location on the map of Agro-ecological Zones of Bangladesh



Appendix II. The mechanical and chemical characteristics of soil of the experimental site as observed prior to experimentation (0- 15 cm depth).

Constituents	**Percent**
Sand	26
Silt	45
Clay	29
Textural class	Silty clay

Chemical composition:

Soil characters	**Value**
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total nitrogen (%)	0.027
Phosphorus	6.3 µg/g soil
Sulphur	8.42 µg/g soil
Magnesium	1.17meq/100 g soil
Boron	0.88 µg/g soil
Copper	3.54 µg/g soil
Zinc	1.54 µg/g soil
Potassium	0.10 µg/g soil

Source: Soil Resources Development Institute (SRDI), Khamarbari, Dhaka

Appendix III. Monthly average temperature and total rainfall of the experimental site during the period from December 2011 to May 2012

Year	Month	Air temperature (^{0}C)		Total rainfall (mm)
		Maximum	Minimum	
2011	December	25.87	15.1	35
2012	January	24.57	14.53	65
	February	26.67	15.1	155
	March	31.15	21.45	184
	April	34.35	24.5	281
	May	33.53	22.57	269

Source: Metrological Centre, Agargaon, Dhaka (Climate Division)

Appendix IV. Analysis of variance of the data on number of weeds m^{-2} plotof riceas influenced by nitrogen and weed control

Source Of variation	Degrees of freedom	Mean square values at			
		15DAT	30DAT	45DAT	60DAT
Replication	2	134.117	530.817	281.617	19050.42
Factor A	3	7.578 NS	408.91 NS	1600.133*	17705.35*
Error (a)	6	17.494	363.061	217.017	10446.28
Factor B	4	46.6*	1702.308*	4679.375*	58126.54*
AB	12	7.967*	290.008*	1109.731*	4738.697*
Error (b)	32	12.088	227.958	258.604	7435.171

NS- Non Significant

* = Significant at 5% level of probability

Appendix V. Analysis of variance of the data on dry weight of weeds $gm^{-2}$of rice as influenced by nitrogen and weed control

Source Of variation	Degrees of freedom	Mean square values at			
		15DAT	30DAT	45DAT	60DAT
Replication	2	4.582	8.683	7.606	2.507
Factor A	3	0.356 NS	18.98 NS	3.965 NS	3.608*
Error (a)	6	0.526	15.191	11.972	2.786
Factor B	4	1.939 NS	60.615*	92.876*	43.29*
AB	12	0.618*	17.139*	11.188*	4.11*
Error (b)	32	0.427	14.061	9.892	1.758

NS- Non Significant

* = Significant at 5% level of probability

Appendix VI.Analysis of variance of the data on plant heightof rice as influenced by nitrogen and weed control

Source Of variation	Degrees of freedom	Mean square values at						
		15DAT	30DAT	45DAT	60DAT	75DAT	90DAT	Harvest
Replication	2	7.306	10.051	14.291	28.305	6.273	13.38	40.153
Factor A	3	3.28 NS	6.21 NS	54.702*	423.54*	996.80*	371.37*	408.23*
Error (a)	6	8.489	7.006	17.118	24.026	67.14	33.121	10.298
Factor B	4	7.30 NS	2.19 NS	8.436	30.98*	10.936*	24.082*	18.909*
AB	12	9.18 NS	10.56*	16.00*	13.95*	41.291*	15.897*	12.246*
Error (b)	32	15.583	8.131	14.876	26.529	43.564	19.038	13.199

Appendix VII.Analysis of variance of the data on total tillers hill^{-1}of rice as influenced by nitrogen and weed control

Source Of variation	Degrees of freedom	Mean square values at					
		15DAT	30DAT	45DAT	60DAT	75DAT	90DAT
Replication	2	0.171	0.434	3.366	1.348	32.055	9.116
Factor A	3	0.155*	0.408*	14.96*	92.30*	97.13*	40.11*
Error (a)	6	0.029	0.634	2.71	4.661	7.104	3.777
Factor B	4	0.165*	0.393*	2.166*	8.074*	4.80*9	12.57*
AB	12	0.05*	0.717*	5.99*	11.04*	10.62*	7.337*
Error (b)	32	0.044	0.392	3.207	2.568	4.847	4.077

* = Significant at 5% level of probability

Appendix VIII.Analysis of variance of the data on leaf area indexof rice as influenced by nitrogen and weed control

Source Of variation	Degrees of freedom	Mean square values at						
		15DAT	30DAT	45DAT	60DAT	75DAT	90DAT	Harvest
Replication	2	0.001	0.004	0.199	0.469	1.278	2.894	0.341
Factor A	3	0^{NS}	0.039*	1.848*	5.061*	33.93*	9.902*	4.267*
Error (a)	6	0	0.002	0.042	0.229	0.431	0.117	0.206
Factor B	4	0^{NS}	0.026*	0.777*	1.791*	15.55*	7.663*	1.684*
AB	12	0^{NS}	0.002*	0.065*	0.101*	1.151*	0.268*	0.129*
Error (b)	32	0.001	0.002	0.046	0.101	0.208	0.125	0.043

NS- Non Significant
* = Significant at 5% level of probability

Appendix IX.Analysis of variance of the data on total dry materof rice as influenced by nitrogen and weed control

Source Of variation	Degrees of freedom	Mean square values at					
		15DAT	30DAT	45DAT	60DAT	75DAT	90DAT
Replication	2	0.022	0.11	3.825	28.322	66.597	1206.137
Factor A	3	0.007^{NS}	2.412*	19.926*	386.977*	4200.262*	6835.875*
Error (a)	6	0.03	0.551	3.122	44.746	220.301	551.09
Factor B	4	0.067*	0.691*	19.825*	149.377*	1191.709*	4186.016*
AB	12	0.028*	0.648*	1.697*	28.19*	62.842*	391.112*
Error (b)	32	0.022	0.47	2.554	11.396	81.926	318.841

* = Significant at 5% level of probability
NS- Non Significant

Appendix X. Analysis of variance of the data on crop growth rateof rice as influenced by nitrogen and weed control

Source Of variation	Degrees of freedom	Mean square values at				
		30DAT	45DAT	60DAT	75DAT	90DAT
Replication	2	0	0.013	0.082	0.189	3.482
Factor A	3	0.01*	0.071*	1.077*	9.718*	3.277*
Error (a)	6	0.003	0.007	0.164	1.513	1.334
Factor B	4	0.004*	0.071*	0.347*	2.648*	6.157*
AB	12	0.003*	0.005*	0.13*	0.201*	1.071*
Error (b)	32	0.002	0.012	0.057	0.443	1.911

* = Significant at 5% level of probability

Appendix XI. ANOVA showing the mean square values of effective tiller no., panicle length,filled grains per panicle, unfilled grains per panicle,total grains per panicleand 1000grain weightof rice as influenced by nitrogen and weed control

Source Of variation	Degrees of freedom	Effective tillers hill^{-1} (No.)	Panicle length (cm)	Filled grains panicle^{-1}	Unfilled grains Panicle^{-1}	Total grains panicle^{-1}	1000 grain weight (gm)
Replication	2	5.691	0.271	1260.31	3.684	1342.46	4.649
Factor A	3	34.67*	2.646*	5045.81*	99.23*	4507.44*	3.17*
Error (a)	6	1.779	0.936	124.623	16.267	116.978	4.366
Factor B	4	9.583*	1.417*	908.288*	32.412*	1637.64*	3.125*
AB	12	8.716*	0.419*	809.578*	29.584*	784.153*	5.416*
Error (b)	32	2.401	0.686	589.211	10.14	298.913	2.829

* = Significant at 5% level of probability

Appendix XII.Analysis of variance of the data on yieldof rice as influenced by nitrogen and weed control

Source Of variation	**Degrees of freedom**	**Grain yield (t ha^{-1})**	**Straw yield (t ha^{-1})**	**Biological yield (t ha^{-1})**	**Harvest index (%)**
Replication	2	0.424	0.405	0.162	18.508
Factor A	3	25.586*	12.616*	62.835*	149.063*
Error (a)	6	1.237	1.426	4.638	10.459
Factor B	4	1.589*	0.784*	4.504*	3.141*
AB	12	0.36*	0.51*	1.287*	6.151*
Error (b)	32	0.562	0.417	1.575	4.982

* = Significant at 5% level of probability

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Plate 1. Field view after havesting in unweeded plot

Plate 2. Field view after harvesting in 1 hand weeding plot

Plate 3. Field view after harvesting in 2 hand weeding plot

Plate 4. Field view after harvesting in Sunrise 150WG treated plot

Plate 5. Field view after harvesting in Topstar 80WG treated plot