EFFECT OF NITROGEN AND WEED MANAGEMENT ON GROWTH AND YIELD OF BRRI dhan46

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CERTIFICATE

This is to certify that thesis entitled, "EFFECT OF NITROGEN AND WEED MANAGEMENT ON GROWTH AND YIELD OF BRRI dhan46'' 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 bona fide research work carried out by A.H.M. MOTIUR RAHMAN TALUKDER, Registration No. 04-01448 under my supervision and guidance. No part of the 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.

(Prof. Dr. A.K.M. Ruhul Amin)
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EFFECT OF NITROGEN AND WEED MANAGEMENT ON GROWTH AND YIELD OF BRRI dhan46

ABSTRACT

A research work was carried out at the Agronomy Farm, Sher-e-Bangla Agricultural University, Dhaka-1207 during the period August to December 2008 to determine the suitable nitrogen dose and weeding method to cultivate transplanted Aman rice variety BRRI dhan46 with higher yield harvest. The experiment comprised five doses of nitrogen viz. N_1 = 50 % lower nitrogen than recommended dose, N_2 = 25 % lower nitrogen than recommended dose, N_3 = Recommended dose of nitrogen, N_4 = 25 % higher nitrogen than recommended dose, N_5 = 50 % higher nitrogen than recommended dose and three weeding methods viz. W_1 = Control (No weeding), W_2 = Hand weeding at 20, 35 and 50 DAT and W_3 = Weeding with Japanese rice weeder at 20, 35 and 50 DAT. The experiment was set up in a split-plot design with three replications. Experimental Results indicated that nitrogen doses had the significant effect on plant height, tillers hill^{-1}, weight of dry matter hill^{-1}, weed dry matter weight m^{-2}, effective tillers hill^{-1}, panicle length, filled grains panicle^{-1}, grain yield, straw yield and harvest index. Nitrogen dose 25 % higher than recommended dose (N_4) showed the highest grain yield (5.34 t ha^{-1}) that mainly attributed by the highest effective tillers hill^{-1} and highest filled grains panicle^{-1}. Among the weeding methods hand weeding treatment gave the highest grain yield (4.73 t ha^{-1}) and it was mainly attributed by the highest effective tillers hill^{-1}, filled grains panicle^{-1} and 1000- seed weight. Combination of nitrogen doses and weed management methods did not significantly influenced the yield of rice.

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LIST OF ACRONYMS

Abbreviation	Full word
AEZ	Agro-Ecological zone
BRRI	Bangladesh Rice Research Institute
^0C	Degree centigrade
cm	Centi-meter
CV	Coefficient of variance
DAT	Days after transplanting
et al.	And others
G	Gram (s)
HI	Harvest index
ha^{-1}	Per hectare (s)
LSD	Least significant difference
m^{-2}	Per meter square
N	Nitrogen
W	Weeding
NS	Non-significant
$t\ ha^{-1}$	Ton per hectare
WCE	Weed control efficiency
%	Percentage
$g\ m^{-2}$	Gram per square meter
WDM	Weed dry matter
GDP	Gross domestic product
USG	Urea super granule
PU	Prilled urea

CHAPTER 1

INTRODUCTION

Bangladesh is an agro-based country. Most of her economic activities mainly depend on agriculture. Geographical and climatic conditions of Bangladesh are favorable for rice (*Oryza sativa* L.) cultivation. Rice is the staple food of Bangladesh where its production has increased more than three times during the last 3 decades and reached more than 25 million tons in 2001-2002 (BBS, 2002). The population of Bangladesh will increase to 173 million in 2020 which is 31 percent higher than the present level (FAO, 1998). National Agricultural Commission says that to feed the increased population in 2020, 47 million tons of rice will be needed to produce in the country. For food security of the country, rice production is needed to be increased from 3 tons ha^{-1} to 5 tons ha^{-1} in next 20 years (Mahbub *et al*., 2001).

In Bangladesh rice occupies 10.58 million hectares which is about 77% of the cultivated land area (BBS, 2008). 45.92% household at national level cultivate aman which indicates that a moderate number of farmers grow aman in Banglade4sh (BBS, 2008) The area and production of rice in the country were 11386000 acre and 17809000 tons respectively in 2008-2009 and per acre yield was 1.53 tons (BBS, 2009). The majority of rice area is covered by aman (Autumn) rice comprising about 52.77% of the total rice area of which transplanted aman rice and broadcast aman rice cover 92.67% and 7.33%, respectively (BBS, 2008). But the yield of transplanted aman rice in Bangladesh is much lower than that of transplanted aman rice in other rice growing countries of the world.

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. There is need to develop appropriate management technique to evaluate the performance and to assess the nutrient requirement for rice cultivation in the country. Among the fertilizers, urea is essential for vegetative growth but excess nitrogen may cause excessive vegetative growth, prolong the growth duration and delay crop maturity with reduction in grain yield.

Among the different elements nitrogen is universally needed for all crops. Many workers have reported a significant response of rice to nitrogen fertilizer in different soils (Islam *et al.*, 1990). The efficient nitrogen 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. 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. Different growth stages of rice need substantial amount of nitrogen for its maxmimum growth, development and yield harvest. Therefore, nitrogen should be applied in rice in such a way that the minimum is leached or washed away and the maximum is utilized for plant growth and grain production.

Among the yield limiting factors, severe weed infestation is the most important (Kurmi and Das, 1993). The prevailing climatic and edaphic conditions are highly favorable for luxuriant growth of numerous species of weeds which offer a keen competition with rice crop. 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. Manual weeding (hand weeding) is generally practiced in major area of rice cultivation in Bangladesh. But the availability of agricultural laborers has now decreased due to employment scope of the laborers in other sectors. To reduce the cost of rice production, it has been urgently needed to adopt alternative method of weed control viz. mechanical weed control, biological weed control, and chemical weed control in combination with manual weeding. Mechanical weeding and herbicides are the alternatives to hand weeding. Japanese rice weeder is in use in some areas of the country. Herbicides are now gaining popularity among the farmers. Now a good number of pre-emergence herbicides are available in the market with different trade names. These herbicides are effective in controlling weeds along with hand weeding

(Ahmed *et al*., 2003). So, an integrated weed management practice is needed to be evaluated in transplanted aman rice cultivation.

Therefore, the present experiment was conducted to achieve the following objectives:

1. To identify the optimum nitrogen dose that give higher yield.
2. To identify the suitable weed control method for T. Aman rice cultivation.
3. To identify the optimum combination of nitrogen doses and weed control method to get higher yield.

CHAPTER 2

REVIEW OF LITERATURE

Higher production of any crop depends on manipulation of basic ingredients of agriculture. The basic ingredients include weed management, environment and agronomic practices (Planting density, fertilizer, weed management, irrigation etc). Among the above factors weed management and nitrogen fertilization are more responsible for the growth and yield of rice. The available relevant reviews of the related works done in the recent past have been presented**.**

2.1 Effect of nitrogen

2.1.1 Plant Height

Salem (2006) reported that, the nitrogen levels had a positive and significant effect on growth parameters of rice plants in boro season. Increasing nitrogen levels up to 70 kg ha^{-1} significantly increased plant height. The highest plant height at harvest was recorded about 92.81cm when rice plants were fertilized with the highest nitrogen 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 nitrogen 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 nitrogen fertilizer application. Plants receiving no nitrogenous fertilizers were significantly shorter than other treatments. They also stated that nitrogen influences cell division, mid cell enlargement that ultimately increases plant height.

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).

Sahrawat *et al*. (1999) found that nitrogen level significantly influenced plant height of rice. Increasing levels of nitrogen increased the plant height significantly up to 120 kg N ha^{-1}.

Chowdhury *et al*. (1998) noted that the longest plant height of 112.1 cm was produced by nitrogen application at 100 kg ha^{-1} and was followed by 75 kg ha^{-1} due to the excellent vegetative growth of rice.

Thakur (1993) observed that the highest plant height of rice was attained from 120 kg N ha^{-1} and the lowest one from the control.

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

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 nitrogen (T_1), 30 kg N ha^{-1} at basal, 30 and 70 days after planting (DAP) (T_2); 45 kg N ha^{-1} at 30 and 70 DAP (T_3), 32 kg N ha^{-1} at basal, 30 and 70 DAP and 25 kg N ha^{-1} at panicle initiation stage (T_4), 4.5% controlled release N at 60% of the recommended dose and 6.0% controlled release N at 6o% of the recommended dose. The highest plant height 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 at the Rice Research and Training Center (Etai El- Baroud Agricultural Research Station Farm) in Egypt during the year of 1996-97 to find out the productivity and also the plant height of Giza 177 rice (*Oryza sativa*), Nitrogen 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 nitrogen 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.

Prasad *et al*. (1999) conducted an experiment on growth of rice plants as influenced by the method of seeding, seed rate and split application of nitrogen and reported that plants were generally tallest with N applied 25% at 15 days after sowing, 50% at active tillering and 25% at panicle initiation stages.

Vijaya and Subbaiah (1997) showed that plant height, number of tillers, and weight of panicles, N and P uptake, dry matter and grain yield of rice increased with the increasing USG size and were greater with the deep placement method of application both N and P compared with broadcasting.

Sharma (1995) reported in an experiment that split application of nitrogenous fertilizer increased the plant height significantly compare to the basal nitrogen application where as Akanda *et al*. (1991) pointed out that split application of nitrogen had no significant effect on plant height.

Wagh and Thorat (1988) observed that (30+30+10+10) kg N ha^{-1} applied at 4 days after transplanting, maximum tillering, primordial initiation and flowering, respectively produced the longest plant.

Singh and Singh (1986) reported that plant height increased significantly with the increase in the level of nitrogen from 27 to 87 kg ha^{-1}. Deep placement of USG resulted in the highest plant height than prilled urea (PU).

Akanda *et al*. (1986) observed that applying nitrogen in three splits 20 kg at basal, 40 kg at active tillering and 20 kg at panicle initiation stage had no significant effect on plant height.

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

Ahsan (1996) stated that tillering is strongly correlated with nitrogen content of the plant. The incremental level of nitrogen increase the number of tiller $hill^{-1}$. Result showed that the highest number of tiller $hill^{-1}$(31) was obtained at 150 kg ha^{-1} and declined with the lower level of nitrogen.

Kumar *et al.* (1995) stated that an increase in N level from 80 to 120 kg N ha^{-1} significantly increased total tillers $hill^{-1}$.

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 nitrogen significantly increased total tiller $hill^{-1}$.

Ehsanullah *et al.* (2001a) carried out a field experiment to determine the effect of various methods of nitrogen application for increasing nitrogen 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 nitrogen by incorporating in between hills wrapped tissue paper produced more tillers $hill^{-1}$ than other treatments and the differences were significant.

Munnujan *et al.* (2001) conducted a field experiment at Gazipur in 1993 to determine the effects of nitrogen (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.

Sahrawat *et al.* (1999) also observed that nitrogen level significantly affected tillering in rice.

Hari *et al*. (1997) carried out an experiment with rice hybrids PMS 2A/IR 30802 to study the effect of different levels of nitrogen and observed significant increase in productive tillers $hill^{-1}$ with increasing levels of nitrogen from 0 to 150 kg ha^{-1}.

BINA (1996) reported that the effect of different levels of nitrogen was significant for number of tillers $hill^{-1}$.

Chander and Pandey (1996) found that application of 120 kg N ha^{-1} resulted in significant increase in number of productive tillers $hill^{-1}$ compared to 60 kg N ha^{-1}.

Mirza and Reddy (1989) concluded that increase in N levels significantly increased the total tiller $hill^{-1}$.

Kamal *et al*. (1988) concluded that the highest rate of nitrogen (120 kg ha^{-1}) fertilizer gave the maximum number of tillers $hill^{-1}$ which was significantly grater than all other treatments.

Mondal *et al*. (1987) stated that increasing rate of N from 40 to 160 kg ha^{-1} increased the numbers of productive tillers $hill^{-1}$.

Nossai and Vargas (1982) stated that number of tillers $hill^{-1}$ and panicle length was increased linearly with increased N level.

Geethadevi *et al.* (2000) conducted an experiment with four splits application of nitrogen and found that higher number of tillers, filled grains $panicle^{-1}$ and higher grain weight $hill^{-1}$ for split application of nitrogenous fertilizer.

Islam *et al*. (1996) reported that number of effective tillers $hill^{-1}$ increased with increasing nitrogen level and split application was more effective compare to basal application during transplanting.

Shoo *et al.* (1989) reported that nitrogen application at transplanting or in two equal split dressing at transplanting and tillering stages increased the total number of tillers $hill^{-1}$.

Wagh and Thorat (1988) reported that 30+30+10+10 kg N ha^{-1} applied at 8 days after transplanting, maximum tillering, primordial initiation and flowering, respectively produced the highest number of tillers $hill^{-1}$.

Akanda *et a*l. (1986) observed that application of nitrogen in three splits 20 kg at basal, 40 kg at active tillering and 20 kg at panicle initiation stage gave the highest number of total tillers $hill^{-1}$.

Singh and Singh (1986) worked with different levels of nitrogen as USG, sulphur coated and PU @ 27, 54 and 84 kg ha^{-1} respectively. They reported that number of tillers m^{-2} increased with the increasing nitrogenous fertilizer. The number of tillers m^{-2} was significantly greater in USG than PU in all levels of nitrogen.

2.1.3 Effective tillers hill^{-1}

Tanaka *et al.* (1964) reported that at a higher N level, rice plants have vigorous growth, maximum tillers plant^{-1} but lower percentage of effective tillers hill^{-1}.

Wagh and Thorat (1988) observed that, nitrogen at 30+30+10+10 kg ha^{-1}, applied at 80 days after transplanting, maximum tillering, and primordial initiation and flowering respectively produced the highest number of effective tillers hill^{-1} of rice.

Thakur (1991) concluded that the yield attributes of rice like number of productive tillers m^{-2} and grain weight panicle $^{-1}$ increased with increasing levels of nitrogen.

Chander and Pandey (1996) found that application of 120 kg N ha^{-1} resulted in significantly increased number of productive tillers hill^{-1} of rice compared to 60 kg N ha^{-1}.

Hari *et al.* (1997) carried out an experiment with rice hybrids PMS 2A/IR2 and observed a significant increase in productive tillers hill^{-1} with increasing of N from 0 to 150 kg ha^{-1}.

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}.

Islam *et al.* (1996) reported that number of effective tillers hill^{-1} increased with the increasing nitrogen level and split application was more effective compared to basal application during transplanting.

Shoo *et al.* (1989) reported that the number of effective tillers hill^{-1} was the highest with N applied in 2-3 splits at tillering, panicle emergence and flowering stages.

Akanda *et al.* (1986) observed that applying nitrogen in three splits 20 kg at basal, 40 kg at active tillering and 20 kg at panicle initiation stage gave the highest number of tillers hill^{-1}.

2.1.4 Panicle length

Patel and Mishra (1994) carried out an experiment with rice cv. IR36 and were given 0, 30, 60 or 90 kg N ha^{-1} as Muossorie rock phosphate-coated urea, neem cake-coated urea, gypsum coated urea and USG or PU. The coated materials as incorporated before transplanting and USG as placed 5-10 deep a week after transplanting and urea as applied in 3 split doses. They showed that N rate had no significant effect on panicle length, percent sterility and harvest index.

Sen and Pandey (1990) reported that the application of USG or PU @ 38.32 kg N ha^{-1} gave higher yield than broadcast PU and there were no significant differences in panicle length.

Latchanna and Yogeswara (1977) reported that the longest panicle was obtained when N was applied in three split dressings 1/3 at planting, 1/3 at tillering and 1/3 at panicle initiation.

Ebaid and Ghanem (2000) indicated that increasing nitrogen levels up to 144 kg N ha^{-1} significantly increased plant height, panicle length, straw yield and grain yield of rice.

El-Batal *et al.* (2004) showed that increasing nitrogen rate from 50 to 80 kg ha^{-1} significantly increased plant height, panicle length, number of filled graisn $panicle^{-1}$ and grain and straw yields.

Azad *et al.* (1995) stated that the panicle length of rice increased significantly with the incremental level of N from 0 to 75 kg ha^{-1}.

Idris and Matin (1990) noted that the length of panicle of rice was highly related with the application of increased level of nitrogen. They also stated that panicle formation and elongation was directly related with the contribution of nitrogen.

Kumar *et al*. (1986) observed that the highest panicle length was recorded with 80 kg N ha^{-1} which was significantly superior to 40 kg ha^{-1}.

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 nitrogen 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.

Sharma and Mishra (1986) found that the maximum length of panicle was recorded with higher nitrogen level. The application of different levels on rice increased panicle length significantly (Awan *et al*., 1984).

2.1.5 Number of grains panicle^{-1}

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} respectively.

Rajarathinum and Balasubramaniyan (1999a) reported that application of 150 kg N ha^{-1} produced higher number of grains panicle^{-1} of rice than 250 kg, N ha^{-1}. They also noticed that the reduction of grains panicle^{-1} was occurred at higher nitrogen dose due to the production of higher vegetative parts of plant.

Chowdhury *et al.* (1998) reported that increasing level of N increased the number spikelet panicle^{-1} of rice and the highest number of panicle was obtained with the application of 75 kg ha^{-1} but after this dose the number of spikelet become reduced.

Chander and Pandey (1996) stated that a significant increase in grains panicle^{-1} tillers m^{-2} and grain yield of rice were obtained from application of 120 kg N ha^{-1}compared to 60 kg N ha^{-1}.

Hussain and Sharma (1991) stated that application of nitrogen increased the number of spikelets panicle^{-1} of rice up to 80 kg N ha^{-1}. The highest number of spikelets panicle^{-1} was produced at 80 kg N ha^{-1} and the lowest was produced in the control.

Yoshida and Parao (1976) reported that in rice at higher nitrogen level the number of grain become decreased due to lodging.

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.

Ehsanulla *et al*. (2001) pointed out that the nitrogen level of 125 kg ha^{-1} produced maximum number of grains panicle^{-1}. The number of grains panicle^{-1} increased with increasing rate of nitrogen from 0 to 60 kg ha^{-1} (Rafey *et al.*, 1989). Nitrogen significantly influenced the number of grains particle^{-1} (Bhuiyan *et al*., 1989).

Maskina and Singh (1987) stated that nitrogen fertilizer application at 90, 120 and 150 kg ha^{-1} influenced number of grains panicle^{-1} in rice.

Faraji and Mirlohi (1998) reported that plant height, number of tillers per unit area and days to heading and maturity increased with the increase of rate of N fertilizer application at 60, 90, 120 or 150 kg N ha^{-1}, were given before transplanting or in 2 or 3 splits while grain yield and panicle number increased up to 120 kg N ha^{-1} but then decreased with increasing N rate.

Kapre *et al*. (1996) reported that USG has favorable effects on rice. They also observed from a study with 8 slow releasing fertilizers that grain yield, straw production, panicle hill-, grains panicle^{-1} and 1000-grain weight increased significantly with USG and sulphur coated urea (SCU).

Surendra *et al*. (1995) conducted an experiment during rainy season with nitrogen level @ 0, 40, 80, 120 kg ha^{-1} and sources, of nitrogen, USG and urea dicyandiamide g 80 kg ha^{-1}. They showed that USG and urea dicyandiamide produced more panicle hill^{-1}, filled grains panicle^{-1}, panicle weight and grain yield than PU @ 80 kg N ha^{-1}.

Nassem *et al*. (1995) indicated that percent grains remained unchanged in response to different levels but a significantly lower 1000-grain weight was recorded in the control treatment than in the plots received nitrogen fertilizer.

Thakur (1991) reported that total spikelets panicle^{-1} was the highest when 40%, 30% and 20% nitrogen was applied as basal, at maximum tillering and panicle initiation stages, respectively. He also observed in another experiment that yield attributes and grain yield differed significantly due to the levels and sources of nitrogen applied. Placement of nitrogen at 60 kg ha^{-1} through USG produced the highest number of panicle unit^{-1}area.

Kamal *et al*. (1991) conducted a field experiment in Kharif season of 1985 and 1986 on rice cv. Joya with different forms of urea and level of nitrogen @ 29.58, 87 kg ha^{-1}. They reported that total tiller varied significantly due to forms of urea in 1995, but during 1996 there was no significant variation. PU was significantly inferior to the other forms. The highest number of tillers was produced in the treatment where USG was applied.

Rama *et al.* (1989) observed that the number of grains panicle^{-1} were significantly higher @ 40, 80 or 120 kg N ha^{-1} as USG applied as deep out a field trial to study the effect of placement of USG (5, 10 or 15 cm deep) and broadcast PU on rice yields of tall long duration Mashuri and dwarf, short duration Mashuri. They revealed that Mashuri had significantly higher yield, panicles m^{-2}, panicle length and weight, grains panicle^{-1} and 1000-grain weight than Mashuri, probably due to Mashuri's long duration. All depths of USG placement resulted in higher yield characters than broadcast PU; however, differences except for panicle lengths were not significant.

Reddy *et al*. (1987) reported that total number of spikelets panicle^{-1} increased with 120 kg with N ha^{-1} in three split dressings at tillering, panicle initiation and booting stages.

Akanda *et al.* (1986) observed that applying nitrogen in three splits 20 kg at basal, 40 kg at active tillering and 20 kg at panicle initiation stage gave the highest number of grains panicle^{-1}.

2.1.6 Weight of 1000-grain (g)

BRRI (2006) reported that the weight of rice 1000 - grain was increased up to 90 kg ha^{-1} and after that the weights become declined.

Ibrahiem *et al.* (2004) found that number of grains $panicle^{-1}$, 1000-grain weight, panicle weight and grain and straw yields ha^{-1} of rice were not significant effect by increasing nitrogen levels from 30 to 60 kg N ha^{-1}.

Ahsan (1996) in an experiment showed that higher level of N decreased the weight of 1000 grains of rice due to smaller rice. He also stated that among 4 doses of N, 150 kg ha^{-1} gave the lowest weight of grain yield and the weight was increased gradually from 150 to 0 kg ha^{-1} and finally 0 kg ha^{-1} gave the highest weight of 1000 grains.

Ali *et al.* (1993) reported that the weight of 1000 grains was higher when 100 kg N ha^{-1} was applied in three equal splits at basal, 30 days and 60 days after transplanting.

Lawal and Lawal (2002) conducted three field experiment during the rainy season of 1996, 1997 and 1998 in Nigeria to evaluate the growth and yield responses of lowland rice to varying N rates and placement methods. The treatment consisted of four N rates (0, 40, 80 and 120 kg ha^{-1}) and two fertilizer placement method (deep and surface placement). They found that the nitrogen rate up to 120 kg ha^{-1} has a positive effect on the 1000-grain weight.

Ehsanullah *et al.* (2001a) conducted a field experiment to evaluate the effect of split application of nitrogen at three different stages like sowing, tillering and panicle emergence @ 125 kg N ha^{-1}. They found that the split application of N fertilizer at different growth stages significantly affected the 1000 grain weight

Deva senamma *et al*. (2001) conducted a field experiment in Andhra Prodesh, India during the rabi season of 1996-97 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 N ha^{-1}). They found that the TNRH 16 exhibits the highest 1000-grain weight (20.50 g) than others.

Sadeque *et al*. (1990) conducted an experiment with 50, 100 and 120 kg N $ha^{-1}$and reported that 50 kg N ha^{-1} gave the maximum 1000-grain weight.

There was an increased trend of 1000-grain weight with an increased level of nitrogen up to 80 kg ha^{-1} (Islam *et al*., 1990).

Subhendu *et al.* (2003) conducted a field experiment during *kharif* season at Hyderabad, India. They found that the application of nitrogen (120 kg N ha^{-1}) as urea in equal splits during transplanting, tillering, panicle initiation and 50% flowering resulted in the highest 1000 grain weight (22.57 g).

Ali *et al.* (1992) reported from their earlier findings that 1000 grain weight was the highest when 100 kg N ha^{-1} was applied in three equal splits at basal, 30 and 60 days after transplanting.

Akanda *et al*. (1986) reported that the weight of 1000-grain was the highest when 80 kg N ha^{-1} was applied in three splits such as 20 kg ha^{-1} basal, 40 kg ha^{-1} at active tillering and 20 kg ha^{-1} at panicle initiation stages.

2.1.7 Grain and straw yield (t ha^{-1})

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

Zayed *et al*. (2005) found that increasing nitrogen levels up to 165 kg N ha^{-1} significantly increased growth and yield of rice and its components.

Elbadry *et al*. (2004) in pot and lysimeter experiment showed that the increasing level of N had statistically significant difference on growth parameters and yield attributes like dry weight, number of productive tillers, grain and straw yields of rice. They also noted that after inoculation the grain yields of Giza 176 were 0.63, 0.93 and 1.22 t ha^{-1} at 0, 47.6 and 95.2 kg N h m^{-2}, respectively.

Yang *et al*. (2003) conducted an experiment with two varieties and three levels of nitrogen and observed that four times split application of 160kg N hm^{-2} gave the highest yield about 5,916 kg hm^{-2}.

El-Rewainy (2002) recorded that applying 40 kg N ha^{-1} caused significant increase in plant height, number of panicles m^{-2}, panicle length, and panicle weight, number of filled grains panicle^{-1} as well as grain and straw yields.

Singh *et al*. (2000) stated that each increased dose or N gave significantly higher grain yield and straw yield of rice over its preceding dose, consequently crop fertilized with 100 kg ha^{-1} gave maximum grain yield (2647 kg ha^{-1}).

Hari *et al* (2000) showed that there was a significant increase in grain yield and its attributes with each additional nitrogen application up to 150 or 200 kg ha^{-1}.

Singh *et al*. (1998) evaluated the performance of three rice cultivars (KHRI, Pro. Agro.103 and MGRI) using Jaya and Rasi as standard check giving four levels of N (0, 60, 120 and 180 kg ha^{-1}) and noticed that grain yield increased linearly with increased N level up to 120 kg ha^{-1}.

Hossain *et al*. (1995) observed that application of nitrogen up to 120 kg ha^{-1} increased the grain yield of rice. Increased in yield with 40, 80 and 120 kg N ha^{-1} over the control was 24, 33 and 34%, respectively. He noted significantly higher yields with 80 and 120 kg N ha^{-1} than 0 and 40 kg N ha^{-1}.

Thakur *et al.* (1995) found that grain yield of rice increased up to 120 kg N ha^{-1}. The performances of genotypes IET 6760 and IET 8002 were evaluated against national check Pankij and local checks Radha and Rajashree at five levels of N (0, 10, 40, 80, 120 and 160 kg ha^{-1}) and observed that the genotype IET 8002 gave significantly higher grain and straw yields than the other genotypes.

Singh and Pillai (1994) noted that increased doses of nitrogen increased grain yield of rice significantly up to 90 kg ha^{-1} after that it declined.

BRRI (1992) reported that both grain and straw yields of rice increased significantly up to 80 kg N ha^{-1}and after that the yield become reduced.

Dalai and Dixit (1987) reported that nitrogen had marked effect both on yield and yield attributes of rice. They observed that grain and straw yields increased significantly at each successive level of N due to increase in the number of panicle m^{-2}, length of panicle, spikelet panicle^{-1} and weight of 1000-grain.

Sidhu *et al.* (2004) conducted field experiment from 1997 to 2001 in Indian Punjab, India to determine the optimum N requirement of Basmati rice in different cropping sequences i.e. Fallow-Basmati rice-Wheat, green manuring (GM; 50-days-old *Sesbania aculeala*), Basmati rice-Wheat and GM-Basmati rice-Sunflower. N fertilizers were applied at 0, 20, 40 and 60 kg ha^{-1}. Nitrogen fertilizers substantially increased the mean grain yield of Basmati up to 40 kg N ha^{-1} in the fallow Basmati-wheat sequence while 60 kg N ha^{-1} reduced Basmati yield.

Singh *et al.* (2004) conducted a field experiment during the rainy (kharif) season, in New Delhi India, to study the effect of nitrogen levels (0, 60, 120 and ISO kg ha^{-1}) on the yield nitrogen use efficiency (NUE) of the rice cultivars Pusa Basmati- I (traditional high avidity aromatic rice) and pusa ricehybrid (aromatic hybrid rice). They found that Pusa rice hybrid -10 had than the significantly higher value for the yield attributes and nutrient accumulation than the non hybrid Pusa Basmati- I. The highest grain yield (5.87 t ha^{-1}) was recorded at the highest level of N nutrient (180 kg N ha^{-1}) and was 4.2, 15.5 and 39.3% higher than in the 120, 60 and 0 kg N ha^{-1} treatments respectively.

Jena *et al*. (2003) conducted field experiment on a Typic Haplaquept Orissa, India to evaluate the use efficiency of nitrogen and volatilization losses of amonia in rice by the following application of grilled urea (PU) and urea super granules (USG) at 76 and 114 kg N ha^{-1}. They found that deep placement of urea super-granules (USG) significantly improved grain and straw yield and nitrogen use efficiency of rice and reduced volatilization loss of ammonia relative to the application of prilled urea.

Choudhury and Khanif (2002) pointed out that yield of rice significantly increase with application of 120 kg N ha^{-1} over farmers practice (80 kg N ha^{-1}).

Fageria and Baligar (2001) conducted a field experiment during three consecutive years (1995-96, 1996-97 and 1997-98) in Goias, central part of Brazil on a Haplaquept inceptisol. The nitrogen levels used were 0, 30, 60, 90, 120, 150, 180 and 210 kg N ha^{-1}. They found that nitrogen fertilizer application significantly increased grain yield. Ninety percent of the maximum grain yield (6400 kg ha^{-1}) was obtained with the application of 120 kg N ha^{-1} in the first year and in the second and third years

90% of the maximum yields (6345 and 5203 kg ha^{-1}) were obtained at 90 and 78 kg N ha^{-1}, respectively.

Sudhakar *et al*. (2001) carried out an experiment to evaluate the effects of various rice cultivars and nitrogen levels on yield and economics of direct sown semidry rice during khrif 1996 and 1999. They found that cultivar PMK-1 show the maximum grain and straw yield, net return and B:C ratio. There was a significant increase in grain yield, straw yield, net return and B:C ratio with each increment of nitrogen application up to 125 kg ha^{-1}.

Sahrawat *et al.* (1999) found that N levels significantly affected the grain and straw yield.

Rajarathinam and Balasubramaniyan (1999b) reported that the higher grain yield of hybrid rice CoRH-2 was produced due to the application of 200 kg N ha^{-1}. However, application of 250 kg N ha^{-l} reduced the grain yield significantly.

Devaraju *et al*. (1998) reported that KHR2 out yielded to IR 20 at all levels of N application ranging from 0 to 100 kg ha^{-1}.

Singh (1997) found that the grain yield increased with each increment of N up to 80 kg ha^{-1} which registered the highest yield.

Kumar *et al*. (1995) reported that an increase in N level from 80 to 120 kg ha^{-1} significantly increased the grain and straw yields, decreased the sterility percent.

Jha *et al.* (1991) observed that a variety responded up to 60 kg ha^{-1}, but another two varieties up to 40 kg N ha^{-1}, beyond which the grain yield declined.

Katayama *et al*. (1990) found that yield of Suweon 258 hybrid cultivar and IR 24 increased as N level increased.

Pandey *et al*. (1989) found that grain yield of rice increased with N application up to 90 kg ha^{-1}.

Singandhupe and Rajput (1989) from an experiment with four N levels (0, 50, 100 and 150 kg ha^{-1}) and two varieties of rice (PR 106 and PR 109) stated that application of nitrogen up to 150 kg ha^{-1} increased both the grain and straw yield significantly compared with the unfertilized control.

Mirza and Reddy (1989) concluded that increase in N level from 30 to 90 kg ha^{-1} significantly increased the grain and straw yields of rice.

Gill and Shahi (1987) concluded that the grain yield of rice increased significantly with an increase in N application from 60 to 150 kg ha^{-1} with significant difference between 60 and 120, 60 and 150 & 90 and 150 kg N.

Katoch *et al*. (1987) also observed that the increasing N levels raised the grain yield in general with 0 to 60 kg ha^{-1} of N but the straw yield did not differ significantly.

Nitrogen application delayed flowering but the yield attributes were improved significantly. Grain and straw yields were also increased with every increase in N level by 20 kg ha^{-1} (Rao and Raju, 1987).

Budhar *et al*. (1987) reported that grain yield of rice was higher at 150 kg N ha^{-1} than that at 100 kg N ha^{-1}.

Grain yield of rice significantly increased with increase in the level of N up to 1000 kg ha$^{-1.}$ The yield and yield attributes increased with increasing levels of N up to 100 kg ha^{-1} reflecting their effect on yield (Thakur and Singh, 1987).

Significant increase in grain yield (49%) was observed with increase in N from 0 to 20 kg ha^{-1}. There was no improvement in yield with further increase in up to 40 or 60 kg ha^{-1}. The effect of interaction between cultivars (CR 1016 and CR 1018) and N levels was significant in respect of grain yield (Ghosh *et al*., 1987)

Reddy *et al*. (1986) observed that the grain yield of rice increased significantly with successive increment in the level of nitrogen from 30 to 90 kg ha^{-1}.

Kumar *et al*. (1986) stated that the grain yield attributes of rice were significantly influenced by nitrogen. The highest grain yield recorded 80 kg N ha^{-1}was due to the highest number of panicles m^{-2}, increase in panicle length and filled grains particles^{-1} which was significantly superior to 40 kg N ha^{-1} and control.

Awan *et al*. (1984) reported that application of different levels of nitrogen increased grain and straw yields of rice significantly.

Application of nitrogen significantly influenced the yield components of rice. Significantly increase in number of tillers panicles hill^{-1}, panicle length, 1000-grain weight and grain yield of rice (Sharma and Prasad, 1980).

The highest grain yield of rice was, recorded with an application of 180 kg N ha^{-1}, which was followed by 120, 60 and control. The response per kg N application was 24.0, 14.2 and 15.2 kg of rice at 60, 120 and 180 kg N ha^{-1}, respectively (Singh and Paliwal, 1980).

Bowen *et al*. (2005) conducted 531 on-farm trials during the boro and aman seasons in 7 districts of Bangladesh from 2000-2004. The results showed that UDP (Deep placement of urea super granule) increased grain yield by 1120 kg ha^{-1} and 890 kg ha^{-1} during the boro season and aman season, respectively.

Ikeda *et al*. (2003) stated the efficiency of the non-split fertilizer application to the rice variety 'Koshihikari' was evaluated in order to dispense with top dressing and improve the recovery rate of fertilizer in pneumatic direct sowing culture of rice on a submerged paddy field in Aichi Prefecture, Japan. The fertilizer used in this study, which was a combination of a linear-type coated urea and a sigmoidal-type coated urea, was found effective in this cultivation system. Results also showed that nitrogen recovery rate, yield rate and quality were improved with this system. The accumulative nitrogen release rates of the combined fertilizer were 40% at panicle formation stage, 80% at heading stage and 95% at maturity stage. Furthermore, the nitrogen release pattern was adapted for the growth phase of this cultivation system.

Jaiswal and Singh (2001) conducted an experiment with USG and PU both at 60 and 120 kg ha^{-1} under different planting methods. They found that transplanting method with urea super granules proved to be the best for maximum grain yield (4.53 t ha^{-1}).

Angayarkanni and Ravichandran (2001) conducted a field experiment at Tamill Naru from July to October, 1997 and found that split application of nitrogen for rice cv. IR20, treatment applying 16.66% of the recommended N as basal, followed by 33.33% N at 10 DAT, 25% N at 20 DAT and 25% N at 40 DAT recorded the highest grain yield e.g. 6189.4 kg ha^{-1}.

Ehsanullah *et al*. (2001) when work with split application of nitrogenous fertilizer and reported that nitrogen as split application at different growth stages significantly affected grain yield.

Ahmed *et al*. (2000) revealed that USG was more efficient than PU at all respective levels of nitrogen in producing all yield components and in turn, grain and straw yields. Placement of USG @ 160 kg N ha^{-1} produced the highest grain yield (4.32 t ha^{-1}) which was statistically identical to that obtained from 120 kg N ha^{-1} as USG and significantly superior to that obtained from any other level and source of nitrogen.

Geethadevi *et al*. (2000) showed that four split applications of nitrogen in KRH-1 recorded the maximum yield, as well as increased growth and yield components

Surekha *et al*. (1999) found that N application in four equal splits, the last at flowering improved the grain yield as well as nutrient uptake of hybrid rice.

Asif *et al*. (1999) noticed that application of 60 : 67 : 67 or 180 : 90 : 90 kg NPK ha^{-1}, with N at transplanting and early tillering or a third each at transplanting, early tillering and panicle initiation resulted in higher grain yield with the higher NPK rates. Split application of N gave higher yields than a single application.

Thakur and Patel (1998) reported that the highest grain yield (3.84 t ha^{-1} was recorded with the application of 80 kg N ha in three split rates with 5 t FYM ha^{-1} and 60 kg N ha^{-1} in three split rates with 5 t FYM gave 3.81 t ha^{-1}.

Islam *et al*. (1996) reported that grain yield was increased with increasing nitrogen level and split application was more effective compare to basal application during transplanting.

Panda and Mohanty (1995) observed that grain yield was the highest with 60 kg ha^{-1} applied 30 kg at transplanting and 15 kg each at 21 and 75 days after transplanting.

Das and Singh (1994) reported that grain yield and N use efficiency by rice were greater for deep placed USG than for USG broadcast and incorporated or three split applications of PU.

Subhendu *et al*. (2003) conducted a field experiment during kharif season at Hyderabad, India. They found that the application of nitrogen (120 kg N ha^{-1}) as urea in equal split during transplanting, tillering, panicle initiation and 50% flowering resulted straw yield is 5322 kg ha^{-1}.

Ehsanullah *et al.* (2001a) conducted an experiment with the application of nitrogenous fertilizer as split at different growth stages and reported that split application significantly affected straw yield.

Salam *et al.* (1988) reported that straw yield was the highest with split application of nitrogen and also application of nitrogen at tillering stage it was more effective than basal application.

Paturde and Rahate (1986) reported that straw yield was the highest due to N application in split, the rates of 40 kg N ha^{-1} at transplanting, 20 kg N ha^{-1} at panicle initiation and 20 kg ha^{-1} at heading stage.

2.1.8 Harvest Index

Ahmed *et al*. (2005) conducted an experiment with five levels of nitrogen on aman rice and observed that the harvest index was significantly higher with 40kg N ha^{-1}, compared to that of other treatments except 20 kg N ha^{-1} and the lowest harvest index was produced with maximum N dose (80 kg ha^{-1}) that was statistically identical to 0 and 60 kg N ha^{-1}.

Mondal and Swamy (2003) found that application N (120 kg ha^{-1}) as urea in equal split during transplanting, tillering, panicle initiation and flowering resulted in the highest number of panicles, number of filled grain $panicle^{-1}$, 1000-grains weight, straw yield and harvest index.

2.2 Effect of weed management methods

2.2.1 Weed vegetation in transplanted aman rice

Venkataraman and Goplan (1995) observed that the most important weed species in transplanted low land rice in Tamil Nadu, India were *Echinochloa crusgalli, Cyperus* *difformis, Echinochloa colonum, Cyperus iria, Fimbristylis miliacea, Scirpus spp, Eclipta alba, Ludwigia parviflora, Marsilea quadrifolia* and *Monochoria vaginaliz.*

Bari *et al.* (1995) observed 53 weed species to grow in transplanted rice field. In respect of abundance value the three most important weeds were *Fimbristylis miliacea, Paspalum scrobiculaturm* and *Cyperus rotundus.*

Mamun *et al*. (1993) from the same location identified 60 weed species in T. aman rice of which *Fimbristylis miliacea, Lindernia antipoda* and *Eriocaulen cinereesm* were the most important weed species.

Elliot *et al*. (1984) reported that in transplanted rice *Monochoria vaginalis* was the important weed and other weed species were *Ischaemum rogusum, Scirpus supinus, Cyperus difformis, Ipomoea aquatica* and *Marsilea minuta*.

In the irrigated and rainfed area, Carbonell and Moody (1983) observed various weed species in transplanted rice in Nueva Ecija, Philippines. The most important weeds in the rainfed area were *Ischaemum rogusum, Fimbristylis miliacea, Echinochloa cars-galli* and *Monochoria vaginalis.*

2.2.2 Weed control efficiency

Weed control efficiency is one of the important measurements of weed control in crop field. High weed control efficiency throughout the growing period by a weed control treatment ensures proper crop growth and profitable weed control. Weed control efficiency varies with weed control technology.

Sharma and Bhunia (1999) reported that Pendimethalin @ 1.5 ka ha^{-1} plus one hand weeding resulted in highest weed control efficiency than any other treatments.

Ahmed *et al.* (1997) reported that higher weed control efficiency (90.35%) was observed in herbicides with one hand weeding treatment than sole herbicides or conventional weed control methods.

Weed control efficiency was higher in two hand weeding (90.67%) than those of Oxadiazon and Cinosulfuron treatments (Alam *et al*., 1996).

In another experiment Singh and Bhan (1992) found that two hand weeding resulted better weed control efficiency (72.3%) than Butachlor @, 1.5 kg ha^{-1} (54.40%) in transplanted rice under medium land condition.

Burhan *et al.* (1989) reported that Cinosulfuron @ 20g ha^{-1} resulted in 85% control of *Monochoria vaginalis, Marsileaa crenata, Cyperus spp., Fimbristylis miliacea* and *Scirpus juncoides* but only 50-60% control of *Echinochloa crus-galli* in transplanted rice.

2.2.3 Effect of no weeding

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 nitrogen uptake in transplanted rice and weeds and reported that weed control until maturity removed significantly higher amount of nitrogen through weeds (12.97 kg ha^{-1}) and reduced the grain yield of rice by 49% compared to that of weed free crop up to 60 DAT.

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

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 yield due to weed competition was 56 percent.

2.2.4 Effect of hand weeding

Ashraf *et al.* (2006) made 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} 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 *et al*. (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.

Balaswamy (1999) found that hand weeding twice at 20 and 40 days after transplanting resulted in low weed numbers, followed by herbicides

Gogoi (1998) observed that Anilofos at 0.4 kg ha^{-1} gave significantly higher yield and the yield was not significantly different from the hand weeding at 20 days after transplanting.

Nandal *et al*. (1998) evaluated the herbicide in direct seeded paddled rice during Kharif season. They observed that Pretilachlor (1.0 kg ha^{-1}) + hand weeding reduced weed population and weed dry weight significantly than other treatments. They also found that the highest grain yield and gross margin was obtained from the Pretilachlor (1.0 kg, ha^{-1}) + hand weeding.

Angiras and Rana (1998) observed that greatest yield and desired weed control was achieved form the Pretilachlor (0.8 kg ha^{-1}) + hand weeding.

BRRI (1997) reported that two hand weeding performed best than chemical treatments but two hand weeding gave the higher weeding cost than herbicidal treatments.

Navarez *et al*. (1982) showed in rainfed condition that the lack of weed control in tall rice cultivars resulted in the yield reduction by 41% but one hand weeding at 40 days after transplanting reduced the grain yield by 31%.

2.2.5 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.

Islam and Haq (1987) concluded that use of a low cost weeder could eliminate 90% weeds in the sandy loam soil with a weed density of 375 m^{-2}

Singh *et al*. (1985) reported that two inter row cultivation with hand hoe plus hand, weeding in the row 14 and 28 days after emergence (DAE) resulted in equivalent yields with those from the weed control and there were no significant differences in grain yields between the plots where hand weeder used twice.

CHAPTER 3

MATERIALS AND METHODS

The research work was carried out at the experimental field of Agronomy Department of Sher-e- Bangla Agricultural University, Dhaka-1207 during the period from August to December 2008 to evaluate the effect of nitrogen and weed management on transplanted Aman variety BRRI dhan46. The details of the materials and methods applied in this experiment have been presented below.

3.1 Description of the experimental site

3.1.1 Location

The present research work was conducted in the experimental field of Sher-e-Bangla Agricultural University, Dhaka-1207. The location of the site was $23^{0}74^{/}$ N latitude and $90^{0}35^{/}$ E longitude with elevation of 8.2 meter from sea level Appendix I.

3.1.2 Soil

The soil of the experimental site was clay loam belonging to the Modhupur Tract under AEZ 28. The selected plot was medium high land. The land was above flood level and sufficient sunshine was available during the experimental period. Soil samples from 0-15 cm depths were collected from experimental field. Details of the soil analysis have been shown in the Apendix II.

3.1.3 Climate

The geographical situation of the experimental site was under the subtropical climate, characterized by three distinct seasons, winter season from November to February, the pre-monsoon period or hot season from March to April and monsoon period from May to October. Metrological data of air temperature, relative humidity, rainfalls during the period of the experiment were collected from the Bangladesh Meteorological Department (Climate and weather division), Agargoan, Dhaka presented in Appendix III.

3.2 Experimental Step up

BRRI dhan46 was the test rice variety of this experiment. This variety was developed by Bangladesh Rice Research Institute (BRRI), Gazipur. It is an Aman variety but can be cultivated as late Aman. Average plant height of the variety is about 110 cm at the ripening stage. The grains are coarse and whitish golden in color. It requires about 124 days for completing its life cycle with an average yield of 6.5 tonne per hectare.

3.3 Experimental details

3.3.1 Treatments

The experiment comprised two factors

Factor A: Nitrogen dose (N) : 5

i. **N_1 =** 50% lower nitrogen than recommended dose (30 kg N ha^{-1})
ii. **N_2 =** 25% lower nitrogen than recommended dose (45 kg N ha^{-1})
iii. **N_3 =** Recommended dose of nitrogen (60 kg N ha^{-1}which was 130 kg urea ha^{-1} BRRI, 2008 Adunik Dhaner Chash, in Beangali)
iv. **N_4 =** 25% higher nitrogen than recommended dose (75 kg N ha^{-1})
v. **N_5 =** 50% higher nitrogen than recommended dose (90 kg N ha^{-1})

Factor B: Weeding method (**W**): **3**

i. W_1 = No weeding (Control)
ii. W_2 = Hand weeding
iii. W_3 = Japanese rice weeder

3.3.2 Experimental design and layout

The experiment was laid out following split-plot design with three replications where nitrogen dose was assigned in main plot and weeding method in sub-plots. There were total 45 plots, each measuring 4m x 2.5m. The distance between plot to plot and replication to replication was 0.75 m and 1 m, respectively. The layout of the experiment has been shown in Appendix IV.

3.4 Growing of crops

3.4.1 Raising seedlings

Seed collection

The seeds of the test variety i.e. BRRI dhan46 were collected from Bangladesh Rice Research Institute, (BRRI) Joydebpur, Gazipur.

Seed sprouting

Healthy seeds were selected by specific gravity and immersed in water in a bucket for 24 hours. Then the seeds were taken and kept thickly in gunny bags. The seeds started sprouting after 48 hours and were sown after 72 hours.

Preparation of nursery bed and seed sowing

Common procedure was followed in raising seedling in the seedbed. The seedbed was prepared by puddling with repeated ploughing followed by laddering. Weeds were removed and irrigation was gently provided to the bed as and when necessary. No fertilizer was used in the nursery bed. The sprouted seeds were sown on seedbed on 10 August, 2008.

Preparation of main field

The plot for the experiment was opened in the first week of August 2008, with a power tiller and was exposed to the sun for a week. After one week the land was harrowed, ploughed and cross ploughed several times followed by laddering to obtain a good tilth. Weeds and stubbles were removed and finally obtained a desirable tilth for transplanting.

3.4.2 Fertilization

The following fertilizer dose was used in the experimental field as recommended dose (BRRI, 2008 Adunik Dhaner Chash, in Beangali)

Urea	: 130 kg ha^{-1}
T.S.P	: 90 kg ha^{-1}
MoP	: 70 kg ha^{-1}
Gypsum	: 60 kg ha^{-1}
Zinc Sulphate	: 10 kg ha^{-1}

Whole amount of TSP, MP and Gypsum along with one third ($^1/_3$) amount of urea as per treatment were applied as basal dose during final land preparation. Rest amount of urea ($^1/_3$+$^1/_3$) were applied in two installments as top dressing at 30DAT, and 50 DAT, respectively.

3.4.3 Uprooting of seedlings

The nursery bed was made wet by the application of water one day before uprooting of seedlings. The seedlings were uprooted on 04 September, 2008 without causing much mechanical injury to the roots and they were immediately transferred to the main field.

3.4.4 Transplanting of seedlings in the field

Transplanting was done with 25 days old seedlings on 04 September, 2008. Seedlings were transplanted in lines following line to line distance of 25 cm and hill to hill distance of 15 cm.

3.4.5 After care

After establishment of seedlings, various intercultural operations were accomplished for better growth and development of rice seedlings.

3.4.6 Irrigation and drainage

Irrigation was given in each plot as per requirements. The field was finally dried out 15 days before harvesting.

3.4.7 Gap filling

Gap filling was done for all of the plots at 10 days after transplanting (DAT) with the same ages of seedlings from the same source.

3.4.8 Weeding

During plant growth period three weedings were done. First weeding was done at 20 days after transplanting, 2^{nd} and 3^{rd} weeding was done at 35 DAT and 50DAT.

3.4.9 Top dressing

Urea was top dressed as per treatment.

3.5 Plant protection

Plants were infested with rice stem borer and rice hispa to some extent which was successfully controlled by applying Diazinon (60 EC) two times @ 10 ml/10 liter of water for 5 decimal lands at tillaring and before panicle initiation stage.

3.5.1 Harvesting, threshing and cleaning

The rice was harvested depending upon the maturity of the crop and 3 m^2 area of each plot was harvested manually on 19 December 2008. The harvested crop of each plot was bundled separately, properly tagged and brought to the threshing floor. Enough care was taken for harvesting, threshing and also cleaning of rice seed. The grains were weighted in plot wise and finally the weight was adjusted to a moisture content of 14%. The straw was also sun dried, and weighed the yields of grain and straw $plot^{-1}$ was converted to ha^{-1}.

3. 5.2 Data recording

The following data were recorded

A. Growth parameters

1. Plant height (cm)
2. Number of tillers hill^{-1}
3. Dry weight hill^{-1}
4. Dry weight of weed

B. Yield and yield component parameters

1. Number of non-effective tillers hill^{-1}
2. Number of effective tillers hill^{-1}
3. Panicle length (cm)
4. Weight of 1000-grains (g)
5. Grain yield (t ha^{-1})
6. Straw yield (t ha^{-1})
7. Harvest index (%)
8. Weed control efficiency (%)

3.5.3 Plant height (cm)

The plant height was recorded in centimeter (cm) at 20, 40, 60 and 80 DAT, and at harvest. Data were recorded as the average of 5 hills selected randomly from the inner rows of each plot. The height was measured from the ground level to the tip of the leaf before heading and tip of the flag leaf after heading.

3.5.4 Number of tillers hill^{-1}

Number of tillers hill^{-1} was recorded at 20, 35, 50 and 65 DAT and at harvest. Data were recorded as the average of 5 hills selected randomly from the inner rows of each plot.

3.5.5 Dry matter hill^{-1}(g)

Dry matter hill^{-1} was recorded at the time of panicle initiation stage, grain filling stage and at harvest. Data were recorded as the average of 5 hills selected randomly from the inner rows of each plot. For drying randomly selected plant sample previously sliced into very thin pieces were put into envelop and placed in oven maintained at 60^0 for 72 hours. The samples was then transferred into desiccators and allowed to cool down at room temperature. Then the final weight of sample was taken. The average weight of five hills was considered as dry matter hill^{-1}.

3.5.6 Effective tillers hill^{-1}(no.)

The total number of effective tillers hill^{-1} was counted as the number of panicle bearing plant hill^{-1}. Data on effective tillers hill^{-1} was counted from 5 randomly selected hills from inner side of the plot and the average value was recorded.

3.5.7 Non-effective tillers hill^{-1}(no.)

The number of non-effective tillers hill^{-1} was counted as the number of non panicle bearing plant hill^{-1}. Data on non-effective tillers hill^{-1} was counted from 5 randomly selected hills from inner side of the plot and the average value was recorded.

3.5.8 Total tillers hill^{-1}(no.)

Total number of tillers hill^{-1} was counted as the number of effective tillers hill^{-1} and non-effective tillers hill^{-1}. Data on total tillers hill^{-1} was counted from 5 selected hills and average value was recorded.

3.5.9 Panicle length (cm)

Panicle length was measured with a meter scale from the panicles of 5 randomly selected plants and the average value was recorded as panicle length.

3.6 Grains panicle^{-1} (no.)

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

3.6.1 Weight of 1000-grains (g)

One thousand grains were counted randomly from the total cleaned harvested seeds from each plot and then weighted in grams to have weight of 1000-grains.

3.6.2 Grain yield (t ha^{-1})

The dry weight of grains from central 3 m^{-2} areas was taken from each plot and finally converted them to t ha^{-1}. The grains weight was adjusted with 14% moisture basis.

3.6.3 Straw yield (t ha^{-1})

The dry weight of straw of central 3 m^{-2} areas from each plot was recorded and finally converted to t ha^{-1}.

3.6.4 Weed dry matter weight (gm^{-2})

Weed dry matter weight (gm^{-2}) was recorded at 20, 35 and 50 DAT. collected data was recorded as one metere square area from treated and untreated plot.

3.6.5 Harvest index (%)

The harvest index were calculated on the ratio of economic yield (grain yield) to biological yield and expressed in terms of percentage. It was calculated by using the following formula (Gardner *et al*., 1985).

$$\text{Harvest index (\%)} = \frac{\text{Economic yield (grain weight)}}{\text{Biological yield (grain+straw weight)}} \times 100$$

3.6.6 Weed control efficiency (%)

Weed control efficiency was calculated on the ratio of weed dry matter weight (g m^{-2}) of treated plot to weed dry matter weight (g m^{-2}) of control plot and expressed in terms of percentage. It was calculated by using the following formula (Patel *et al*., 1987).

$$\text{WCE (\%)} = \frac{\text{WDM weight (g m}^{-2}\text{) in weedy check} - \text{WDM weight (g m}^{-2}\text{) in treated plot}}{\text{WDM in weedy check}} \times 100$$

3.6.7 Relative density (%)

The relative density of weed was caculated by using following formula

$$\text{Relative density} = \frac{\text{Absolute density of one species}}{\text{Population density of weed}} \times 100$$

3.6.8 Statistical analysis

The collected data on each plot were statistically analyzed to obtain the level of significance using the computer based software MSTAT-C devolved by Russel (1986). Mean differences among the treatments were tested with the least significant difference (LSD) test at 5% level of significance.

CHAPTER 4

RESULTS AND DISCUSSION

This chapter comprised with presentation and discussion of the results obtained from the study to observe the effect of nitrogen and weed management on growth, yield and yield attributes of Aman variety BRRI dhan46. The effects of nitrogen and weed management on all the studied parameters have been presented in Table 1 to Table 28 and Figure 1 to Figure 7. Summary of mean square values at different parameters are also given at in appendices from I to IX

4.1 Growth performance

4.1.1 Plant height (cm)

4.1.1.1 Effect of nitrogen doses

Plant height differed significantly due to the effect of nitrogen doses at all sampling dates (Table 1). At harvesting stage, the tallest (100.70 cm) plant was recorded from the 50 % higher nitrogen than recommended dose (N_5) while lowest plant height (88.11 cm) was recorded from the 50 % lower nitrogen (N_1) than recommended dose of nitrogen. At 20, 40, 60 and 80 DAT, the trends of plant height were observed which was similar to the harvesting time sampling. Meena *et al*. (2003), Sahrawat *et al*. (1999) and Thakur (1993) also reported that higher plant height with the higher dose of nitrogen.

Table 1. Effect of nitrogen doses on plant height (cm) of rice at different days after transplantation

Nitrogen doses	Plant height (cm) at different DAT				
	20	40	60	80	At harvest
N_1	33.72	56.30	69.45	80.16	88.11
N_2	34.76	58.89	74.61	83.69	91.44
N_3	35.36	58.60	76.40	87.30	95.68
N_4	36.24	63.40	77.65	89.65	98.15
N_5	37.23	63.55	78.41	91.24	100.70
LSD0.05	2.04	2.67	2.90	4.85	6.22
CV (%)	5.30	4.08	3.55	5.17	6.03

N_1= 50 % lower nitrogen than recommended dose, N_2= 25 % lower nitrogen than recommended dose, N_3 =Recommended dose of nitrogen, N4= 25 % higher nitrogen than recommended dose and N_5= 50 % higher nitrogen than recommended dose.

4.1.1.2 Effect of weed management

The plant height (cm) differed significantly among the different weed management methods for all sampling dates except 20 DAT (Table 2). Hand weeding treatment (W_2) showed the tallest plant for all the sampling dates (36.2, 61.27, 77.30, 91.51 and 99.7 cm for 20, 40, 60 and 80 DAT and at harvest respectively. Weeding done with Japanese rice weeder showed the second highest plant height for all sampling dates.

Table 2. Effect of weed management methods on plant height of rice at different days after transplantation

Weed management methods	**Plant height (cm) at different DAT**				
	20	**40**	**60**	**80**	**At harvest**
W_1	34.35	57.65	72.31	81.51	90.3
W_2	36.12	61.27	77.30	91.51	99.7
W_3	35.91	61.50	76.32	86.21	94.5
$LSD_{0.05}$	2.04	1.76	3.60	3.39	4.40
CV (%)	6.75	8.55	6.27	5.15	6.08

W_1= Control (No weeding), W_2= Hand weeding and W_3= Japanese rice weeder

4.1.1.3 Interaction effect of nitrogen and weed management method

Plant height (cm) did not differ significantly due to the interaction of nitrogen doses and weed management methods at all sampling dates (Table 3). It was found that plant height ranged from (38.26cm) in the combination $N_5 \times W_3$ to (33.10cm) in the combination $N_1 \times W_1$ at 20 DAT. At 40 DAT, the combination $N_4 \times W_3$ had the maximum plant height (64.31cm) while $N_3 x W_1$ had the minimum plant height (52.28cm). Plant height ranged from 65.40 cm to 80.62 cm at 60 DAT. The combination of $N_5 \times W_2$ had the maximum plant height and $N_1 \times W_1$ had the minimum. Plant height ranged from (76.3cm) in $N_1 \times W_1$ combination to (96.3cm) in $N_5 \times W_2$ combination. At harvest $N_5 \times W_2$ combination gave the maximum plant height (106.56 cm) and $N_1 \times W_1$ combination gave the minimum plant height (86.10cm).

Table 3. Interaction effects of nitrogen doses and weed management methods on plant height at different days after transplantation

Interaction (Nitrogen doses × weed management methods)	Plant height (cm) at different DAT				
	20	40	60	80	At harvest
$N_1 \times W_1$	33.10	55.17	65.40	76.3	86.10
$N_1 \times W_2$	34.54	56.40	71.71	84.0	90.10
$N_1 \times W_3$	33.52	57.33	71.29	80.2	88.03
$N_2 \times W_1$	33.50	56.46	71.64	78.4	86.87
$N_2 \times W_2$	34.73	60.22	76.81	90.2	96.10
$N_2 \times W_3$	36.04	59.96	75.40	82.4	91.40
$N_3 \times W_1$	34.31	52.28	74.10	83.0	90.43
$N_3 \times W_2$	36.52	61.20	77.81	91.7	102.80
$N_3 \times W_3$	35.24	62.19	77.30	87.2	93.83
$N_4 \times W_1$	35.06	61.58	75.33	83.6	93.10
$N_4 \times W_2$	37.16	64.29	79.44	95.4	102.86
$N_4 \times W_3$	36.49	64.31	78.17	89.9	98.50
$N_5 \times W_1$	35.78	62.74	75.11	86.2	94.84
$N_5 \times W_2$	37.65	64.21	80.62	96.3	106.56
$N_5 \times W_3$	38.26	63.71	79.51	91.3	100.70
$LSD_{0.05}$	NS	NS	NS	NS	NS
CV (%)	6.75	8.55	6.27	5.15	6.80

NS= Non significant; N_1 = 50 % lower nitrogen than recommended dose, N_2 = 25 % lower nitrogen than recommended dose N_3 = Recommended dose of nitrogen, N_4 = 25 % higher nitrogen than recommended dose and N_5 = 50 % higher nitrogen than recommended dose; W_1= Control (No weeding), W_2= Hand weeding and W_3= Japanese rice weeder

4.1.2 Tillers hill^{-1}(no.)

4.1.2.1 Effect of nitrogen doses

Total tillers number hill^{-1} was significantly influenced by the variation of nitrogen doses at different sampling dates (Table 4). The highest number of tillers hill^{-1}(16.10) was obtained at 65 DAT with the application of 50% higher nitrogen than the recommended dose (N_5) which was statistically similar to the recommended dose of nitrogen (N_3) and 25 % higher than the recommended dose (N_4). The lowest number of tillers hill^{-1} (11.29) was obtained from the 50 % lower dose of nitrogen than the recommended dose (N_1). At 20, 35 and 50 DAT the trend of tillers number hill^{-1} was similar as observed in 65 DAT.

Table 4. Effect of nitrogen doses on total tiller number hill^{-1} of rice at different days after transplantation

Nitrogen doses	Total tiller number hill^{-1} at different DAT			
	20	35	50	65
N_1	4.03	7.94	9.76	11.29
N_2	4.51	9.52	12.74	13.45
N_3	5.65	10.41	13.73	15.00
N_4	5.74	11.50	13.80	15.96
N_5	6.00	11.65	13.84	16.10
$LSD_{0.05}$	1.45	0.539	1.85	2.013
CV (%)	3.80	4.86	13.31	12.90

N_1 = 50 % lower nitrogen than recommended dose, N_2 = 25 % lower nitrogen than recommended dose, N_3 = Recommended dose of nitrogen, N_4= 25 % higher nitrogen than recommended dose and N_5 = 50 % higher nitrogen than recommended dose

4.1.2.2 Effect of weed management methods

The production of tillers hill^{-1} was significantly influenced by the different weeding method (Table 5). The total tillers number hill^{-1} was increased with the advances of sampling dates. The highest tillers number hill^{-1} (15.50) was obtained from the hand weeding treatment (W_2) at 65 DAT which was significantly different from others. The lowest number of tillers hill^{-1} (13.47) was obtained from the control treatment (W_1) which was statistically similar to the Japanese rice weeder treatment (W_3) for the same DAT. At all sampling dates hand weeding treatments performed best in respect of tiller production hill^{-1} except 20 DAT. The trend of tillers number hill^{-1} in earlier stages was similar to 65 DAT sampling.

Table 5. Effect of weed management methods on total tiller number hill^{-1} of rice at different days after transplantation

Weed management methods	Total tiller number hill^{-1} at different DAT			
	20	35	50	65
W_1	5.50	9.45	12.01	13.47
W_2	5.10	10.91	13.56	15.50
W_3	5.00	10.24	12.75	14.10
$LSD_{0.05}$	0.267	0.478	1.20	1.27
CV (%)	6.76	6.14	12.29	11.61

W_1= Control (No weeding), W_2 = Hand weeding and W_3 = Japanese rice weeder

4.1.2.3 Interaction effect of nitrogen and weed management methods

The result revealed that there were not significant variation due to the interaction effect of nitrogen and weeding levels in terms of total tillers number hill^{-1} at different

DAT (Fig.1). Numerically, tiller production hill^{-1} showed an increasing trend from the first sampling date (20 DAT) and this trend continued upto 65 DAT for all interactions. After 65 DAT tiller production showed a decreasing trend and it continued upto harvesting for all interactions. Among the interactions, $N_5 \times W_2$ showed the maximum tillers hill^{-1} at 65 DAT. The interaction of $N_1 \times W_1$ showed the lowest tiller hill^{-1} for all sampling dates.

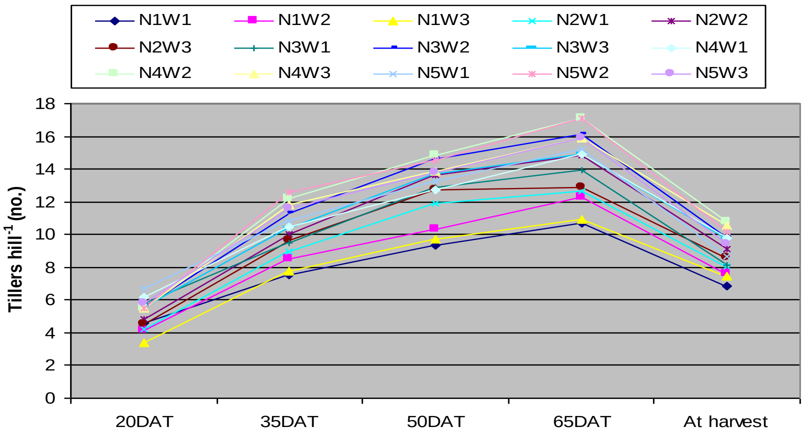


Figure 1. Number of total tollers hill^{-1} of T. Aman rice as influenced by the interaction 0f nitrogen doses and weed management methods

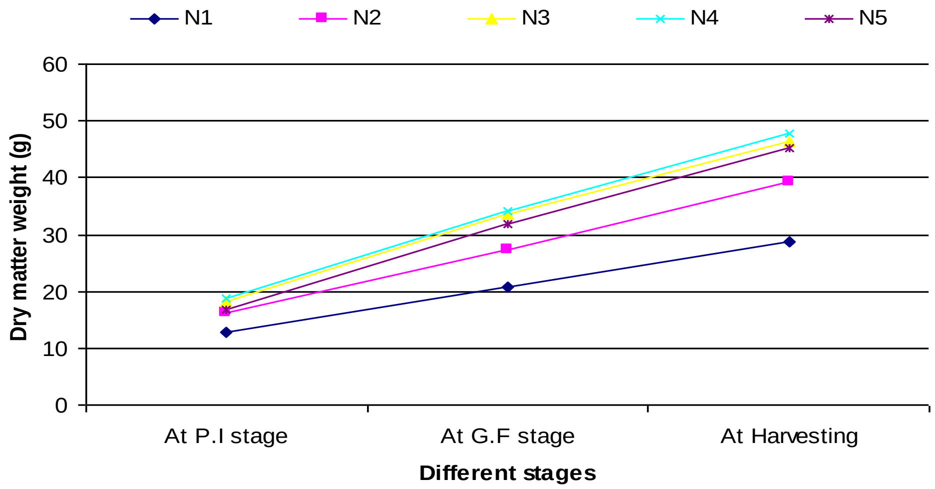
N_1 = 50 % lower nitrogen than recommended dose, N_2 = 25 % lower nitrogen than recommended dose, N_3 = Recommended dose of nitrogen, N_4= 25 % higher nitrogen than recommended dose and N_5 = 50 % higher nitrogen than recommended dose, W_1= Control (No weeding), W_2= Hand weeding and W_3= Japanese rice weeder

Figure 1. Number of tillers hill^{-1} of T. Aman rice as influenced by the the interaction of nitrogen doses and weed management methods

4.1.3 Dry matter weight hill^{-1} (gm)

4.1.3.1 Effect of nitrogen doses

Significant variation was observed on the dry matter weight hill^{-1} due to the effect of nitrogen doses for all growth stages (Fig. 2). Nitrogen application at 25 % higher nitrogen than the recommended dose (N_4) produced the highest dry matter weight (18.81, 34.01 and 47.75 for panicle initiation, grain filling and at harvesting stages respectively). Second highest dry matter weight was observed with N_3 treatment for all sampling stages. However, the lowest weight was found with N_1 treatment for all sampling stages.



N_1 = 50 % lower nitrogen than recommended dose, N_2 = 25 % lower nitrogen than recommended dose, N_3 = Recommended dose of nitrogen, N_4= 25 % higher nitrogen than recommended dose and N_5 = 50 % higher nitrogen than recommended dose

Figure 2. Effect of nitrogen doses on dry matter production hill^{-1} at different growth stages

4.1.3.2 Effect of weed management methods

Dry matter weight hill^{-1} was significantly differed due to the effect of different weed management methods at all sampling stages (Table 6). The dry matter weight (g) hill^{-1} was found the highest in hand weeding treatment (W_2) which was statistically at par with Japanese rice weeder (W_3) at all sampling stages. Control treatment showed the lowest dry matter (14.99, 26.02 and 39.14 g respectively at panicle initiation, grain filling and harvesting stages respectively.

Table 6. Effect of weed management methods on dry matter weight (g) hill^{-1} at different growth stages

Weed management methods	Dry matter wt. (g) hill^{-1} at different growth stages		
	At panicle initiation stage	Grain filling stage	At harvesting stage
W_1	14.99	26.02	39.14
W_2	17.60	31.53	43.10
W_3	17.21	30.93	42.22
$LSD_{0.05}$	0.995	2.13	1.87
CV (%)	7.87	9.47	5.92

W_1= Control (No weeding), W_2= Hand weeding and W_3= Japanese rice weeder

4.1.3.3 Interaction effect of nitrogen doses and weeds management method

Dry matter weight hill^{-1} at different days after transplantation (DAT) showed non significant variation due to interaction effect of nitrogen doses and weeding methods (Table 7). However, numerically maximum dry matter was recorded from the $N_4 \times W_2$ combination and minimum dry matter was recorded from $N_1 \times W_1$ at panicle initiation stage. The combination $N_4 \times W_2$ also produced maximum dry matter hill^{-1} at grain filling and harvesting stages. The $N_1 \times W_1$ had the minimum dry matter hill^{-1} at these stages.

Table 7. Interaction effect of nitrogen doses and weed management methods on dry matter weight hill^{-1} at different growth stages

Interaction (Nitrogen doses × weed management methods)	Dry matter wt. (g) hill^{-1} at different growth stages		
	At panicle initiation stage	Grain filling stage	At harvesting stage
$N_1 \times W_1$	11.55	16.72	25.73
$N_1 \times W_2$	13.75	22.87	30.43
$N_1 \times W_3$	13.48	22.50	30.18
$N_2 \times W_1$	14.81	22.66	36.70
$N_2 \times W_2$	16.87	30.38	40.41
$N_2 \times W_3$	17.05	29.24	40.31
$N_3 \times W_1$	16.35	30.76	44.71
$N_3 \times W_2$	19.56	35.07	47.75
$N_3 \times W_3$	18.47	34.60	46.99
$N_4 \times W_1$	16.45	31.27	45.77
$N_4 \times W_2$	20.40	35.56	49.54
$N_4 \times W_3$	19.59	35.22	47.91
$N_5 \times W_1$	15.76	28.68	42.78
$N_5 \times W_2$	17.40	33.77	47.18
$N_5 \times W_3$	17.45	33.12	45.74
$LSD_{0.05}$	NS	NS	NS
CV (%)	7.87	9.47	5.92

NS= Non significant; N_1 =50 % lower nitrogen than recommended dose, N_2 = 25 % lower nitrogen than recommended dose, N_3 = Recommended dose of nitrogen, N_4 = 25 % higher nitrogen than recommended dose and N_5 = 50 % higher nitrogen than recommended dose; W_1= Control (No weeding), W_2= Hand weeding and W_3= Japanese rice weeder

4.1.4 Dry matter wt. of weed (g) m^{-2}

4.1.4.1 Effect of nitrogen

The dry matter weight of weed (g m^{-2}) differed significantly due to the effect of nitrogen doses at different sampling dates after transplantation (Table 8). Dry matter wt. (g) of weed increased with the increasing rate of nitrogen than the lower as well as recommended dose at all sampling dates. The highest weed dry matter weight. (49.62 g m^{-2}) was found from the 50 % higher dose than the recommended dose (N_5) at 20 DAT which was significantly different from other lower doses. At later stages similar trends was observed incase of weed dry matter weight of weed m^{-2}.

Table 8. Effect of nitrogen doses on dry matter weight of weed at different days after transplantation

Nitrogen doses	Dry matter weight of weed (g m^{-2}) at different DAT		
	20	35	50
N_1	39.02	32.65	25.33
N_2	42.04	33.14	27.69
N_3	43.74	37.28	32.50
N_4	46.83	39.41	34.62
N_5	49.62	40.52	35.74
$LSD_{0.05}$	2.54	3.12	2.13
CV (%)	5.28	7.83	6.29

N_1 = 50 % lower nitrogen than recommended dose, N_2 = 25 % lower nitrogen than recommended dose, N_3 = Recommended dose of nitrogen, N_4 = 25 % higher nitrogen than recommended dose, N_5 = 50 % higher nitrogen than recommended dose.

4.1.4.2. Effect of weed management methods

Dry matter wt. of weed (g m^{-2}) differed significantly among the different weeding methods except 20 DAT (Table 9). At 50 DAT the highest weed dry matter weight (69.24 g) of weed m^{-2} was obtained from the control treatment (W_1) which was significantly different from others. The lowest dry matter weight (11.74 g) of weed m^{-2} was obtained from the hand weeding treatment (W_2) which was statistically similar to the Japanese rice weeder treatment (W_3). At 35 DAT the trend of dry matter weight of weed m^{-2} was similar as observed in 50 DAT.

Table 9. Effect of weed management methods on dry matter weight of weed at different days after transplantation

Weed management methods	Dry matter wt. of weed (g m^{-2}) at different DAT		
	20	**35**	**50**
W_1	44.27	58.70	69.24
W_2	44.51	24.87	11.74
W_3	43.98	26.24	12.53
$LSD_{0.05}$	NS	2.05	2.52
CV (%)	7.16	7.37	10.63

NS= Non significant; W_1= Control (No weeding), W_2= Hand weeding and W_3= Japanese rice weeder

Table 10. Interaction effect of nitrogen doses and weed management methods on dry matter weight (g m^{-2}) of weed at different days after transplantation

Interaction (Nitrogen doses × weed management methods)	Dry matter weight of weed (g m^{-2}) at different DAT		
	20	**35**	**50**
$N_1 \times W_1$	39.33	54.66	62.19
$N_1 \times W_2$	40.12	20.73	6.65
$N_1 \times W_3$	37.60	22.55	7.15
$N_2 \times W_1$	42.54	55.19	65.38
$N_2 \times W_2$	41.80	21.09	8.48
$N_2 \times W_3$	41.80	23.13	9.20
$N_3 \times W_1$	42.06	59.00	71.31
$N_3 \times W_2$	44.96	25.19	13.22
$N_3 \times W_3$	44.20	27.65	12.90
$N_4 \times W_1$	46.67	61.52	72.87
$N_4 \times W_2$	45.85	28.54	14.36
$N_4 \times W_3$	47.98	28.17	16.64
$N_5 \times W_1$	50.76	63.08	74.46
$N_5 \times W_2$	49.81	28.79	15.98
$N_5 \times W_3$	48.29	29.70	16.77
$LSD_{0.05}$	5.40	4.60	5.64
CV (%)	7.16	7.37	10.63

N_1 = 50 % lower nitrogen than recommended dose, N_2 = 25 % lower nitrogen than recommended dose, N_3 = Recommended dose of nitrogen, N_4 = 25 % higher nitrogen than recommended dose, N_5 = 50 % higher nitrogen than recommended dose; W_1= Control (No weeding), W_2= Hand weeding and W_3= Japanese rice weeder

4.1.4.3 Interaction effect of nitrogen doses and weed management methods

Dry matter weight of weed at different days after transplanting exerted significant differences among the treatment combination (Table 10).The combination of $N_5 \times W_1$ (50% higher nitrogen × no weeding) showed the higher dry weight of weed m^{-2} (50.76, 63.08 and 74.46 g respectively for 20, 35 and 50 DAT) for all sampling dates. For 35 and 50 DAT, the lowest dry weight of weed m^{-2} was found in the combination of $N_1 \times W_2$ comprised with 25% higher nitrogen and hand weeding.

4.1.5 Weed density m^{-2} and weed control efficiency (%)

Weed density (m^{-2}) was greater in the unwedded plot than the treated plot both at 35 and 50 DAT (Table 11). Similar results were also observed by Mitra *et al* (2005) and Ahmed *et al.* (1997). Hand weeding treatment (W_2) at 35 DAT more effectively reduced weed number than Japanese rice weeder treatment (W_3). The weed density was reduced 88-92 % in the treated plot than control. The highest weed control efficiency (70.5 %) was observed from the hand weeding treatment (W_2) than using Japanese rice weeder treatment (W_3)

Table 11. Weed density and weed control efficiency as affected by different weed management methods

Treatments	Weed density (no. m^{-2})		Weed control efficiency (%)	
	35 DAT	50 DAT	35 DAT	50 DAT
W_1	169	192	0.00	0.00
W_2	12	10	58.00	83.04
W_3	19	17	55.30	82.00

W_1= Control (no weeding), W_2= Hand weeding and W_3= Japanese rice weeder

4.1.6 Weed infestation rate (%)

The rice field was infested with different weed species and their infestation rate was also different (Table 12). At 35 DAT, 9 weed species of different families were observed from the untreated and treated plot. The weed species *Sagittaria guyanesis* was observed most dominant species followed by the *Fimbristylis miliacea* and *Sphenoclea zelanica.* AT 50 DAT *Cynodon dactylon, Polygonum hydropiper,* *Cyperus difformis, Commelina benghalensis* species emerged in the field but frequency was low.

Table 12. Relative weed density (%) of different weed species in the untreated and treated plot at two different stages after transplanting of T. Aman rice

Weed species	Relative density (%)	
	35 DAT	**50 DAT**
Cynodon dactylon	0.00	1.89
Polygonum hydropiper	4.23	1.53
Sphenoclea zelanica	18.23	15.63
Cyperus difformis	3.45	2.36
Monochoria vaginalis	2.03	7.21
Sagittaria guyanesis	34.60	10.92
Enhydra fluctuans	6.30	21.54
Commelina benghalensis	5.22	4.23
Echinochloa colona	5.86	19.42
Fimbristylis miliacea	20.56	16.23

4.2 Yield contributing characters of T. Aman rice

4.2.1 Effective tillers hill^{-1}

4.2.1.1 Effect of nitrogen doses

Effective tillers hill^{-1} was increased with the increases of nitrogen doses (Table 13). The highest number of effective tillers hill^{-1} (10.34) was obtained from the 50 % higher nitrogen than recommended dose (N_5) treatment which was statistically similar to the recommended dose of nitrogen (N_3) and 25% higher nitrogen than the recommended dose (N_4). The lowest number of effective tillers hill^{-1} was obtained from the 50% lower nitrogen than the recommended dose. Hari *et al.* (1997), Thakur (1991) and Tanaka *et al*. (1964) also reported the similar result that increasing the level of nitrogen increased the level of effective tillers hill^{-1}.

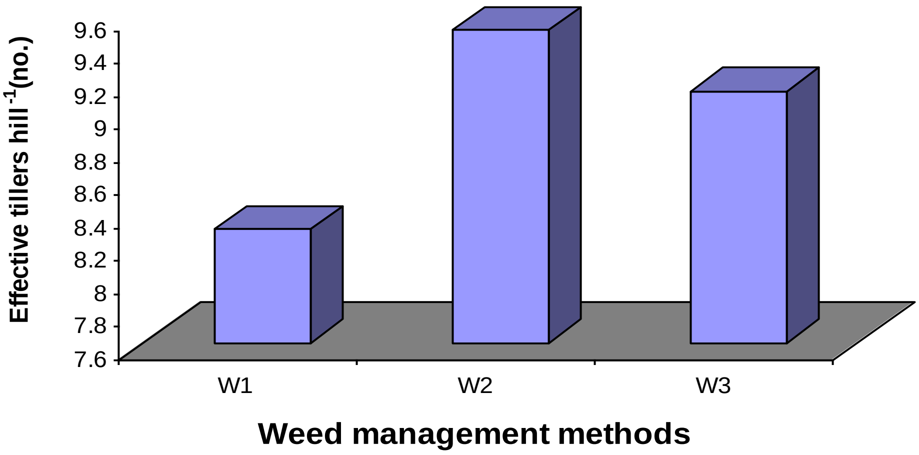
Table 13. Effect of nitrogen doses on effective tiller hill^{-1} of T. aman rice

Nitrogen doses	Effective tillers hill^{-1}(no.)
N_1	7.31
N_2	8.60
N_3	9.21
N_4	9.41
N_5	10.34
$LSD_{0.05}$	1.15
CV(%)	11.76

N_1 = 50 % lower nitrogen than recommended dose, N_2 = 25 % lower nitrogen than recommended dose, N_3 = Recommended dose of nitrogen, N_4 = 25 % higher nitrogen than recommended dose, N_5 = 50 % higher nitrogen than recommended dose

4.2.1.2 Effect of weed management method

The number of effective tillers hill^{-1} differed significantly due to the effect of weed management methods (Fig 3). Hand weeding treatment (W_2) produced the highest number of tillers hill^{-1} (9.50) which was statistically at par with Japanese rice weeder treatment (W_3). Control treatment (W_1) produced the lowest number of tillers hill^{-1}.



W_1= Control (no weeding), W_2= Hand weeding and W_3= Japanese rice weeder

Figure 3. Effect of weed management methods on the number of effective tillers hill^{-1}

4.2.1.3 Interaction effect of nitrogen and weed management

Interaction of nitrogen dose and weeding method was significant in respect of production of effective tillers hill^{-1} of rice (Table 14). Numerically, interaction of $N_5 \times W_2$ showed the highest value (10.75) of effective tillers hill^{-1} that was statistically similar to the $N_4 \times W_2$, $N_5 \times W_3$, $N_3 \times W_2$, $N_3 \times W_3$ combination and that of lowest (6.86) was obtained from the interaction of $N_1 \times W_1$.

Table 14. Interaction effect of nitrogen doses and weed management methods on effective tillers hill^{-1} (no.) of T. aman rice

Interaction (N doses × weed management methods)	Effective tillers hill^{-1}(no.)
N_1 × W_1	6.86
N_1 × W_2	7.64
N_1 × W_3	7.44
N_2 × W_1	8.04
N_2 × W_2	9.14
N_2 × W_3	8.62
N_3 × W_1	8.16
N_3 × W_2	9.78
N_3 × W_3	9.70
N_4 × W_1	8.66
N_4 × W_2	10.18
N_4 × W_3	9.41
N_5 × W_1	9.76
N_5 × W_2	10.75
N_5 × W_3	10.51
$LSD_{0.05}$	1.22
CV (%)	7.96

N_1 = 50 % lower nitrogen than recommended dose, N_2 = 25 % lower nitrogen than recommended dose, N_3 = Recommended dose of nitrogen, N_4 = 25 % higher nitrogen than recommended dose and N_5= 50 % higher nitrogen than recommended dose; W_1= Control (No weeding), W_2= Hand weeding and W_3= Japanese rice weeder

4.2.2 Panicle length (cm)

4.2.2.1 Effect of nitrogen

The panicle length showed an increasing trend with the increasing level of nitrogen (Table 15). The longest panicle (24.04 cm) was found in 50 % higher nitrogen the recommended dose (N_5) treatment, whereas the shortest panicle length (21.60 cm) was obtained from the 50% lower dose of nitrogen than the recommended dose. The result corroborates with the findings of Ebaid and Ghanem (2000), Azad *et al.* (1995) and Idris and Main (1990) who reported that length of panicle was highly related with the application of increased level of nitrogen.

Table 15. Effect of nitrogen doses on panicle length of T. aman rice

Nitrogen doses	Panicle length (cm)
N_1	21.60
N_2	22.51
N_3	23.11
N_4	23.50
N_5	24.04
$LSD_{0.05}$	1.51
CV(%)	6.10

N_1 = 50 % lower nitrogen than recommended dose, N_2 = 25 % lower nitrogen than recommended dose, N_3 = Recommended dose of nitrogen, N_4 = 25 % higher nitrogen than recommended dose, N_5 = 50 % higher nitrogen than recommended dose

4.2.2.2 Effect of weeding

The weed management method did not show significant difference of panicle length (Table 16). The longer panicle was found from the hand weeding treatment (W_2).

Table 16. Effect of weed management methods on panicle length of T. Aman rice

Weed management methods	Panicle length (cm)
W_1	22.10
W_2	23.60
W_3	23.13
$LSD_{0.05}$	NS
CV(%)	12.48

NS= Non significant; W_1= Control (No weeding), W_2= Hand weeding and W_3= Japanese rice weeder

4.2.2.3 Interaction effect of nitrogen doses and weeds management methods

Interaction effect of nitrogen levels and weed control methods exerted no significant variation on the panicle length (Table 17). Hand weeding method with any nitrogen levels had the higher panicle length while no weeding (control) with any nitrogen levels had the lower panicle length.The results revealed that hand weeding 50% higher nitrogen than the recommended dose produced the maximum panicle length and no weeding (control) with 50% lower nitrogen than the recommended dose produced the minimum panicle length.

Table 17. Interaction effect of nitrogen doses and weed management methods on panicle length of T. aman rice

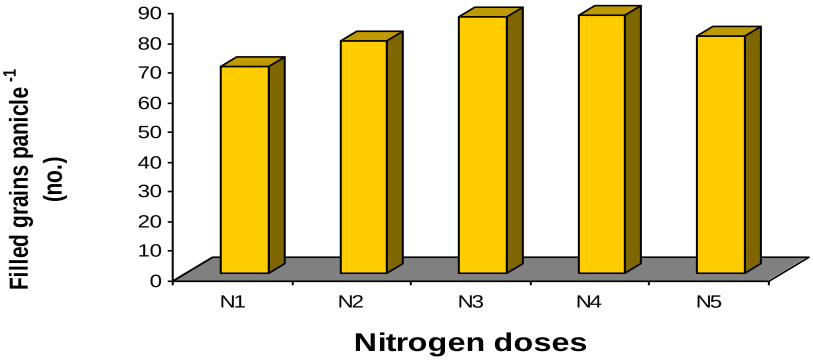
Interaction (N doses × weed management methods)	Panicle length (cm)
$N_1 \times W_1$	20.33
$N_1 \times W_2$	22.31
$N_1 \times W_3$	22.14
$N_2 \times W_1$	21.88
$N_2 \times W_2$	22.90
$N_2 \times W_3$	22.74
$N_3 \times W_1$	22.70
$N_3 \times W_2$	23.53
$N_3 \times W_3$	23.14
$N_4 \times W_1$	22.91
$N_4 \times W_2$	24.10
$N_4 \times W_3$	23.54
$N_5 \times W_1$	22.56
$N_5 \times W_2$	25.47
$N_5 \times W_3$	24.10
$LSD_{0.05}$	NS
CV(%)	12.48

NS= Non significant; N_1 = 50 % lower nitrogen than recommended dose, N_2 = 25 % lower nitrogen than recommended dose, N_3 = Recommended dose of nitrogen, N_4 = 25 % higher nitrogen than recommended dose and N_5= 50 % higher nitrogen than recommended dose; W_1= Control (No weeding), W_2= Hand weeding and W_3= Japanese rice weeder

4.2.3 Filled grains panicle^{-1} (no.)

4.2.3.1 Effect of nitrogen

Nitrogen had the significant influence on the number of grains panicle^{-1} (Fig 4). The figure showed that number of filled grains panicle^{-1} was increased with the increased levels of nitrogen up to 25 % higher nitrogen than the recommended dose (N_4). Further increase of nitrogen dose reduced the grains panicle^{-1}. However, the highest number of filled grains panicle^{-1}(87.19) was recorded from the 25% higher nitrogen than the recommended dose (N_4). The lowest number of filled grain panicle^{-1} (69.88) was obtained from the 50% lower nitrogen the recommended dose (N_1). Decreased the number of filled grains panicle^{-1} with higher level of nitrogen might be due to the lodging of the plant. Kumar *et al.* (1995) and Thakur and Singh (1987) also reported that increasing the level of nitrogen significantly increased the number of filled grains panicle^{-1}.

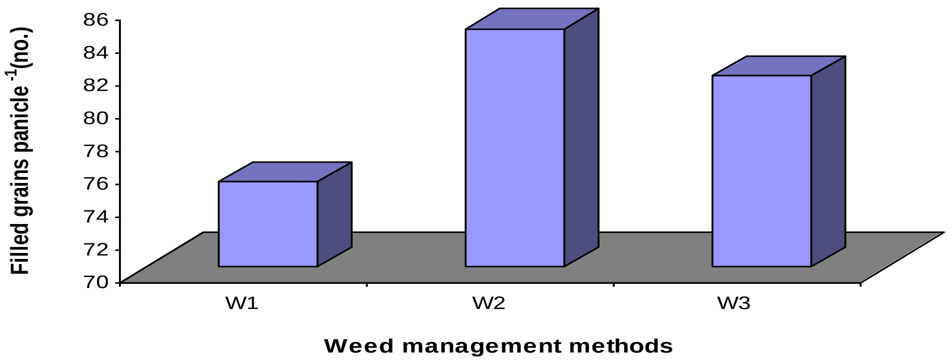


N_1 = 50 % lower nitrogen than recommended dose, N_2 = 25 % lower nitrogen than recommended dose,N_3 = Recommended dose of nitrogen, N_4 = 25 % higher nitrogen than recommended dose and N_5= 50 % higher nitrogen than recommended dose

Figure 4. Effect of nitrogen doses on the number of filled grains panicle^{-1}

4.2.3.2 Effect of weed management methods

Due to the effect of weed management methods filled grain panicle^{-1} also differed significantly (Fig. 5). Hand weeding treatment (W_2) produced the highest number of filled grains panicle^{-1} followed by the Japanese rice weeder treatment (W_3). The lowest grains panicle^{-1} was observed with control treatment (no weeding).



W_1= Control (No weeding), W_2= Hand weeding and W_3= Japanese rice weeder

Figure 5. Effect of weed management methods on number of filled grains panicle^{-1}

4.2.3.3 Interaction effect of nitrogen dose and weed management method

Filled grain panicle^{-1} had significant effect due to the interaction of nitrogen doses and weed management methods (Table 18). Filled grains panicle^{-1} ranged from 65.60 to 91.20. The interaction of $N_3 \times W_2$ showed the maximum filled grain panicle^{-1} that was statistically similar to the $N_3 \times W_3$, $N_4 \times W_2$ and $N_4 \times W_3$ respectively while the minimum was found in the interaction of $N_1 \times W_1$.

Table 18. Interaction effect of nitrogen doses and weed management methods on number of filled grains panicle^{-1} of T. aman rice

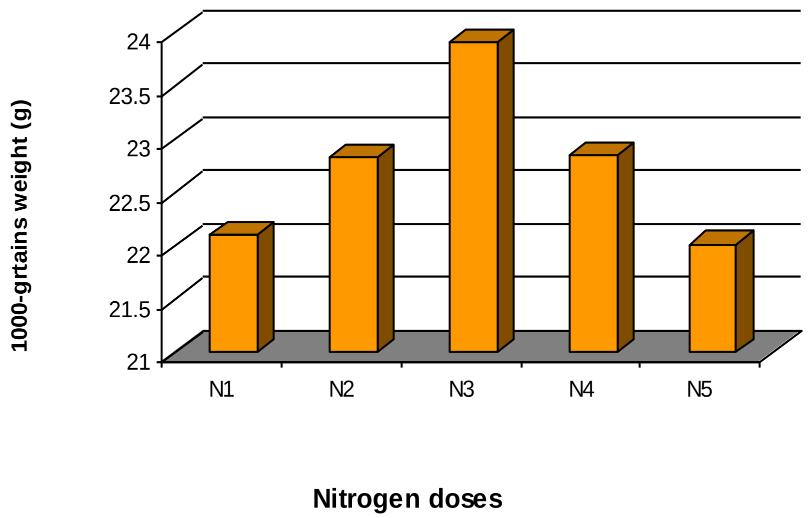
Interaction (N doses × weed management methods)	**No. of filled grains panicle^{-1}**
$N_1 \times W_1$	65.60
$N_1 \times W_2$	72.80
$N_1 \times W_3$	71.30
$N_2 \times W_1$	73.01
$N_2 \times W_2$	83.70
$N_2 \times W_3$	79.10
$N_3 \times W_1$	80.50
$N_3 \times W_2$	91.20
$N_3 \times W_3$	88.60
$N_4 \times W_1$	83.45
$N_4 \times W_2$	90.86
$N_4 \times W_3$	87.30
$N_5 \times W_1$	73.70
$N_5 \times W_2$	84.30
$N_5 \times W_3$	82.22
$LSD_{0.05}$	6.73
CV (%)	4.91

N_1 = 50 % lower nitrogen than recommended dose, N_2 = 25 % lower nitrogen than recommended dose, N_3 = Recommended dose of nitrogen, N_4 = 25 % higher nitrogen than recommended dose and N_5= 50 % higher nitrogen than recommended dose; W_1= Control (No weeding), W_2= Hand weeding and W_3= Japanese rice weeder

4.2.4 Thousand grain weight (g)

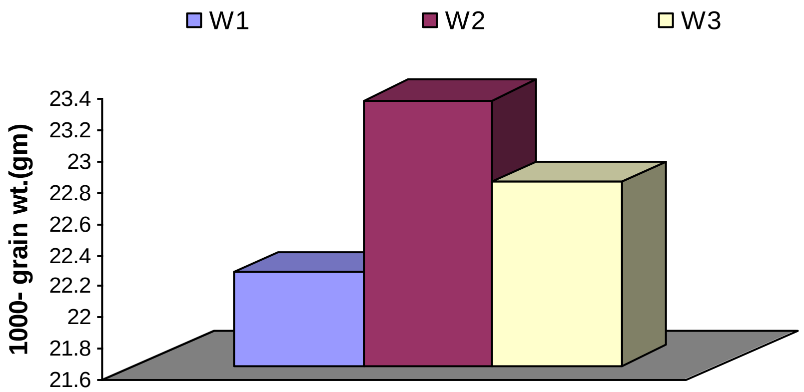
4.2.4.1 Effect of nitrogen

The weight of thoudand grains due to nitrogen doses have been presented in (Figure 6) that showed the maximum values of thousand seed weight (23.92g) with N_3 which was statistically at par with N_2 (25% lower nitrogen than recommended dose) and N_4 (25% higher nitrogen than recommended dose). The highest and lowest dose of nitrogen gave the lower and statistically similar values of thousand seed weight.



N_1 = 50 % lower nitrogen than recommended dose, N_2 = 25 % lower nitrogen than recommended dose, N_3 = Recommended dose of nitrogen, N_4 = 25 % higher nitrogen than recommended dose and N_5= 50 % higher nitrogen than recommended dose

Fig 6. Effect of nitrogen doses on the weight of 1000-grains of rice



W_1= Control (No weeding), W_2= Hand weeding and W_3= Japanese rice weeder

Fig 7. Effect of weed management methods on the weight of 1000 - grains of rice

4.2.4.2 Effect of weed management methods

Weed management methods exerted a significant effect on thousand grain weight of rice (Fig. 7). Hand weeding treatment (W_2) gave the highest 1000-grain weight (23.30 g) which was statistically similar to the Japanese rice weeder treatment (W_3). The control treatment (W_1) gave the lowest 1000-grain weight which was also statistically similar to the Japanese rice weeder treatment (W_3).

4.2.4.3 Interaction effect of nitrogen dose and weed management method

Thousand grain weights did not differ significantly due to the interaction effect of nitrogen levels and weed control methods (Table 19). Maximum 1000-grain weight was obtained from the $N_3 \times W_2$ while minimum 1000-grain weight was obtained from the $N_1 \times W_1$.

Table 19. Interaction effect of nitrogen doses and weed management methods on thousand grains weight of T. aman rice

Interaction (N doses × weed management methods)	1000-grain wt.(g)
$N_1 \times W_1$	21.32
$N_1 \times W_2$	22.80
$N_1 \times W_3$	22.14
$N_2 \times W_1$	22.24
$N_2 \times W_2$	23.20
$N_2 \times$ W3	23.10
$N_3 \times W_1$	23.40
$N_3 \times W_2$	24.54
$N_3 \times W_3$	23.90
$N_4 \times W_1$	22.60
$N_4 \times W_2$	23.23
$N_4 \times W_3$	22.74
$N_5 \times W_1$	21.42
$N_5 \times W_2$	22.56
$N_5 \times W_3$	22.10
$LSD_{0.05}$	NS
CV (%)	5.60

NS= Non significant; N_1 = 50 % lower nitrogen than recommended dose, N_2 = 25 % lower nitrogen than recommended dose, N_3 = Recommended dose of nitrogen, N_4 = 25 % higher nitrogen than recommended dose and N_5= 50 % higher nitrogen than recommended dose; W_1= Control (No weeding), W_2= Hand weeding and W_3= Japanese rice weeder

4.3 Yield

4.3.1 Grain yield (t ha^{-1})

4.3.1.1 Effect of nitrogen

Grain yield (t ha^{-1}) was significantly influenced by the different level of nitrogen doses (Table 20). The highest grain yield (5.34 t ha^{-1}) was obtained from the 25 % higher nitrogen than the recommended dose of nitrogen (N_4) which was statistically similar to the recommended dose of nitrogen (N_3). The result agreed with the findings of Zayed *et al*. (2005), Hari *et al*. (2000) and Singh and Pillai (1994) who reported that grain yield increased at certain increasing levels of nitrogen and after that the yield declined.

Table 20. Effect of nitrogen doses on grain yield of T. aman rice

Nitrogen doses	Grain yield (t ha^{-1})
N_1	2.88
N_2	3.91
N_3	5.30
N_4	5.34
N_5	4.22
$LSD_{0.05}$	0.14
CV(%)	3.01

N_1 = 50 % lower nitrogen than recommended dose, N_2 = 25 % lower nitrogen than recommended dose, N_3 = Recommended dose of nitrogen, N_4 = 25 % higher nitrogen than recommended dose and N_5 = 50 % higher nitrogen than recommended dose

4.3.1.2 Effect of weed management methods

Grain yield differed significantly due to the different weed management methods in rice (Table 21). The table showed that the highest yield was recorded from hand weeding method which was 4.65% and 26.88% higher than Japanese rice weeder and control respectively.

Table 21. Effect of weed management methods on grain yield of T. aman rice

Weed management methods	Grain yield (t ha^{-1})
W_1	3.73
W_2	4.73
W_3	4.52
$LSD_{0.05}$	0.20
CV(%)	6.15

W_1= Control (No Weeding), W_2= Hand weeding and W_3= Japanese rice weeder

4.3.1.3 Interaction effect of nitrogen doses and weed management methods

Interaction between nitrogen levels and weed control methods exhibited significant effect on grain yield (Table 22). Numerically grain yield increased in the weeded plot compared to control plot. Maximum grain yield (5.71 t ha^{-1}) was found in $N_3 \times W_2$ followed by $N_4 \times W_2$ (5.70 t ha^{-1}) and $N_4 \times W_3$ (5.50 t ha^{-1}) respectively. Minimum grain yield (2.13 t ha^{-1}) was obtained from $N_1 \times W_1$ combination. It was found that grain yield decreased with the maximum levels of nitrogen (N_5) beyond (N_4) with different weed control methods.

Table 22. Interaction effect of nitrogen doses and weed management methods on grain yield of T. aman rice

Interaction (Nitrogen doses × weed management methods)	Grain yield (t ha^{-1})
$N_1 \times W_1$	2.13
$N_1 \times W_2$	3.40
$N_1 \times W_3$	3.13
$N_2 \times W_1$	3.40
$N_2 \times W_2$	4.30
$N_2 \times$ W3	4.05
$N_3 \times W_1$	4.66
$N_3 \times W_2$	5.71
$N_3 \times W_3$	5.54
$N_4 \times W_1$	4.87
$N_4 \times W_2$	5.70
$N_4 \times W_3$	5.50
$N_5 \times W_1$	3.64
$N_5 \times W_2$	4.62
$N_5 \times W_3$	4.40
$LSD_{0.05}$	0.45
CV (%)	6.15

N_1=50%lower nitrogen than recommended dose, N_2=25 % lower nitrogen than recommended dose, N_3= Recommended dose of nitrogen, N_4 = 25 % higher nitrogen than recommended dose, N_5 = 50 % higher nitrogen than recommended dose; W_1= Control (No weeding), W_2= Hand weeding, W_3= Japanese rice weeder

4.3.2 Straw yield (t ha^{-1})

4.3.2.1 Effect of nitrogen

Straw yield varied significantly with the different doses of nitrogen (Table 23). The straw yield was significantly highest (6.31 t ha^{-1}) at 50 % higher nitrogen than the recommended dose of nitrogen (N_5) which was statistically similar to the 25% higher nitrogen than the recommended dose (N_4). The lowest straw yield was obtained from the 50% lower nitrogen than the recommended dose of nitrogen (N_1) treatment. Similar result was observed by Elbadry *et al.* (2004), Meena *et al.* (2003) and El-Rewainy (2002).

Table 23. Effect of nitrogen doses on straw yield of T. aman rice

Nitrogen doses	Straw yield (t ha^{-1})
N_1	4.22
N_2	5.16
N_3	5.75
N_4	6.03
N_5	6.31
$LSD_{0.05}$	0.482
CV(%)	8.10

N_1 = 50 % lower nitrogen than recommended dose, N_2 = 25 % lower nitrogen than recommended dose, N_3 = Recommended dose of nitrogen, N_4 = 25 % higher nitrogen than recommended dose and N_5 = 50 % higher nitrogen than recommended dose

4.3.2.2 Effect of weed management methods

Straw yield (t ha^{-1}) was influenced significantly by the different weed management methods (Table 24). The highest straw yield (5.89 t ha^{-1}) was obtained from the hand weeding treatment (W_2) which was significantly higher from other methods. The lowest straw yield was obtained from the control treatment.

Table 24. Effect of weed management methods on straw yield of T. aman rice

Weed management methods	Straw yield (t ha^{-1})
W_1	4.96
W_2	5.89
W_3	5.63
$LSD_{0.05}$	0.23
CV(%)	5.43

W_1= Control (No Weeding), W_2= Hand weeding and W_3= Japanese rice weeder

4.3.2.3 Interaction effect of nitrogen doses and weed management methods

There was significant variation among the treatment combinations in terms of straw yield due to the interaction of nitrogen levels and weed control methods (Table 25). The combination of $N_1 \times W_1$ gave the minimum straw yield while $N_5 \times W_2$ gave the maximum. Straw yield increased with the increasement of nitrogen levels at all weed control methods.

Table 25. Interaction effect of nitrogen doses and weed management methods on straw yield of T. aman rice

Interaction (Nitrogen doses ×weed management methods)	Straw yield (t ha^{-1})
$N_1 \times W_1$	3.43
$N_1 \times W_2$	4.80
$N_1 \times W_3$	4.43
$N_2 \times W_1$	4.58
$N_2 \times W_2$	5.60
$N_2 \times W_3$	5.30
$N_3 \times W_1$	5.40
$N_3 \times W_2$	6.00
$N_3 \times W_3$	5.90
$N_4 \times W_1$	5.54
$N_4 \times W_2$	6.34
$N_4 \times W_3$	6.21
$N_5 \times W_1$	5.90
$N_5 \times W_2$	6.70
$N_5 \times W_3$	6.34
$LSD_{0.05}$	0.51
CV (%)	5.43

N_1=50%lower nitrogen than recommended dose, N_2=25 % lower nitrogen than recommended dose, N_3= Recommended dose of nitrogen, N_4 = 25 % higher nitrogen than recommended dose, N_5 = 50 % higher nitrogen than recommended dose; W_1= Control (No weeding), W_2= Hand weeding, W3= Japanese rice weeder

Harvest index (%)

Table 26. Effect of nitrogen doses on harvest index of T. aman rice

Nitrogen doses	Harvest index (%)
N_1	40.34
N_2	43.29
N_3	47.90
N_4	47.00
N_5	39.90
$LSD_{0.05}$	1.45
CV(%)	3.05

N_1 = 50 % lower nitrogen than recommended dose, N_2 = 25 % lower nitrogen than recommended dose, N_3 = Recommended dose of nitrogen, N_4 = 25 % higher nitrogen than recommended dose and N_5 = 50 % higher nitrogen than recommended dose

4.3.3.1 Effect of nitrogen doses

Effect of nitrogen dose exerted significant variation on harvest index (Table 26). Harvest index was maximum (47.90 %) at recommended dose of nitrogen (N_3) followed by (47.00%) from the 25% higher nitrogen than the recommended dose of nitrogen (N_4) treatment. The lowest harvest index (39.87 %) was obtained from the 50% higher nitrogen than the recommended dose of nitrogen (N_5)

4.3.3.2 Effect of weed management methods

Harvest index influenced significantly by the different weed management methods (Table 27). The maximum hrvest index (44.30%) was obtained from the hand weeding treatment followed by the Japanese rice weeder treatment. The lowest harvest index (42.51%) was obtained from the control treatment (W_1).

Table 27. Effect of weed management methods on harvest index of T. aman rice

Weed management methods	Harvest index (%)
W_1	42.51
W_2	44.30
W_3	44.21
$LSD_{0.05}$	1.75
CV (%)	5.46

W_1= Control (No Weeding), W_2= Hand weeding and W_3= Japanese rice weeder

4.3.3.3 Interaction effect of nitrogen doses and weed management methods

Harvest index variation was not significant due to the combined effect of nitrogen levels and weed management methods (Table 28). The minimum harvest index (37.90%) was found in $N_5 \times W_1$ and maximum (48.73%) was in $N_3 \times W_2$. Comparatively higher harvest index (%) was attained in the nitrogen levels of N_2 to N_3 than N_1 and N_5.

Table 28. Interaction effect of nitrogen doses and weed management methods on harvest index of T. aman rice

Interaction (Nitrogen doses × weed management methods)	Harvest index (%)
$N_1 \times W_1$	38.27
$N_1 \times W_2$	41.33
$N_1 \times W_3$	41.43
$N_2 \times W_1$	43.20
$N_2 \times W_2$	43.40
$N_2 \times W_3$	43.30
$N_3 \times W_1$	46.50
$N_3 \times W_2$	48.73
$N_3 \times W_3$	48.47
$N_4 \times W_1$	46.77
$N_4 \times W_2$	47.30
$N_4 \times W_3$	46.87
$N_5 \times W_1$	37.90
$N_5 \times W_2$	40.10
$N_5 \times W_3$	41.00
$LSD_{0.05}$	NS
CV (%)	5.46

NS= Non significant; N_1=50 % lower nitrogen than recommended dose, N_2 = 25 % lower nitrogen than recommended dose, N_3= Recommended dose of nitrogen, N_4 = 25 % higher nitrogen than recommended dose, N_5 = 50 % higher nitrogen than recommended dose; W_1= Control (No weeding), W_2= Hand weeding, W_3= Japanese rice weeder

CHAPTER 5

SUMMARY AND CONCLUSION

The experiment was carried out at the Agronomy Farm, Sher-e-Bangla agricultural University, Dhaka - 1207 during the period from August to December 2008 in order to determine the suitable nitrogen doses and weeding methods to observe the growth performances and yield of T. Aman rice variety BRRI dhan46. The experiment comprises five doses of nitrogen viz. 50 % lower nitrogen than recommended dose, 25 % lower nitrogen than recommended dose, recommended dose of nitrogen, 25 % higher nitrogen than recommended dose, 50 % higher nitrogen than recommended dose and three weeding methods viz. Control (No weeding), hand weeding and weeding by Japanese rice weeder.

Results revealed that nitrogen doses and weed management methods had the significant effect on plant height at different days after transplanting. The tallest plants were observed in 50 % higher nitrogen than recommended dose of nitrogen treatment (N_5) for all sampling dates. At harvest the tallest plant (99.7 cm) was observed from the hand weeding treatment (W_2) and the shortest plant was observed from the control (no weeding) (W_1) treatment. Among the interactions of nitrogen doses and weed management method. 50 % higher nitrogen than recommended dose of nitrogen $N_5 \times$ hand weeding treatment (W_2) performed better incase of the tallest plant production.

The highest number of tillers hill^{-1} was produced by the 50 % higher nitrogen than the recommended dose of nitrogen (N_5) at 20, 35, 50 and 65 DAT. The lowest tillers hill^{-1} was produced from the no weeding treatment (W_1) for all sampling dates. The interaction of 50% higher nitrogen than the recommended dose of nitrogen (N_5) $\times$ hand weeding treatment (W_2) was found effective in producing higher tillers hill^{-1} at 65 DAT.

The maximum dry matter hill^{-1} (47.75 g) was weighed from 25 % higher nitrogen than the recommended dose of nitrogen (N_4) which was statistically similar to the recommended dose of nitrogen (N_3) (46.48 g). The highest dry weight hill^{-1} was obtained from the hand weeding treatment (W_2) followed by the Japanese rice weeder treatment (W_3) at harvesting. The interaction of nitrogen and weed management showed the highest dry matter weight at harvesting stage than the earlier stages.

The highest dry matter weight (49.62 g) of weed m^{-2} area was obtained from the 50 % higher nitrogen than the recommended dose of nitrogen which was significantly different from others while lowest weed dry matter weight (25.33 g) was produced from the 50 % lower nitrogen than the recommended dose of nitrogen at 50 DAT.

The highest number of effective tillers $hill^{-1}$ (10.34) was obtained from the 25% higher nitrogen than the recommended dose of nitrogen. Hand weeding treatment showed the highest number of effective tillers $hill^{-1}$(9.50) followed by the Japanese rice weeder treatment (9.13). Interaction of 25% higher nitrogen than the recommended dose of nitrogen × hand weeding treatment performed best in producing effective tillers $hill^{-1}$.

Nitrogen @ 50% higher than the recommended dose produced the longest panicle (24.04 cm) whereas the shortest panicle (21.60 cm) was obtained from the 50% lower nitrogen than the recommended dose. The weed management method did not show the significant variation on panicle length. The longest panicle length (25.47 cm) was obtained from the 50% higher nitrogen than the recommended dose with hand weeding treatment.

Nitrogen and weed management treatment showed the significant variation in producing filled grains $panicle^{-1}$. The highest number of filled grains $panicle^{-1}$ (87.19) was counted at 25% higher nitrogen than the recommended dose of nitrogen while 50% lower nitrogen than the recommended dose produced the lowest number of filled grains $panicle^{-1}$. The highest number of filled grains $panicle^{-1}$ was obtained from the hand weeding treatment and the lowest number of filled grains $panicle^{-1}$ (75.24) was obtained from the control treatment. The interaction of 25% higher nitrogen than the recommended dose and hand weeding treatment showed the highest number of filled grains $panicle^{-1}$ followed by recommended dose of nitrogen with hand weeding treatment.

Significant variation was observed in case of 1000 grains weight due to the effect of nitrogen. The recommended dose of nitrogen produced the highest 1000 grains weight (23.92 g) and lowest (22.02 g) was obtained from the 50% higher dose of nitrogen than recommended dose. The interaction of recommended dose of nitrogen with hand weeding treatment produced the highest 1000 grains weight (24.54 g).

Grain yield varied significantly due to the effect of nitrogen dose and weed management methods. The highest grain yield (5.34 t ha^{-1}) was obtained from the 25% higher nitrogen than the recommended dose while the lowest grain yield (2.88 t ha^{-1}) was obtained from the 50% lower nitrogen than the recommended dose of nitrogen. Hand weeding treatment produced the highest grain yield (4.73 t ha^{-1}). The interaction of recommended dose of nitrogen with hand weeding treatment produced the highest grain yield (5.71 t ha^{-1}) followed by the 25% higher nitrogen than the recommended dose of nitrogen.

The highest straw yield (6.31 t ha^{-1}) was obtained from the 50% higher nitrogen than the recommended dose while hand weeding treatment produced the highest straw yield (5.89 t ha^{-1}). The highest straw yield (6.70 t ha^{-1}) was obtained from the interaction of 50% higher nitrogen than the recommended dose of nitrogen with hand weeding treatment.

Nitrogen and weed management methods showed the significant variation on harvest index (%). The maximum harvest index (47.90 %) was obtained from the recommended dose of nitrogen followed by the 25% higher nitrogen than the recommended dose of nitrogen. The minimum harvest index (39.90 %) was obtained from the 50% higher nitrogen than the recommended dose of nitrogen. The hand weeding and Japanese rice weeder treatment produced the maximum harvest index (%). Due to the effect of interaction recommended dose of nitrogen with hand weeding treatment produced the maximum harvest index (%) followed by the recommended dose of nitrogen with Japanese rice weeder treatment.

The conducted experiment revealed that 25% higher nitrogen than recommended dose gave the highest yield which was statistically similar to the recommended dose of nitrogen (130 kg urea ha^{-1}), that means there was no significantly yield difference between the treatments. So, the recommended dose of nitrogen (130 kg urea ha^{-1}) may be recommended for T.Aman rice cultivation for obtaining highest yield. Among the weeding treatments the highest grain yield was obtained from the hand weeding which differed significantly from the japaneese rice weeder treatment. So, the hand weeding treatments may be recommended for the T.Aman rice cultivation for obtaining the highest yield. Among the interaction effect the combination of recommended dose of nitrogen and hand weeding treatment performed best in case of grain yield production.

CHAPTER 6

REFFERENCES

Ahmed, G.J.U., Mamun, A.A., Hossain, S.M.A., Siddique, S. B. and Mirdha, A. J. (1997). Effect of Bosagran and raking combined with hand weeding to control weeds in aus rice. *Bangladesh Agron. J.* **7** (1&2): 31-32.

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. 17-21 March, 2003. Philippines. No. **1**: 84-92.

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.

Ahmed, M.H., Islam, M.A., Kader, M.A. and Anwar, M.P. (2000). Evaluation of USG as a source of nitrogen in T. aman rice. *Pakistan J. Biol. Sci.* **25**(5): 735-737.

Ahsan, K. (1996). Effect of rate of N fertilizer on growth and yield of Japonica and Japonica- indica hybrid rice. *Bangladesh J. Agril*. **7** (1&2): 17-21.

Akanda, M.R.U., Eunus, M., Islam, M.A. and Ali, M.I. (1986). Nitrogen application timing and performance of BR4 transplant aman rice. *Bangladesh J Agrl.* **11**(1): 39-43.

Akanda, M.R.U., Singh, A. and Mowla, G. (1991). Split application of urea on the yield of aus rice. *Philippines J. Crop Sci*. **7**(1): 10-12.

Alam, M.S., Islam, M.N., Zaman, A.K.M., Biswas, B.K. and Saha, M.K. (1996). Relative efficiency and economics of different cultural methods and herbicides for weed control in transplanted aus rice. *Bangladesh J. Agril. Sci.* **23**(1): 67-73.

Ali, A., Karim, M.A. Hassan, G., Ali, A.S.S. and Majid, A. (1992). Rice grain quality as influenced by split application of nitrogenous fertilizer. *Intl. Rice. Res. Newsl.* **17**(3): 7.

Ali, A., Karim, M.A., Hassan, G., Ali, A., Ali, S.S. and Majid, A. (1993). Rice grain quality as influenced by split application of nitrogenous fertilizer. *Intl. Rice Res. Newsl*. **17**(3): 7.

Angayarkanni, A. and Ravichandran, M. (2001). Judicious fertilizer N split for higher use efficiency in transplanted rice. *Indian J. Agril. Res***. 35(**4):278-280.

Angiras, N.N. and Rana, S.S. (1998). Integrated weed management in direct seeded puddled sprouted rice. *Indian J. Agron.* **43** (4): 644-649.

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.

Asif, M., Chaudhary, F.M., and Saeed, M. (1999). Influence of NPK levels and split N application on grain filling and yield of fine rice. *Intl. Rice. Res. Notes*. **24(**1): 30-31.

Awan, LU., Ahmed, H.K. and Gandapur, S.U.D. (1984). Effect of different Nitrogen application on rice grain yield. *Intl. Rice Res. Newls*. **9**(6): 26.

Azad, A.K., Gaffer, M.A., Samanta, S.C., Kasheni, M.A. and Islam, M.T. (1995). Response of BR rice to different levels of nitrogen and spacing. *Bangladesh J. Sci. Ind. Res.* **30** (1):131-38.

Balaswamy, K. (1999). Effect of urea and herbicides on weed composition and density in transplanted rice. *J. Res.* ANGRAU. **27** (3): 5 -11.

Baloch, M.S., Awan, 1.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

Bari, M.N., Mamun, A.A. and Anwar, S.M.S. (1995). Weed infestation in transplanted aman rice as affected by land topography and time of transplanting. *Bangladesh J. Agril. Sci*. **22** (2): 227-235.

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). (2002). Yearbook of Agricultural Statistics of Bangladesh. Bangladesh Bureau of Statistics, Stat. Div., Min. Plan., Govt. of the People's Repub. Bangladesh. p.21

BBS (Bangladesh Bureau of Statistics). (2008). Statistical yearbook of Bangladesh. Statistics Division. Ministry of Planning, Government of the People's Republic of Bangladesh. p.22

BBS (Bangladesh Bureau of Statistics). (2009). Statistical yearbook of Bangladesh. Statistics Division. Ministry of Planning, Government of the People's Republic of Bangladesh. pp. 60-64.

Bhattacharya, S.P., Gash, R.P., Brahmachari, K., Pal, T. K. and Kumar, T.K.K. (1996). Efficiency of some new generation herbicides in controlling weed of transplanted born paddy. *Etwiron. Exot.* **14** (2): 657-661.

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

BINA (Bangladesh Institute of Nuclear Agriculture). (1996). Annual Report for 1993-94. Bangladesh Institute of Nuclear Agriculture Mymensingh. p 173.

Bowen, W.T., Diamand, R.B., Singh, U. and Thompson, T.P. (2005). Urea deep placement increases yield and saves nitrogen fertilizer in farmers' field in Bangladesh. Rice in life: scientific perspectives for the 21st century proceeding of the World Rice Research Conference held in Tsukuba, Japan, 4-7 November, 2004. pp.369-372.

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

BRRI (Bangladesh Rice Research Institute). (1997). Internal Review for 1996.

BRRI (Bangladesh Rice Research Institute). (1998). Annual Report for 1995. Bangladesh Rice Res. Inst., Joydebpur, Gazipur, Bangladesh. pp. 12-14.

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

BRRI (Bangladesh Rice Research Institute). (2008). Adunik Dhaner Chash (in Bangla). Bangladesh Rice Res. Inst., Jodebpur, Gazipur, Bangladesh. p. 34

Budhar, M.N., Elangovan, K., Rangasamy, A., Palanippan, S.P. and Vellisailly, R. (1987). Effect of different levels of Nitrogen and forms of urea oil rice yield. *Indian J. Agron*. **32**(4): 463-464.

Burhan, H.D., Sozzi and Zosehke (1989). Set-off for weed control in rice. Practical. experience for Indonesia. Proc. 12th Asian Pacific Weed Sci. Soc. Conf. 1989. Taipei, Tainwan. No. 1:127-131.

Carbonell, P.U. and Moody, K. (1983). Weed control practices in irrigated and rainfed rice farms in Nueva, Ecija, Philippines. *Philippines Agric*. **66**: 458-469.

Chander, S. and Pandey, J. (1996b). Effect of herbicide and nitrogen on yield of scented rice (*Oryza sativa*) under different rice cultures. *Indian J. Agron.* **41(**2): 209-214

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

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

Choudhury, A.T. and Khanif, Y.M. (2002). Effect of Nitrogen, Copper and Magnesium fertilization oil yield and nutrition of rice. *Pakistan J. Sci. Indus. Res.* **45**(2): 102-107.

Chowdhury, M.M.U., Ullah, M.H., Islam, M.S., Nabi, S.M. and Hoque, A.F.M.E. (1998). Rice cultivation in hill valley after dhaincha manuring as affected by different levels of nitrogen. *Banglactesh J. Agril. Sei.* **23** (2): 299-306.

Dalai, P.K. and Dixit, L. (1987). Response of medium rice varieties (dwarf indica) to different levels of N. *Indian J. Agron.* **32** (3): 286-287

Das, S. and Singh, T.A. (1994). Nitrogen use efficiency by rice and flood water parameters as affected by fertilizer placement techniques. *J. Indian Soc. Soil Sci*. **42**(1): 46-50.

Devaraju, K.M., Gowada, H. and Raju, B.M. (1998). Nitrogen response of Karnataka Rice Hybrid 2. *Intl. Rice Res. Notes*. **23**(2): 43.

Deva senamma,V., Reddy, M.R. and Soundaranklan, 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.

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. (2001). 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).

Elbadry, M., Gamal Eldin, H. and Elbanna, K. (2004). Effect of Rhodobacter capsulatus inoculation in combination with graded levels of nitrogen fertilizer on growth and yield of rice in pots and lysimeter experiments. *World J. Microbiol. Biotech.* **15** (3): 393-395.

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,

Elliot, P. C., Navarez, D. C. and Moody, K. (1984). Yield of rainfed transplanted rice as affected by cultivar, fertilizer level and weeding regime. Rice Farming Systems Program. Intl. Rice Res. Inst., Los Banos, Philippines. pp. 1-6.

El-Rewainy, I.M.O. (2002). The effect of different nitrogen fertilizer source on yield and some agricultural characters in rice. Ph.D., Thesis, Fac. Agric. Shebin El-Korn, Menofia Univ., Egypt.

Fageria, N.K. and Baligar, V.C. (2001). Lowland rice response to nitrogen fertilization. Commun. *Soil Sei. Plant Annul.* **32**: 9-10.

FAO (Food and Agriculture Organization). (1998). Production Yearbook for 1998. FAO, UN. Rome, Italy. p.118.

Faraji, A and Mirlohi, A. (1998). Effect of splitting and rate of nitrogen application on yield and yield components of rice (*Oryza sativa* L.) in Isfahan. *J. Agril. Sci.* **2**(3): 25-34.

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.

Gardner, F.,R. Pearce and R. L. Mitchell, 1985. Physiology of Crop Plants. Lowa state university Press, Ames, USA, Pp : 66

Geethadevi, T., Gowada, A., Vidyachandra, B. and Babu, B.T.R. (2000). Studied on split application of nitrogen and their timings on growth and yield of rice genotypes. *Current Res. Univ. Agril. Sci.* **29**(3-4): 42-44.

Ghosh, B.C., Reddy, B.B., Panda, M.M. and Reddy, M.D. (1987). Response of direct seeded rice to nitrogen under intermediate deep water conditions. *Indian J. Agron*. **23**(1): 44-48.

Gill, P.S. and Shahi, H.N. (1987). Effect of Nitrogen levels in relation of age of seedlings and time of transplanting on growth yield and milling characteristics of rice. *Indian J. Agric. Sci.* **57**(9): 6310-614.

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. (1998). Weed control in late transplanted tow land rice. *Indian J. Agron.* 43 (2): 298-301.

Hari, O.K., Katyal, S.K. and Dhiman, S.D. (1997). Effect of Nitrogen and seed rate in nursery on growth and yield of hybrid rice (*Oryza sativa* L.). *Indian J. Agron***.** **42**(2): 275-277.

Hari, O.K., Katyal, S.K. and Dhiman, S.D. (2000). Response of two rice hybrids to graded levels of nitrogen. *Indian J. Agric. Sci*. **70**: 140-142.

Hossain, A., Islam, R. and Miah, N.A. (1989). Response of rice of sulphur and zinc fertilization. *Bangladesh .J. Agril. Sci.* **16**(1): 131-134.

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.

Hossain, M.A., Salahuddin, A.B.M., Ray, S.K., Nasreen, S. and Ali, M.A. (1995). Effect of green manuring on the growth and yield of transplant aman rice. *Bangladesh J. Agril. Sci.* **22** (1): 21-29.

Hussain, S.M. and Sharma, U.C. (1991). Response of rice (*Oryza sativa*) to nitrogen fertilizer in acidic soil of Nagaland. *Indian J. Agric. Sci.* **61**(9): 662-664.

Ibrahiem A.A., El-Khawaga, A.A., Sharabash, M.T.M. and Iman, A.A Farg. (2004). The use of mineral and biofertilizer nitrogen source in rice. *Zagazig J. Agric. Res*. **31**: 509-521.

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.

Ikeda, A., Yoshida, T., Shirota, M. and Takei, M. (2003). Method of the non-split application of fertilizer to ricr "Koshihikari" on pneumatic direct seeding culture on submerged paddy filed. *Research Bulletin of the Aichi ken Agricultural Research Center*. **35**: 23-29.

Islam, M.S., and Haq, K.A, (1987). Development of a low cost weeder for low-land paddy. *Bangladesh J. Agric*. **12** (4): 255 -262.

Islam, M.R., Hague, M.S. and Bhuiya, Z.H. (1990). Effect of nitrogen and sulphur fertilization on the growth, yield and nutrient uptake of deep water rice. *Bangladesh Agril. Sci*. **24**(2): 93-96.

Islam, N., Inanagta, S., Chishaki, N. and Horiguchi, T. (1996). Effect of nitrogen top-dressing on dry matter and nitrogen distribution in Indian rice. *Japanese J. Trop. Agric.* **40**(2): 89-92.

Jaiswal, V.P. and Singh, G.P. (2001). Performance of urea super granules and grilled urea under different planting methods in irrigated rice (*Oryza sativa*). *Indian J. Agril. Sci*. **71**(3): 187-189.

Jena, D., Misra, C. and Bandyopadhyay, K.K. (2003). Effect of prilled urea and urea super granules on dynamics of ammonia volatilization and nitrogen use efficiency of rice. *J. Indian Soc. Soil Sci*. **51**(3): 257-261

Jha, K.P., Gangadharan, C. and Matuia, G.B. (1991). Onfarm evaluation of promising lowland rice (*Oryza sativa*) genotypes and their response to date of seedling and nitrogen level under flood-pron rainfed lowlands of Orissa. *Indian J. Agric. Sci.* **61**(4): 232-242.

Kamal, A.M.A., Azam, M.A. and Islam, M.A. (1988). Effect of cultivars and NPK combination on the yield contributing characters of rice. *Bangladesh J. Agril Sci.* **15**(1): 105-110.

Kamal, J., Tomy, P.J. and Rajappan, N. (1991). Effect of sources and levels of nitrogen on the growth of wetland rice. *Indian J Agron*. **36**(1): 40-43.

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

Kapre, M.M., Bisen, C.R. and Johar, M.S. (1996). Effect of slow release N fertilizers on rice under low land conditions. *Crop Res, Hisar*. **11(**1): 17-23.

Katayama, K., Song, X., Hiroto, O., Agata, W. and Takeda, T. (1990). Comperision of Fertilizer responsiveness between rice cultivars in warmer area and Japonica-Indica hybrid rice. Sci. Bull. Facul. Agri., Kyushu Univ. **45**(1-2): 91-98.

Katoch, K.K., Shan-na, B.R. and Bhatnagar, V.K. (1987). Response of rainfed rice to nitrogen level and post planting soil management practices. *Intl. Rice Res. Newsl*. **12**(1): 32.

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

Kumar, G.H., Reddy, S.N. and Ikramullah, M. (1995). Effiect of age of seedling and nitrogen levels on the performance of rice (*Oryza sativa*) under late planting. *Indian J. Agric. Sci*. **65** (5): 354-355.

Kumar, S.R., Reddy, M.R., Reddy, T.M.M. and Reddy, B.B. (1986). Nitrogen management in direct seeded and transplanted rice. *Indian J. Agron.* **31**(1): 100-101.

Kurmi, S. and Das, N. (1993). Effect of herbicides on weed control in transplanted rice. Integrated weed management for sustainable agriculture. *Proceedings of an Ind. Soc. of India*. Vol. III. pp. 27-29.

Latchanna, A. and Yogeswara, R.Y. (1977). Effect of level and time of applicator of nitrogen on rice varieties. *Andhre, J. Agric*. **24**(6): 213- 215.

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.

Madhu, M., Najappa, H.V. and Naik, H.R. (1996). Economics of weed control treatment in puddled seeded rice. *Crop Res. Hisar.* **12** (2): 133-137.

Mahbub, A.M.M., Hossain M. and Janaich, A. (2001). Hybrid rice adoption in Bangladesh. A socioeconomic assessment of farmers' experience: Research Monograph, Seriel no. 18. Social Sciences Division, 2001. Los Banos, Philippines. p.38.

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.

Mamun, A.A., Karim, S.M.R., Begum, M., Uddin, M.I. and Rahman, M.A. (1993). Weed survey in different crops under three Agroecological Zones of Bangladesh. Baures Prog. **8**:41-51.

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.

Maskina, M.S. and Singh, B. (1987). Response of new rice varieties to N. *Intl. Rice Res. Newsl.* **12**(4): 8-9.

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

Miah, M.N.H., Sudarshan, T., Sarker, M.A.R. and Ansari, T.H. (2004). Effect of number of seedling hill^{-1} and urea super granules on growth and yield of the rice cv. BINA dhan4. *J. Biol. Sci.* **4**(2): 122-129.

Milani, M.R., Mobley, O.G. and Sheppard, R. (1988). Influence of Relationship. 1988. Influence of per-plant Nitrogen cultivar, Nitrogen rate and date of flood on yield and agronomic traits of rice. In: Annual. Prog. Rept. Lonsiana Agric. Res. Station. 50-56.

Mirza, W.A. and Reddy, S.N. (1989). Performance of modified urea materials at graded levels of nitrogen wider experimental and farmers management condition in low land rice (*Oryza sativa*). *Indian J. Agron*. **33**(2): 218-220.

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.

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

Mondal, S.S., Dasmahapatra, A.N. and Chetterjee, B.N. (1987). Effect of high rates of potassiurn and nitrogen on rice yield components. *Environ. Eeol*. **5**(2): 300-303.

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

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.

Nandal, D. P., Hari, O.M. and Om, H. (1998). Weed control in direct seeded puddled rice. *Indian J. Weed Sci*. **30** (1-2): 18-20.

Nassem, S.B., Mollah, M.I.U. and Ali, M.H. (1995). Yield response of upland rice to varying levels of weeding and nitrogen. *Bangladesh J. Sci. Res*. **30**(2-3): 65-71.

Navarez, D. E., Estano, D. B. and Moody, K. (1982). Preliminary evaluation of farmers weed control practices in Cagayan in Philippines. *Philippines J. Weed Sci*. **8** (2): 49-55.

Nossai, E. and Vargas, Z.P. (1982). Response of IR8 rice variety to nitrogen fertilizers under irrigated field condition. *Agric. Res. J. Kerala.* **36**(4): 294.

Panda, M.M. and Mohanty, S.K. (1995). Time of application of low dose of nitrogen to rainy season rice (*Oryza sativa* L.) for increasing N use efficiency. *Indian J. Agric. Sci*. **65**(4): 283-285.

Pandey, P.C., P.S., and Lal, P. (1989). Effect of rice yield of N applied during reproductive phase. *Int. Rice Res. Newsl*. **14**(4): 32-33.

Patel, S.R. and Mishra, V.N. (1994). Effect of different forms of urea and levels of nitrogen on the yield and nitrogen uptake of rice. *Advn. PI. Sci*. **7**(3): 297-401.

Patel, S. N., 1987, Integrated weed management in brassica species. Annals of Botany, 34: 76-83

Paturde, J.T. and Rahate, V.T. (1986). Yield and yield attributory characters of paddy (*Oryza sativa*) variety IR20 as affected by split application of nitrogen at different growth stages under irrigated conditions. *Agric. Sci. Digest*. **61**(l):38-40.

Prasad, M.K., Singh, S.B., Singh, J.M. and Shinha, R.P. (1999). Growth of rice plants as influenced by the method of seeding, seed rate and split application of nitrogen. *J. Appl. Biol*. **9**(1): 52-54.

Rajarathina, P. and Balasubramaniyan, P. (1999a). Optimum plant population, seedling density and N levels for medium duration hybrid rice (*Oryza sativa* L.). *Indian J. Agron*. **44**(4): 583-585.

Rajarathinam, P. and Balasubramaniyan, P. (1999b). Effect of plant population and Nitrogen on yield attributes and yield of hybrid rice (*Oryza sativa*). *Indian J. Agron.* **44**(4).717-721,

Rajkhowa, D.J., Gogoi, A.K. and Kandali, R. (2001). Effect of weed control and nutrient management practices in rice. *Indian J. Weed Sci*. **33** (1&2): 41-55.

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

Rangaraju, G. (2002). Weed flora and weed dynamics of pre-monsoon dry seeded rainfed rice as influenced by herbicide and it's time of application. *Indian J. Weed Sci*. **34** (1-2):123-125.

Rao, C.P. and Raju, M.S. (1987). Effect of age of seedling, nitrogen and spacing on rice. *Indian J. Agron.* **32**(1): 100-102.

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.

Reddy, G.R.S., Reddy, G.B., Ramajah, N.V. and Reddy, G.B. (1987). Effect rates and sources of nitrogen on transplanted lowland rice. *Indian J. Agril. Sci*. **31**(4): 416-418.

Russel, D.F. 1986. MSTAT-C. MSTAT Director, Crop and Soil; Sci. Dept., Michigan State Univ., USA.

Sadeque, M.A., Zarnan, S.M., Karim, M.A. and Miah, M.A.J. (1990). Studies on nitrogen economy of rice plants. *Progress. Agric*. **1**(2): 19-23.

Sahrawat, K.L., Diatta, S. and Singh, B.N. (1999). Nitrogen responsiveness of lowland rice varieties under irrigated condition in West Africa. *Intl. Rice Res. Notes*. **24** (2): 30.

Salam, N.A., Tazuddin, E., Varghese, K., Hameed, M.S. and Thomas, Y. (1988) Effect of N source and application time on rice. *Intl. Rice Res. Newsl.* **13**(5):25.

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.

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

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.

Savithri, K.E., Chidandra, M.R. and Tomy, P.J. (1994). Efficiency of pre-emergence herbicides in transplanted rice. *J. Trop. Agril*. **32**: 27-29.

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

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

Sharma, A.R. (1995). Effect of basal and post-flood nitrogen fertilization on performance of rice (*Oryza sativa*) under conditions intermediate deep water and simulated flush fooding. *Indian J. Agric. Sci.* **65**(6): 399-404.

Sharma, M.L. and Mishra, V.R. (1986). Effect of fertilizer nitrogen and algal inoculation on rice crop. *Madras Agric. J*. **71**(2): 155-159.

Sharma, S.K. and Bhunia, S.R. (1999). Weed management in transplanted rice under Ghaggar floodplains of northwest Rajasthan. *Indian J. Agron.* **44** (3): 543-547.

Sharma, S.N. and Prasad, R. (1980). Relative efficiency of urea nitrification inhibition treated urea and sulphur coated urea of rice. *Indian J. Agron*. **25**(3): 403-409.

Shoo, N.C., Mishra, R.K. and Mohanty, J.P. (1989). Effect of single versus split application of nitrogen on growth and physiological growth parameters of rice. *Orissa J. Agril. Res*. **2**(3-4): 194-195.

Sidhu, M.S., Sikka, R. and Singh, T. (2004). Performance of transplanted Basmati rice in different cropping systems as affected by N application. *Intl. Rice Res. Notes*. **29(**1.): 63-65.

Singandhupe, R.B. and Rajput, R.K. (1989). Effect of moisture regimes and Rajput and levels of Nitrogen on yield of rice (*Oryza sativa* L.) in alkali soil. *Indian J. Agric*. **59**(8): 532-533.

Singh, 0.P. and Bhan, V.M. (1992). Effect of herbicides and water submergence levels on control of weeds in transplanted rice. *Indian J. Weed Sci*. **24** (4): 226-230.

Singh, B.K. and Singh, R.P. (1986). Effect of modified urea materials on rainfed low and transplanted rice and their residual effect on succeeding wheat crop. *Indian J. Agron.* **31**(2): 198-200.

Singh, C.M., Moody, K. and Cho, S.C. (1985). Weed control through inter-row cultivation in upland rice. *Sarhad J. Agric*. **16** (3): 35-40.

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, G., Singh, R.K., Singh, V.P., Nayak, R. and Singh, R.S. (1999). Weed management in transplanted rice (*Oryza sativa*) under rainfed lowland situation. *Indian J. Agron.* **44** (4): 728-732.

Singh, M.K., Thakur, R., Verma, U.N., Upasam, R.R. and Pal, S.K. (2000). Effect of planting time and nitrogen on production potential of Basmati rice (*Oryza sativa*) cultivar in Bihar Plateau. *Indian J. Agron*. **45** (2): 303-304.

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, S.K. (1997). Response of promising nee genotypes of N levels in rainfed lowlands. *Intl. Rice Res. Notes*. **22**(3): 27-28.

Singh, S.P. and Pillai, K.G. (1994). Response to nitrogen in semi dwarf scented rice varieties. *Intl. Rice Res. Newsl*. **19** (4) : 17.

Singh, S.P., Devi, B.S. and Subbiah, S.V. (1998). Effect of N levels and time of application on grain yield of hybrid rice. *Intl. Rice Res. Newsl*. **23** (1): 25.

Singh, T., Shivay, T.S. and Singh, S. (2004). Effect of date of transplanting and Nitrogen on productivity and nitrogen use indices in hybrid and non-hybrid aromatic rice. *Acta Agronomica Hungarica*. **52**(3) : 245-252.

Singh, U.B. and Paliwal, S.K. (1980). Effect of different dates of sowing in nursery and nitrogen levels on rice yield in Rajasthan. *Indian J. Agron*. **25**(3):38-381.

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. Eeol*. **21**(2): 411-413.

Sudhakar, G., Solaimalai, A. mid Ravisankar, N. (2001). Yield and economic of semidry rice as influenced by cultivars and levels of nitrogen, *Indian J. Dryland Agril. Res. DevIop*. **16**(l): 42-44,

Surekha, K., Reddy, M.N., Kumar, R.M. and Kumar, C.H.M.V. (1999). Effect of nitrogen sources and timing on yield and nutrient uptake of hybrid rice. *Indian J. Agril. Sci*. **69** (7): 477-481.

Surendra, S., Prasad, R. and Sharma, S.N. (1995). Effect of blue green algae, nitrogen levels and modified urea materials on yield attributes and yield of low land rice (*Oryza sativa*). *Indian J. Agron*. **40**(4): 594-597.

Tanaka, S.A., Navasero, C.V., Garcia, P. T., Parao and Raamierz, E. (1964). Growth habit of the rice plant in the tropics and its effects on nitrogen response. *Intl. Rice Res. Inst. Tech. Bull.* **3**: 67-80.

Thakur, D.S. and Patel, S.R. (1998). Response of split application of nitrogen on rice (*Oryza sativa* L.) with and without farm yard manure in inceptisols. *Environ. Ecol*. **16** (2): 310-313.

Thakur, K.S. and Singh, C.M. (1987). Effect of organic wastes and N-levels on transplanted rice. *Indian J. Agron*. **32** (2): 161-164.

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

Thakur, R.B. (1993). Performance of summer rice (*Oriza sativa*) to varying level of nitrogen. *Indian J. Agron*. **38 (**2): 187-190.

Thakur, R.B., Dwivedi, P.K., Choudhury, S.K. and Singh, H. (1995). Effect of nitrogen on lowland late transplanted rice *J. Res. Birsa Agril. Univ*. **7**(2): 163-164.

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.

Venkataraman, N.S. and Gopalan, M. (1995). Current status of weed problems in rice production in Tamil Nadu, India. In. Papaws, H. R. and Heong, K. L. (ed.) Weed Management in Rice Production. *Intl. Rice. Res. Inst., Los. Banos. Laguna, Philippines*. pp. 113-126.

Vijaya, D. and Subbaiah, S.V. (1997). Effect of methods of application of granular forms of fertilizers on growth, nutrient uptake and yield of paddy. *Ann. Agril. Res*. **18**(3): 361-364.

Wagh, R.G. and Thorat, S.T. (1988). Response of (*Oryza sativa*) variety R-24 to different times of application of nitrogen and plant densities in coastal soils. *J. Indian Soc. Coastal Agril. Res*. **6** (2): 133-137.

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

Xie, W. Wang, G., Zhang, Q. and Guo, H. (2007). Effect of nitrogen fertilization strategies on nitrogen use efficiency in physiology, recovery, and agronomy and redistribution of dry matter accumulation and nitrogen accumulation in two typical rice cultivars in Zhejiang, China. *J. Zhejiang Univ. Sci.* **8**(3): 208-216.

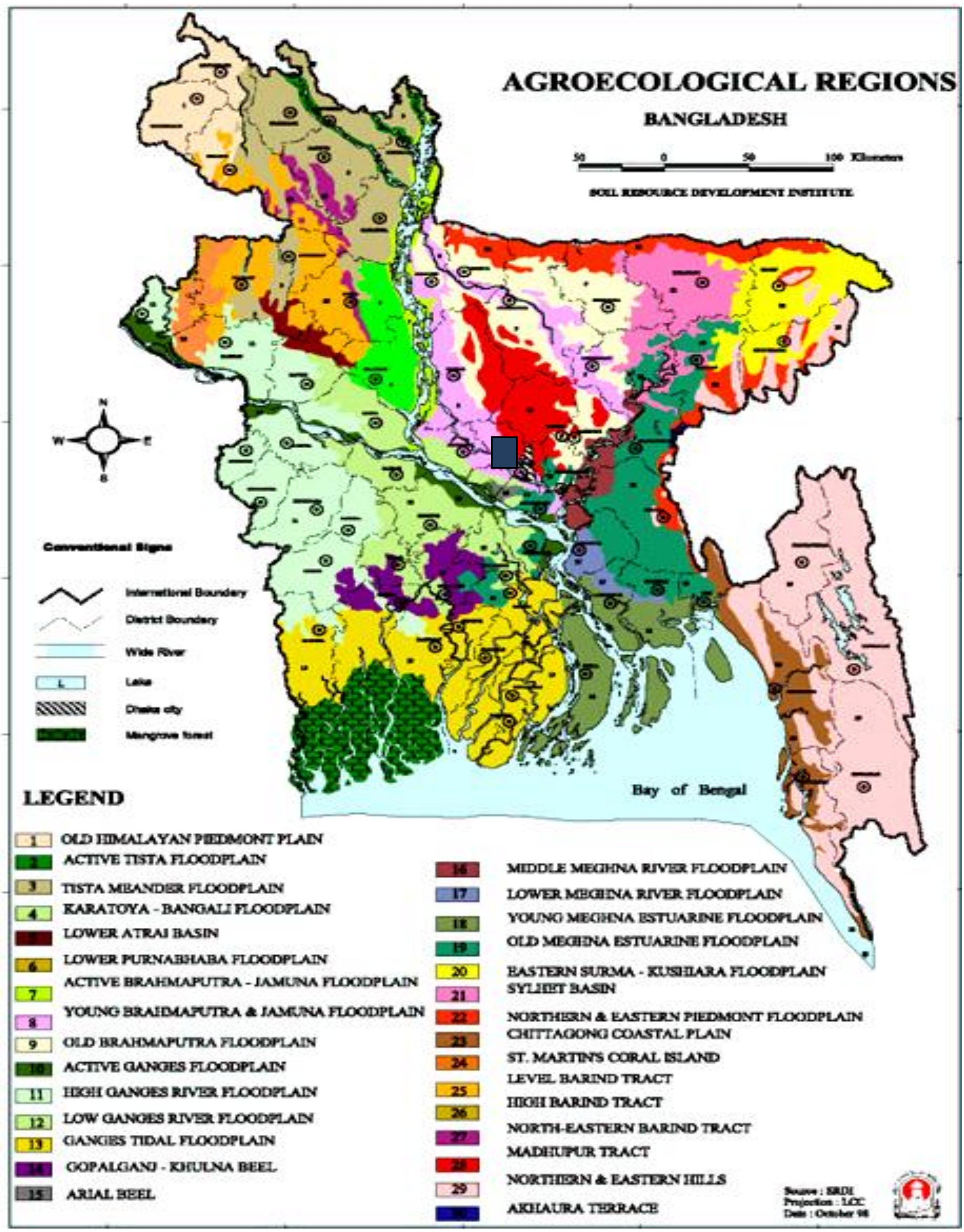
Yang, J., Jiang, N. and Chen, J. (2003). Dynamic, stimulation of nitrogen application level effects on rice yield and optimization analysis of fertilizer supply in paddy field. *Ying Yong ShengTai Xue Bao*. **14** (10): 1654-1660.

Yoshida, S. and Parao, F.T. (1976). Climatic influence on yield and yield components of lowland rice in the tropics. Climate and Rice. Los Banos, Philippines. pp.471- 494.

Zayed, B.A., EL-Reface, I.S., Gorgy, R.N. and Abd El-Rahman, A.A.M. (2005). Effect of sowing dates plant spacing and nitrogen levels on growth and yield of rice under saline soil. The 11th Conference of Agronomy, Dept., Fac. Agric., Assiut Univ., pp: 265-283.

APPENDICES

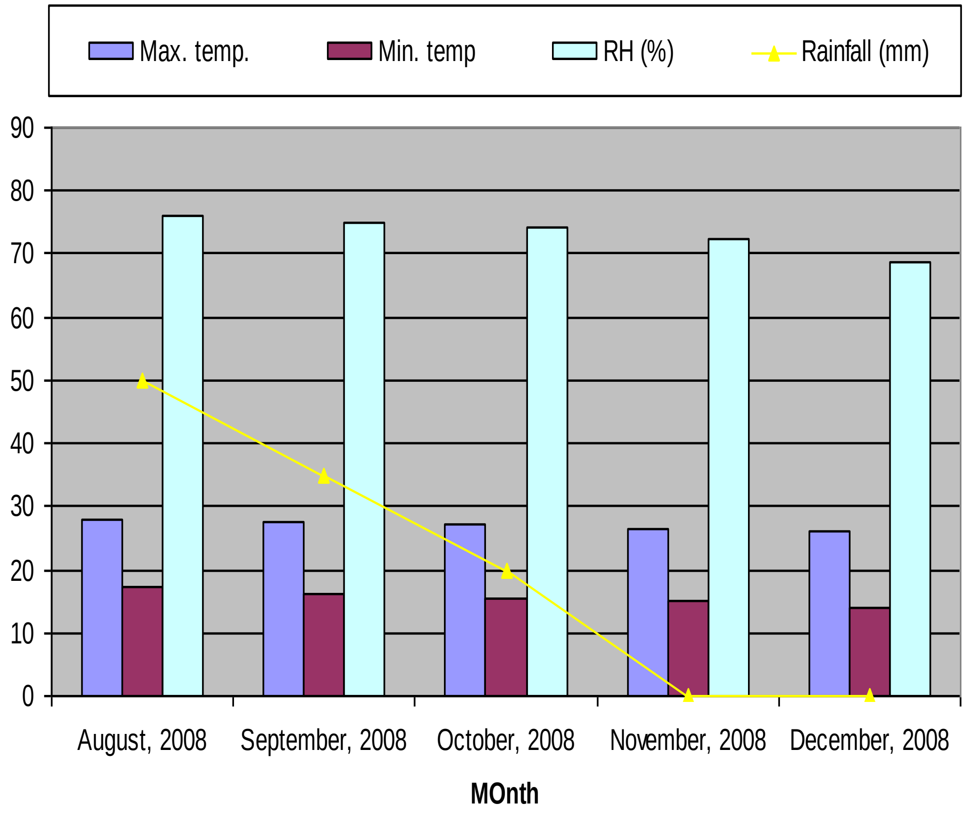
Appendix I. Experimental location



Appendix II. Chemical properties of soil in the study area

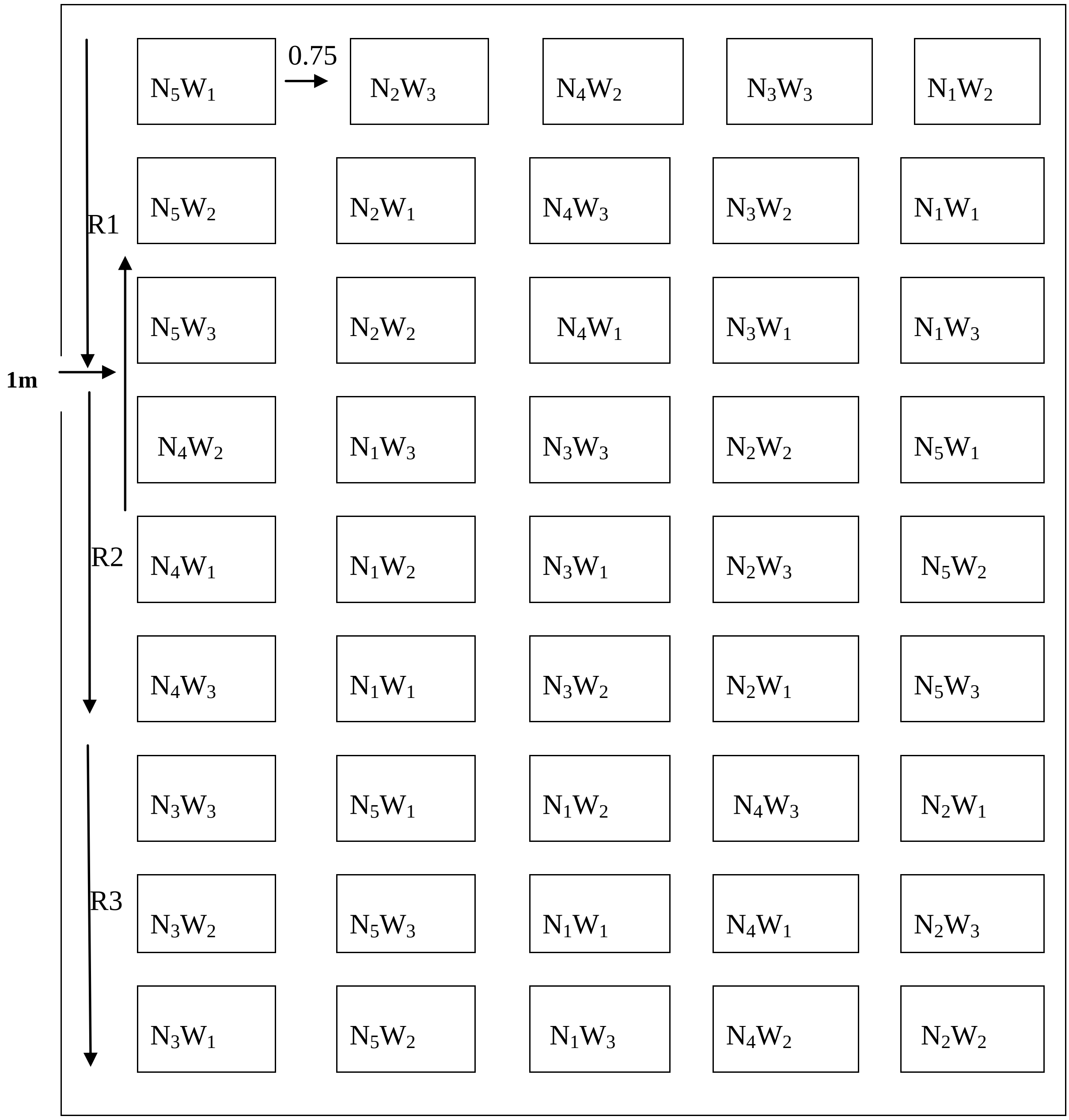
Characteristics	Analytical results
P^H	5.45-5.61
Organic matter (%)	0.90
Total nitrogen (%)	0.083
Available Phosphorus(ppm)	21.30 µg/g soil
Exchangeable Potassium (ml/100 gm soil)	0.15 meq/100 g soil
Zinc(ppm)	3.51 µg/g soil
Sulphur (ppm)	25.03 µg/g soil
Boron(ppm)	0.53 µg/g soil

Appendix III. Monthly record of average air temperature, rainfall, relative humidity of the experimental site during the period from August to December 2008



Source: Bangladesh Meteorological Department, Dhaka-1212

Appendix IV. Layout of the experimental plot



N_1 = 50 % lower nitrogen than recommended dose, N_2 = 25 % lower nitrogen than recommended dose, N_3 = Recommended dose of nitrogen, N_4 = 25 % higher nitrogen than recommended dose and N_5 = 50 % higher nitrogen than recommended dose; W_1= Control (No Weeding), W_2= Hand weeding and W_3= Japanese rice weeder

Appendix V. Mean square values for plant height of T. amam rice at different days after transplantation

Source of Variation	Degrees of freedom	Mean square values at different days after transplantation				
		20	40	60	80	At harvest
Replication	2	15.82	119.27	5.53	62.82	94.27
Nitrogen (N)	4	16.37*	92.37**	114.84**	182.66**	231.27**
Error (a)	8	3.527	6.021	7.13	19.93	32.70
Weeding (W)	2	14.03	69.98**	104.41*	375.6**	335.11**
(N× W)	8	1.16	11.30	1.42	3.23	9.63
Error (b)	20	5.72	5.36	22.30	19.77	33.25

N= Nitrogen, W= weed management methods
** Significant at 1 % level, * Significant at 5% level

Appendix VI. Mean square values for total tillers hill^{-1} of T. amam rice at different days after transplantation

Source of Variation	Degrees of freedom	Mean square values at different days after transplantation				
		20	35	50	65	At harvest
Replication	2	0.23	0.78	11.97	14.53	1.87
Nitrogen (N)	4	6.67	21.11**	27.38**	36.26**	11.27**
Error (a)	8	0.039	0.246	2.89	3.42	1.11
Weeding (W)	2	1.21	8.04**	9.10*	16.20*	5.70**
(N × W)	8	0.46	0.22	0.14	0.16	0.18
Error (b)	20	0.12	0.39	2.47	2.78	0.511

N= Nitrogen, W= weed management methods
** Significant at 1 % level, * Significant at 5% level

Appendix VII. Mean square values for dry matter weight hill^{-1} of T. amam rice at different growth stages

Source of Variation	Degrees of freedom	Mean square values at different growth stages		
		At panicle initiation stage	At grain filling stage	At harvesting stage
Replication	2	3.12	13.37	46.37
Nitrogen (N)	4	47.10**	277.95**	551.47**
Error (a)	8	0.732	5.08	5.22
Weeding (W)	2	29.83**	137.39**	63.90**
(N × W)	8	0.754	1.85	0.92
Error (b)	20	1.705	7.80	6.03

N= Nitrogen, W= weed management methods
** Significant at 1 % level, * Significant at 5% level

Appendix VIII. Mean square values for dry matter weight of weed at different days after transplantation

Source of Variation	**Degrees of freedom**	**Mean square values at different days after transplantation**		
		20	**35**	**50**
Replication	2	0.68	27.93	14.76
Nitrogen (N)	4	152.97**	115.54**	181.7**
Error (a)	8	5.46	8.22	3.84
Weeding (W)	2	1.06	5497.5**	16308.6**
(N × W)	8	4.84	1.15	2.14
Error (b)	20	10.04	7.28	10.98

N= Nitrogen, W= weed management methods
** Significant at 1 % level, * Significant at 5% level

Appendix IX. Summary of analysis of variance for yield and yield components of T. Aman rice

Sources of variation	**Degrees of freedom**	**Mean square values**						
		Effective tillers (no.)	**Panicle length (cm)**	**Filled grains panicle^{-1} (no.)**	**1000 grains weight (g)**	**Grain yield (t ha^{-1})**	**Straw yield (t ha^{-1})**	**Harvest index (%)**
Replication	2	1.875	6.28	10.10	0.041	0.25	0.013	0.57
Nitrogen (N)	4	11.27**	8.01*	450.96**	5.35*	9.63**	6.21**	122.47*
Error (a)	8	1.114	1.94	46.84	1.01	0.017	0.197	1.77
Weeding(W)	2	5.70**	9.80	341.95**	4.32*	4.16**	3.40**	15.17*
(N× W)	8	0.18	0.66	4.25	0.101	0.026	0.072	2.07
Error (b)	20	0.51	8.20	15.60	1.624	0.71	0.089	5.68

N= Nitrogen, W= weed management methods
** Significant at 1 % level, * Significant at 5% level