INFLUENCE OF NITROGEN SOURCES, VARIETY AND WEED CONTROL METHODS ON THE GROWTH AND YIELD OF AROMATIC *T. AMAN* RICE VARIETIES

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CERTIFICATE

This is to certify that thesis entitled, "***INFLUENCE OF NITROGEN SOURCES, VARIETY AND WEED CONTROL METHODS ON THE GROWTH AND YIELD OF AROMATIC T. AMAN RICE VARIETIES***" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE (MS) IN AGRONOMY**, embodies the result of a piece of bona-fide research work carried out by MD. IMRAN HOSSEN, Registration no. 08-03123 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.

Date:
Place: Dhaka, Bangladesh

……………………………
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DEDICATED

TO

MY BELOVED PARENTS

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The author

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ABSTRACT

A field experiment was conducted at the experimental field of Sher-e-Bangla agricultural university during July to December 2013 to find out the effect of three sources of Nitrogen *viz.* control (N_1), Prilled urea (N_2) and USG (N_3) and three weed control treatment viz control (W_1), two hand weeding (W_2) and pre-emergence herbicide Rifit 20EC (W_3) on growth, yield and yield components of Kalijira (V_1), BRRI dhan37(V_2) and BRRI dhan38 (V_3) transplant aromatic *T. aman* rice. The experiment was laid out in a split-split-plot design with three replications. Half of the urea applied at the time of final land preparation and rest half applied in two equal splits at 20 and 40 DAT. The USG (1.8 g) was placed at 5-10 cm soil depth at 10 DAT in the center of four hills in alternate rows @ 1 granule in one spot to supply 58 kg N ha^{-1} and Rifit 20EC was applied at 5 DAT. USG performed well in growth and gave higher grain yield (3.33 t ha^{-1}) over PU. USG gave 18% more yield then Prilled urea. Results showed that rice varieties differed significantly in all growth characters and BRRI dhan38 produced higher grain yield (3.23t ha^{-1}). Rifit 20EC applied plot gave highest grain yield (3.23 t ha^{-1}) while no weeding had the lowest plant height, numbers of total tiller $hill^{-1}$, CGR and total dry matter. Interaction results showed that significantly higher grain yields were given by PU X BRRI dhan38 (3.5 t ha^{-1}), USG X BRRI dhan38 (3.82 t ha^{-1}) and on the other hand, Rifit 20EC X BRRI dhan38 (3.71 t ha^{-1}) and interaction of USG X BRRI dhan38 X Rifit 20EC (4.28 t ha^{-1}). The higher grain yield was attributed mainly to the number of effective tillers $hill^{-1}$, filled grains $panicle^{-1}$ and 1000-grain weight.

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LIST OF ACRONYMS

AEZ	=	Agro- Ecological Zone
AIS	=	Agriculture Information Service
BARC	=	Bangladesh Agricultural Research Council
BBS	=	Bangladesh Bureau of Statistics
B:C	=	Benefit Cost ratio
BINA	=	Bangladesh Institute of Nuclear Agriculture
BRRI	=	Bangladesh Rice Research Institute
cm	=	Centi-meter
cv.	=	Cultivar
DAT	=	Days after transplanting
^{0} C	=	Degree Centigrade
DF	=	Degree of freedom
EC	=	Emulsifiable Concentrate
et al.	=	and others
etc.	=	Etcetera
FAO	=	Food and Agricultural Organization
g	=	Gram
HI	=	Harvest Index
HYV	=	High yielding variety
hr	=	hour
IRRI	=	International Rice Research Institute
Kg	=	kilogram
LV	=	Local variety
LYV	=	Low yielding varieties
LSD	=	Least significant difference
m	=	Meter
m^2	=	meter squares
MV	=	Modern variety
mm	=	Millimeter
viz.	=	namely
ns	=	Non significant
%	=	Percent
CV %	=	Percentage of Coefficient of Variance
ppm	=	Parts per million
SAU	=	Sher-e- Bangla Agricultural University
t ha^{-1}	=	Tons per hectare

Chapter 1

Introduction

INTRODUCTION

Rice (*Oryza sativa* L.) is the dominant staple food for many countries in Asia and Pacific, South and North America as well as Africa. Rice is grown in more than a hundred countries with a total harvested area of nearly 160 million hectares, producing more than 700 million tones every year. Rice cultivation is favoured by the hot, humid climate and the large number of deltas across Asia's vast tropical and subtropical areas. As a main source of nourishment for more than two billion people in Asia and many millions in Africa and Latin America, it is by far one of the most important commercial food crops. Rice is a nutritious food, providing about 90 percent of calories from carbohydrates and as much as 13 percent of calories from protein (Anon., 2005).
Rice is the staple food of about 140.6 million people of Bangladesh (BBS, 2006). In Bangladesh, rice is grown under three distinct seasons namely *aus*, *aman* and *boro* in irrigated, rainfed and deep water conditions. The area and the production of rice in our country in 2011-2012 are 11.53 million hectares and 33.91 million tons, respectively (AIS, 2013). The majority of rice area is covered by *aman* (autumn) rice is 5.58 million hectares with the total production of 12.80 million metric tons and the average yield is 2.29 metric tons per hectare (AIS, 2013).

In Bangladesh, more than four thousand landraces of rice are adopted in different parts of this country. Some of these are unique for quality traits including fineness, aroma, taste and protein contents (Kaul *et al.*, 1982). But most high quality cultivars are low yielding (Shakeel *et al*., 2005). Aromatic rices constitute a small but special group of rice which is considered best in quality. These rice have long been popular in the c ontient but now becoming more popular in Middle East, Europe and the United States (Singh *et al.*, 2000). This contains natural ingredient 2- acetyl-1-pyrroline which is responsible for their fragrant taste and aroma (Gnanavel *et al.*, 2010). The demand for special purpose aromatic rice has dramatically increased over the past two decades in the world. Aromatic rice varieties are rated best in quality and fetch a much higher price than non-aromatic rice. The demands for aromatic rice both for internal consumption and also for export show an increasing trend (Das and Baqui, 2000). Most of the aromatic rice varieties in Bangladesh are traditional photo-period sensitive types and are grown during *aman* season (Baqui *et al.*, 1997). Cultivation of fine as well as aromatic rice has been gaining popularity in Bangladesh over the recent years, because of its huge demand both for internal consumption and export (Das and

Baqui, 2000). Aromatic rice varieties have occupied about 12.5% of the total transplant *aman* rice cultivation (BBS, 2005).

Urea is the principal source of N, which is the essential element in determining the yield potential of rice (Mae, 1997). Nitrogen is accociated with plant growth as well as higher yield of rice. Without Nitrogen it is impossible to achieve a desirable yield from rice or a number of crops. A main source of N is urea fertilizer. Generally urea is broadcast in three equal splits- one as basal dose at the time of final land preparation, one at maximum tillering stage and the remaining one at prior to panicle initiation stage. But under this practices high floodwater, pH, high ammonium N concentration in floodwater, high temperature and high wind speed are the factors, which have been identified to enhance ammonium-N loss. Numerous experiments have shown that the efficiency at which N is utilized by wetland rice is only about 30% of the applied fertilizer N and in many cases even less (Prasad and De Datta, 1979). So, any method of fertilizer N application that reduce the concentration of floodwater N(urea + NH_4) in the rice field will be subjected to less loss of N through NH_3 volatization, algal assimilation, denitrification and surface runoff. Modifying urea materials is an important aspect of nitrogen management in rice from the view points of its efficient utilization. These losses of N may be reduced by the deep placement of urea super granules (USG) instead of broadcasting prilled urea (PU). Point placement of USG can increase the efficiency of N utilization by rice in wet season (Roy, 1985). According to Crasswell and De datta (1980) broadcast application of urea on the surface soil causes losses upto 50% but point placement of USG in 10 cm depth results negligible loss. They also stated that USG placement provides a bonus of nitrogen to the soil. This technology improves N-use efficiency by keeping most of the urea N in the soil close to plant roots and out of the floodwater, where it is more susceptible to loss as gaseous compounds or runoff (Mohanty *et al.*, 1999 and Savant and Stangel, 1990). Moreover, in conventional urea fertilization, it is often difficult to determine when to apply the fertilizer to achieve optimal results.

Weeds grow in the crop fields throughout the world. It is often said, “Crop production is a fight against weeds” (Mukhopadhyay and Ghosh, 1981). 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. Since weeds and crops largely use the same resources for their growth, they will compete when these resources are limited (Zimdahl, 1980). Weeds in tropical zones cause yield loss on rice of about 35% (Oerke and Dehne, 2004). Most of the weeds derive their nourishment through rapid development and manifested by quick root and shoot development. Uncontrolled weeds cause grain yield reduction up to 76% under transplanted conditions in India (Singh *et al*., 2004). Weeds are the most competitors in their early growth stages than the later and hence the growth of crops slows down and grain yield decreases (Jacob and Syriac, 2005). Studying competition between weeds and crops can help many societies reach their goals of increased food production (Ehteshami and Esfehani, 2005).

In a rice field, variety of weeds grown are generally classified into three groups namely, grasses, sedges and broadleaf weeds according to their morphological character. In Bangladesh the traditional methods of weed control practices include preparatory land tillage, hand weeding by hoe and hand pulling. Usually two or three hand weeding are normally done for growing a rice crop depending upon the nature of weeds, their intensity of infestation and the crop grown. Hand weeding is highly labor-intensive (as much as 190 person days ha^{-1}) (Roder, 2001). Due to high wages as well as unavailability of labor during peak season, hand weeding is not an economically viable option for the farmers. Weed control in transplant *aman* rice by mechanical and cultural methods is expensive (Mitra *et al.*, 2005). In contrast, chemical weed control is easier and cheaper. On the other hand chemical methods lead to environmental pollution and negative impact on public health (Phuong *et al.,* 2005). However, herbicide selectivity and application dose may reduce the pollution in some extent. This issue needs to examine weed management practices that help keeping lower weed population and better control. So, the vegetation community consisting of rice crops and weeds should be seen and regarded as a competitive and cooperative system that has to be managed appropriately.

Keeping all the points in mind mentioned above, the present piece of research work was under taken with the following objectives.

1. Compare the performance of modern and traditional variety of aromatic rice in aman season,
2. Select the best nitrogen sources for aromatic aman rice,
3. Evaluate the different weed management methods in aromatic *aman* rice, and
4. Find out interaction effect of variety, nitrogen sources and weed control method on the growth, yield and yield contributing characters of T. *aman* rice aromatic rice.

Chapter 2
Review of literature

REVIEW OF LITERATURE

Variety is an important factor as it influences the plant population per unit area, *ava*ilability of sunlight, nutrient competition, photosynthesis, respiration etc. which ultimately influence the growth and development of the crops. In agronomic point of view weed management for modern rice cultivation has become an important issue. Considering the above points, available literature was reviewed under different rice variety and weed control of rice.

2.1. Effect of nitrogen sources

2.1.1. Effect on growth character

2.1.1.1. Plant height

Mishra *et al.* (2000) conducted 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 and reported that USG application increased plant height.

Vijaya and Subbaiah (1997) showed that plant height of rice increased with the application of USG and were greater with the deep placement method of application both N and P compared with broadcasting.

Singh and Singh (1986) worked with different levels of nitrogen as USG, sulphur coated and PU @ 27, 54 and 87 kg ha^{-1}. They reported that deep placement of USG resulted in the highest plant height than PU.

2.1.1.2 Tillering pattern

Mirzeo and Reddy (1989) worked with different modified urea material and levels of N @30, 60 and 90 kg ha^{-1}. They reported that root zone placement of USG produced the highest number of' tillers at 30 or 60 days after transplanting.

Singh and Singh (1986) also reported that the number of tillers m^{-2} was significantly greater in USG than PU in all levels of nitrogen.

2.1.1.3 Leaf area index and total dry matter production

Miah *et al.* (2004) found that LAI was significantly higher in USG receiving plots th2an urea at heading and the total dry matter production was affected significantly by the forms of N fertilizer. USG applied plots gave higher TDM compared to urea irrespective of number of seedling transplanted hill^{-1}. At the same time it also noticed that the difference between treatments for TDM was narrower at early growth stages but became larger in later stages.

Das (1989) reported that the dry matter yield of rice were higher with application of USG.Of various forms and methods of application of N fertilizers to rice grown under flooded conditions, placement of N as USG (1 and 2 g size) in the root zone at transplanting was the most effective in increasing dry matter production and were the lowest with urea applied as a basal drilling (Rambabu *et al*. 1983).

2.1.2. Effect on yield contributing character

2.1.2.1. Effective tillers hill^{-1}

Jee and Mahapatra (1989) observed that number of effective tillers m^{-2} were significantly higher with 90 kg N ha^{-1}as deep placed USG than split application of urea. Rama *et al.* (1989) mentioned that the number of panicles m^{-2} increased significantly when nitrogen level increased from 40 to 120 kg N ha^{-1} as different modified urea materials and USG produced significantly higher number of panicles m^{-2} than split application of PU.

Nayak *et al.* (1986) carried out an experiment under rainfed low land conditions with the amount of 58 kg N ha^{-1}as USG placed in root zone. They showed that USG was significantly superior to as sulphur coated urea (SCU) or applying in split dressing, increasing panicle production unit^{-1} area.

2.1.2.2. Panicle length, filled grains panicle^{-1}, unfilled grains panicle^{-1}, filled grain percentage, 1000 grain weight

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

Ahmed *et al.* (2000) conducted a field experiment to study the effect of point placement of urea supergranules (USG) and broadcasting prilled urea (PU) as sources of N in T.

aman rice. USG and PU were applied @ 40, 80, 120 or 160 Kg N ha^{-1}. A control treatment was also included in the experiment. They reported that USG was more efficient than PU at all respective levels of nitrogen in producing panicle length, filled grains $panicle^{-1}$ and 1000-grain weight.

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 and gypsum coated urea, USG or PU. The coated materials as incorporated before transplanting and USG as placed 5-10 cm deep a week after transplanting and urea as applied in 3 split doses. They showed that N management practices had no significant effect on panicle length and percent sterility.

Roy *et al.* (1985) compared deep placement of urea supergranules (USG) by hand and machine and prilled urea (PU) by 2 to 3 split applications in rainfed rice during 1986 and 1987. They reported that USG performed better than PU in all the parameters tested. Filled grains $panicle^{-1}$ was significantly identical with USG and PU three split treated plots with the highest from PU three split treated plots. Significant difference was observed in 1000-grain weight and highest grain weight was obtained from USG (by hand) treated plots.

Thakur (1991) observed that yield attributes differed significantly due to levels and sources of' nitrogen at 60 kg N ha^{-1} through USG produced the highest panicle weight, number of grains $panicle^{-1}$, 1000- grain weight.

Sen and Pandey (1990) carried out a field trial to study the effects of placement of USG (5, 10 or 15 cm deep) or broadcast PU @ 38.32 kg N ha^{-1} on rice of tall long duration Mashuri and dwarf, short duration Mashuri. They revealed that all depths of USG placement resulted in higher yield characters than broadcast PU; however, differences except for panicle lengths were not significant.

In a field trial, Sarder *et al.* (1988) found that, 94.8 kg N ha^{-1} as basal application of USG gave longer panicle and total number of filled grains $penicle^{-1}$ than the other N sources.

2.1.3. Effect on grain yield and straw yield

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

Ahmed *et al.* (2000) also 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 N.

Balaswamy (1999) found that in an experiment deep placement of nitrogen as urea supergranules reduced the dry weight of weeds resulting in more panicles and filled grains and increased the grain yield of rice over the split application of prilled urea by 0.43 and 0.3 t ha^{-1} and basal application of large granular urea by 0.73 and 0.64 t ha^{-1} in 1985 and 1986, respectively.

Detailed results of the experiments conducted at BRRI during the period from 1975-1985 on USG were presented in a technical session on fertilizer nitrogen deep placement for rice. The recommendation made in that technical session showed that deep placement of urea for rice was superior to split broadcast application during the dry season and the economics of use appeared favorable. But inconsistent results during wet seasons indicate further research is needed. The economic benefit of USG relative to PU was very high during the *boro* season than the transplant *aman* season. However, the benefit was higher in a lower rate of USG application in both seasons (Bhuiyan *et al*., 1998).

Department of Agricultural Extension conducted 432 demonstrations in 72 Upazilla as of 31 districts in Bangladesh during the 1996-97-winter season of' *boro* rice. It was .reported that USG plots, on an average, produced nearly 5 percent higher yields than the PU treated plots while applying 30-40% less urea in the form of USG (Islam and Black, 1998)

Singh and Singh (1997) conducted a field experiment in 1987 in Uttar Pradesh, India, dwarf rice cv. Jaya was given 90 or 120 kg N ha^{-1} as urea super granules, large granular urea or neem cake coated urea. N was applied basally, or in 2 equal splits (basally and panicle initiation). They found that grain yield was highest with 120 kg N (4.65 t ha^{-1}), was not affected by N source and was higher with split application.

Kumar *et al.* (1996) reported that application of USG in the sub soil gave 22% higher grain yield than control. Pandey and Tiwari (1996) conducted a field trial in 1990-91 at Rewa, Madhya Pradesh , rice was given 87 kg N ha^{-1} as a basal application of urea super granules (USG), prilled urea (PU), Mussoorie rock phosphate urea (MRPU), large granular urea (LGU) or nimin [neem seed extract]-coated urea (NCU) or PU, MRPU, LGU and NCU as 66% basal incorporation + 33% top dressing at panicle initiation and found that grain yield was highest with N applied as a basal application of USG or MRPU applied in 2 split applications. Rashid *et al.* (1996) conducted field experiments in two locations of Gazipur district during *boro* season (Jan-May) of 1989 to determine the nitrogen use efficiency of urea supergranules (USG) and prilled urea (PU) irrigated rice cultivation. It was observed that 87 kg N ha^{-1} from USG produced the highest grain yield. However, 58 kg N ha^{-1} from USG and 87 kg N ha^{-1} from PU produced statistically similar grain yield to that of 87 kg ha^{-1} from USG.

Bastia and Sarker (1995) conducted a field trial in Kharif seasons with rice cv. Jagnnath was given lac-coated urea and observed that grain yield and N content were 4.07 t ha^{-1} and 1.43% respectively with USG and the lowest 2.66 t ha^{-1} and 1.31% with PU.

Dweivedi and Bajpai (1995) observed through using 0 to 90 kg N ha^{-1} as urea, USG + urea or urea spray and they found that grain yield and net returns increased with the increased rate of N application and were highest with USG and lowest with urea spray.

Harun *et al.* (1995) studied in the farmer's fields at the BRRI project area, Gazipur during the *boro* seasons of 1988-89 and 1989-90 to compare of urea supergranules (USG) and prilled urea (PU) application in irrigated rice. Nitrogenous fertilizers were applied at the rate of 29, 58 and 87 kg ha^{-1}, separately, from USG and PU. The performance of USG was found better than that of PU in relation to grain yield.

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 @ 80 ka ha^{-1}. They showed that USG and urea dicyandiamide produced significantly more panicles grains $panicle^{-1}$, panicle weight and grain yield than PU @ 80 kg N ha^{-1}. Swain *et al.* (1995) evaluated the performance of USG application methods in low land transplanted rice. He reported that USG gave higher grain and straw yield.

Das and Singh (1994) pointed out the grain yield of rice cv. RTH-2 during Kharif season was greater for deep placed USG than USG for broadcast and incorporated or three split applications of PU. Mishra *et al*. (1994) conducted a field trial with rice cv. Sita giving 0 or 80kg N ha^{-1} as urea, urea supergranules, *neem* coated urea. They reported that the highest grain yield was obtained by urea in three split applications (3.39 t ha^{-1}). Quayum and Prasad (1994) conducted field trials during Kharif season with 5 rates of N (0, 37.5, 75, 112.5 and 150 kg ha^{-1}) and six different sources of nitrogen with rice cv. Sita and found that application of up to 112.5 kg N ha^{-1} increased grain (4.37 t ha^{-1}) and straw yields (5.49 t ha^{-1}). They also reported that N applied as USG gave the best yield and concluded that slow release fertilizers were effective for rainfed lowland rice.

Bhale and Salunke (1993) conducted a field trial to study the response of upland irrigated rice to nitrogen applied through urea and USG. They found that grain yield increased with up to 120 kg urea and 100 kg USG. Bhardwaj and Singh (1993) observed that placement of 84 kg N as USG produced a grain yield t ha^{-1} which was similar to placing 112 kg USG and significantly greater than nitrogen sources and rates. Budhar and Palaniappan (1993) compared the performance of 30 or 60 kg N ha^{-1} as PU, lac-coated urea or USG applied as basal, split or deep placement in Jalmagna rice. They reported that grain yield and N uptake increased with the rate of N application and was highest with deep placement USG. They also reported that N use efficiency was highest with 30 kg N ha^{-1} as deep placement of USG. Harun *et al.* (1993) compared the benefits of USG application over PU and they found that USG produced at least 25% higher yield than PU and the marginal rate of return highest for USG at 58 kg N ha^{-1}.

Singh *et al*. (1993) pointed out that application of 30 or 60 kg N ha^{-1} as PU or USG gave the highest grain yield and N uptake increase with the rate of N application and were highest with deep placed USG. N use efficiency was the highest with 30 kg N ha^{-1} from deep placed USG.

Zaman *et al.* (1993) conducted two experiments on a coastal saline soil at the Bangladesh Rice Research Institute (BRRI), Regional station, Sonagazi in 1988 and 1989 *aus* seasons to compare the efficiencies of prilled urea (PU) and urea supergranules (USG) as sources of N for upland rice. The N doses used as treatments were 29 kg ha^{-1} and 58 Kg ha^{-1} for both PU and USG. The test variety was BR20. They found that USG consistently produced significantly higher grain yield and straw yield than PU.

Bhagat *et al.* (1992) conducted a field experiment with rice cv. IR 36 and was given 56 kg N ha^{-1} as prilled urea, large granule urea or urea supergranules or 84 kg N as prilled urea produced mean grain yields of 2.15, 2.18, 2.25, 2.58 and 2.72 t ha^{-1}, respectively, compared with the control (given no N) yield of 1.48 t ha^{-1}. They reported that the relative N use efficiency was the highest from the application of 84 kg N as prilled urea. Johnkutty and Mathew (1992) conducted an experiment with different forms of nitrogen on rice cv. Jyothy during rainy season and reported that 84 kg N ha^{-1} USG gave higher yield than PU.

Sahu *et al.* (1991) worked on the method of application of USG in low land rice soil and showed that USG gave higher yields than PU when USG was placed at midway between at every alternate 4 hills. Satrusajong *et al.* (1991) conducted a field experiment to study the effect of N and S fertilizers on yields of' rainfed low land rice. They found that rice yield was statistically greater for deep placement of urea as USG than all other N fertilizer treatments that included PU, urea amended with increase inhibitor and ammonium phosphate sulfate (16% N, 8.6% P). Thakur (1991b) carried out an experiment in 1986 on silty loam soil. The effect of N @ 0, 30 or 60 kg ha^{-1} as PU, USG or urea briquettes were evaluated on yield and N use efficiency of rice cv. IET 7599, IET 7300, IET 6903 and Pankaj, he reported that USG gave highest grain yield and N use efficiency of 19.0 kg $grains^{-1}$ kg N.

Singh *et al.* (1991) studied the effect of sources and level of N on the yield, yield attributes and N uptake of rice and reported that yield was affected significantly due to sources and levels of N. Deep placement of USG showed the highest grain yield (2.59 t ha^{-1}) followed by 2.43, 2.32 and 2.15 t ha^{-1} with sulphur coated urea, Mussoorie rock phosphate-coated urea and PU, respectively.

The USG @ 75 kg N ha^{-1} gave grain yield of 5.22 t ha^{-1} whereas prilled urea gave only 4.29 t ha^{-1} with the same rate. Uptake and use efficiency of N were also higher with USG compared to prilled urea (Chakraborti *et al*., 1989).

Chauhan and Mishra (1989) found that application of N@ 20, 80, 120 kg ha^{-1} as USG gave grain yield 4.08, 4.86 and 5.17 t ha^{-1} and as PU gave 3.95, 3.72 and 4.33 t ha^{-}

^{1}respectively. Deep placement of USG proved superior to PU. Mirzeo and Reddy (1989) also reported that deep placement of USG gave 10.3% more grain yield than PU or *neem* coated urea. The straw yields also the highest with USG.

Mohanty *et al.* (1989) observed that placement of USG in rice gave significantly higher grain and straw yields of 36 and 39% in dry and 17 and 18% in wet season, respectively than split application of PU.

Sahu and Mitra (1989) reported that higher grain yields were obtained with large granular urea @ 60 or 90 kg N ha^{-1} applied in two splits (7 days after transplanting and panicle initiation stage) than with PU. USG gave higher yields than large granular urea or PU.

Lal *et al.* (1988) reported that placement of N as USG and broadcast incorporation of SCU were superior to PU (applied in three split surface dressings) at 29, 58 and 87 kg N ha^{-1} but not at 116 kg N ha^{-1}. SCU gave the highest grain yield followed by USG and both maintained superiority over PU up to 87 kg N ha^{-1}. On other hand Zia *et al*. (1988) reported that urea in three split applications produced the maximum rice yield followed by SCU, USG, UNS.

Raju *et al.* (1987) conducted an experiment with different sources of N fertilizers @ 0, 37.5, 75, 112.5 and 150 kg N ha^{-1}. They reported that among all the sources of N, USG recorded highest grain yield (5.4 t ha^{-1}) and proved significantly superior to rest of the sources. The increase in yield due to USG over urea application was to the turn of 14.7%. The rest of N sources failed to exert any differential effect on yield.

Setty *et al.* (1987) evaluated different levels of modified urea on rice as USG and sulphur coated urea. They observed that grain yield increased significantly with increase N rate up to 87 kg ha^{-1}. Sulphur coated urea and USG gave similar yields, which were significantly higher than urea in 2-3 split application. N use efficiency was greater with sulphur coated and USG than urea.

Tomar (1987) investigated that split applications of PU, sulphur coated urea (SCU), Mussorie phos-coated urea (MPCU) and USG @ 58, 87 or 116 kg N ha^{-1} of rice in Kharif season gave higher grain yield from USG and sulphur coated urea @ 87 kg N ha^{-1} than other two forms of urea.

Patel and Chandrawansi (1986) conducted an experiment with rice cv. Sumridhi (R-23.84) giving without N, or with 40 kg N ha^{-1} as urea broadcast and incorporated as a basal dose before sowing USG applied in furrows and seeds drilled in alternate rows, urea or USG and seed drilled in the same furrow. They reported that the treatments did not significantly affect the number of panicles m^{-2} but yield was highest (2.4 t ha^{-1}) in the last of the above treatments.

Reddy *et al*. (1986) reported that N as USG placed in the root zone in soil gave significantly higher yields than N as *neem* cake coated urea, Dicyandiamide incorporated urea mixed with moist soil or urea.

Savant *et al.* (1983) found that deep application of USG was 11101-c effective in terms of yield than broadcast application of urea for wetland rice.

Evaluation of rice program during 1975 to 78 showed that deep placement of USG is an effective means of increasing rice yields compared with traditional split application of PU (Craswell and De Datta, 1980).

2. 2. Effect of variety

Variety itself is the genetical factor which contributes a lot for producing yield and yield components. Different researcher reported the effect of rice varieties on yield contributing component and grain yield. Some available information and literature related to the effect of variety on the yield of aromatic & non- aromatic rice are discussed below.

2.2.1. Effect on growth characters

2.2.1.1 Plant height

Bisne *et al.* (2006) conducted an experiment with eight promising varieties using four CMS lines and showed that plant height differed significantly among the varieties and Pusa Basmati gave the highest plant height in each line.

BRRI (2000a) evaluated that performance of four varieties viz. Basmati 406(4508),
Kataribhog and BRRI dhan34 during aman season and reported that plant height differed significantly among the varieties Result revealed that the tallest plant (126cm) was recorded from Basmati 406 and the shorter one (115cm) was observed due to kataribhog.

Om *et al.* (1998) conducted an experiment with hybrid rice cultivars ORI 161 and

PMS 2A x IR 31802 and found taller plants in ORI 161 than in PMS 2A x IR 31802.

Alam *et al.* (1996) conducted an experiment to evaluate the performance of different rice varieties. Among that varieties, Kalijira produced the tallest plant, which was followed by pajam. But among the others, BR9 produced the highest plant height followed by BR7 and these were statistically identical with pajam.

BINA (1993) evaluated the performance of four rice varieties- IRATOM 24, BR14, BINA13 and BINA19. It was found that varieties differed significantly in respect of plant height.

BRRI (1991) conducted that plant height differed significantly among BR3, BR11, BR14, Pajam and Zagali varieties in *boro* season.

Hosain and Alam (1991) found that the plant height in modern rice varieties in *boro* season BR3, BR11, BR14 and pajam were 90.4, 94.5, 81.3 and 100.7 cm respectively.

Miah *et al.* (1990) conducted an experiment where rice cv. Nizersail and mutant lines Mut. NSI and Mut. NSS were planted and found that plant height were greater in Mut. NSI than Nizersail.

2.2.1.2 Tillering pattern

Bisne *et al.* (2006) conducted an experiment with eight promising varieties using four CMS lines and showed that tiller number hill^{-1} differed significantly among the varieties and Pusa Basmati gave the highest tiller number hill^{-1} in each line.

Jones *et al.* (1996) reported that two experiments were conducted in 1994 to identify weed competitive cultivars. The varieties CG14 and CG20 gave the maximum tillers under all levels of management.

2.2.1.3 Total dry matter production

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

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

2.2.2. Effect on yield contributing characters

2.2.2.1. Effective tillers hill^{-1}

Jones *et al.* (1996) conducted two experiments in 1994 to identify weed competitive cultivars. The varieties CG14 and CG20 gave the maximum tillers under all levels of management.

2.2.2.2. Panicle length, filled grains panicle $^{-1}$, unfilled grains panicle^{-1}, filled grain percentage, 1000-grain weight

Hossain *et al.* (2007) conducted a field experiment at the Hajee Mohammad Danesh Science and Technology University Farm, Dinajpur, Bangladesh during transplant *aman* (T. *aman)* season of 2004 and found that weight of 1000 grains was highest in BRRI dhan38.

Guilani *et al.* (2003) studied on crop yield and yield components of rice cultivars (Anboori, Champa and LD183) in Khusestan, Iran, during 1997. Grain number panicle^{-1} was not significantly different among cultivars. The highest grain number panicle^{-1} was obtained with Anboori. Grain fertility percentages were different among cultivars. Among cultivars, LD183 had the highest grain weight.

BRRI (1998a) revealed that 1000-grain weight was 24, 22, 25, 20, 23, 18 and 17g in Kuicha Binni, Leda Binni, Dudh methi, Maraka Binni, Nizershail and BR25 respectively.

Ahmed *et al.* (1997) conducted an experiment to compare the grain yield and yield components of seven modern rice varieties (BR4, BR5, BR10, BR11, BR22, BR23, and BR25) and a local improved variety, Nizersail. The fertilizer dose was 60-60-40 kg ha^{-1} of N, P_2O_5 and K_2O, respectively for all the varieties and found that percent filled grain was the highest in Nizersail followed by BR25 and the lowest in BR11 and BR23.

2.2.3. Effect on grain yield and straw yield

Al-Mamun *et al.* (2011) carried out an experiment at the Agronomy Farm of Bangladesh Rice Research Institute, Gazipur, During December 2008 to June 2009 in winter season on Surjamoni and BRRI dhan29 and observed that the highest grain yield (6.96 t ha^{-1}) was obtained from Surjamoni when treated with Bouncer 10WP @ 150g ha^{-1}, which was 49% higher than control. BRRI dhan29 produced also the highest grain yield when treated with same treatment, which was 37% higher than control.

Bhuiyan *et al.* (2011) conducted a field experiment to evaluate the performance of different weed management options regarding effective weed control, yield and yield contributing characters of three popular BRRI *aman* varieties having different growth duration (BRRI dhan39, BRRI dhan49 and BR11) in 2008 and 2009 at Bangladesh Rice Research Institute, regional station, Rajshahi and found that among the varieties, BR11 produced significantly higher yield (5.02 t ha^{-1}) and lowest yield was recorded in BRRI dhan39 (3.58 t ha^{-1}).

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

Reza *et al*. (2010) carried out an experiment at the Agronomy Field Laboratory, Bangladesh Agricultural University (BAU), Mymensingh, during the period from January to April 2008 and found that Pajam produced the higher grain yield (4.0 t ha^{-1}) than BRRI dhan28 (2.79 t ha^{-1}).

Bisne *et al.* (2006) conducted an experiment with eight promising varieties using four CMS lines and showed that grain yield differed significantly among the varieties and Pusa Basmati gave the highest grain yield in each line.

BRRI (2000a) evaluated the performance of three advanced lines BR438-2B-2-2-2-4, BR4384-2B-2-2-6 and BR4284-2B-2-2-HR3 along with two standard checks and seven local checks in 11 locations. Kataribhog and Khaskani were used as standard check and Chinking, Basmati, Kalijira, Philippine Katari, Chinigura, Chiniatop and Bashful as local checks. In Sonagazi and Bogra sadar, the yield performances of advanced lines were excellent with more than 4.0 t/h. About 30% higher yield was obtained from the advanced lines over the checks.

Franje *et al.* (1992) found that tall traditional cultivars to be more competitive than the relatively short stature BRRI advanced lines. However they concluded that yields of modern cultivars improved with increased weeding while yields of traditional cultivars did not.

2.3. Effect of weed control Method

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

2.3.1. Effect on growth characters

2.3.1.1. Plant height

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

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

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

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

2.3.1.2. Tillering pattern

Khan and Tarique (2011) carried out an experiment during June to December 2006 and observed that highest total tillers plant^{-1} was observed in completely weed free condition throughout the crop growth period. On the other hand, total tillers plant^{-1} that appeared next to the highest was found in two hand weeding treatment. However, shorter plant was found in no weeding treatment.

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

Ashraf *et al.* (2006) conducted an experiment in Lahore, Pakistan, during 2004 and 2005 in kharif seasons, for screening of herbicides for weed management in transplanted rice (cv. Basmati-2000). Hand weeding resulted in 20.8 compared to 16.6 for the control in case of total tillers plant^{-1}.

2.3.1.3. Total dry matter production

Bhuiyan *et al.* (2011) conducted a field experiment to evaluate the performance of different weed management options regarding effective weed control, yield and yield contributing characters of three popular BRRI *aman* varieties having different growth duration (BRRI dhan39, BRRI dhan49 and BR11) in 2008 and 2009 at Bangladesh Rice Research Institute, regional station, Rajshahi and found that total dry matter was significantly highest in plot of three hand weeding at 15, 30 & 45 DAT, 20.17 g m^{-2} and post-emergence herbicide + 1 hand weeding at 30 DAT, 22.2 g m^{-2}.

Reza *et al.* (2010) carried out an experiment at the Agronomy Field Laboratory, Bangladesh Agricultural University (BAU), Mymensingh, during the period from

January to April 2008 and found that *Echinochloa crusgalli* was the major weed having the highest absolute density (12.70 m^{-2}), relative density (36.95 m^{-2}), dry matter accumulation (1.85 g m^{-2}) and intensity of weed infestation (0.46).

BRRI (1998) reported that Cinosulfuron and Oxadiazon showed better performance than Butachlor in terms of biomass and plant population and also stated that two hand weeding gave the highest weeding cost of herbicide treatment.

2.3.1.4. Crop growth rate and relative growth rate

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

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

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

Irshad *et al.* (2002) carried out an experiment on growth analysis of transplanted fine rice under different competition durations with Barnyard grass to identify the effect of different competition periods of barnyard grass (0, 20, 40, 60 and throughout the growth period after transplanting) on the growth behavior of fine rice. They stated that CGR showed significant differences due to different durations of barnyard grass competition.

2.3.2. Effect on yield contributing characters

2.3.2.1 Effective tillers hill^{-1}

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

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

Raju *et al.* (2003) observed the effect of pre-emergence application of Pretilachlor plus Safener 0.3 kg ha^{-1}, Butachlor 1 kg ha^{-1} and post-emergence herbicide like Butanil 3.0 kg ha^{-1} on 4, 8 and 15 days after sowing. They found that Pretilachlor plus Safener 0.3 kg ha^{-1} gave the highest productive tillers m^{-2}.

2.3.2.2. Panicle length, filled grains panicle $^{-1}$, unfilled grains panicle^{-1}, filled grain percentage, 1000-grain weight

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

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

Karim and Ferdous (2010) conducted an experiment at the net house of the Department of Agronomy, Bangladesh Agricultural University during the period from June to December 2008 to study the effects of plant density of grass weeds on plant characters and grain production of transplanted *aus* rice cv. BR26. They found that the number of filled grains panicle^{-1} and 1000 grain weight were negatively related to weed density.

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

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

2.3.3. Effect on grain yield and straw yield

Al-Mamun *et al.* (2011) carried out an experiment at the Agronomy Farm of Bangladesh Rice Research Institute, Gazipur, During December 2008 to June 2009 in winter season on Surjamoni and BRRI dhan29 and observed that the highest grain yield (6.96 t ha^{-1}) was obtained from Surjamoni when treated with Bouncer 10WP @ 150g ha^{-1}, which was 49% higher than control. BRRI dhan29 produced also the highest grain yield when treated with same treatment, which was 37% higher than control.

Khaliq *et al.* (2011) reported that manual weeding scored highest paddy yield of 4.17 t ha^{-1}. Bispyribac sodium with 3.51 t ha^{-1} paddy yield appeared superior to penoxsulam.

Sorghum, sunflower and wheat residues resulted in statistically similar paddy yields of 2.85, 2.80 and 2.58 t ha^{-1}, respectively. Bispyribac sodium exhibited maximum marginal rate of return of 23.76%. Chemical control proved to be a viable strategy with higher economic returns.

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

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

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

Ali *et al.* (2010) conducted an experiment at the Agronomy farm, Sher-e- Bangla Agricultural University, Dhaka during the period July-December, 2006 to evaluate weed control and yield of transplanted *aman* rice (cv. BRRI dhan37) as affected by integrated weed management and spacing and observed that among the weed control treatments Pretilachlor + one hand weeding at 40 DAT performed best for controlling weeds which ultimately contributed to the highest grain yield (3.60 t ha^{-1}).

BARI (2010) carried out an experiment at Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh (BSMRAU) during 2007-08 using eight herbicides, i.e. Oxadiazone, Butachlor, Pretilachlor and Anilphos from pre-emergence, and MCPA, Ethoxysulfuran, Pyrazosulfuran Ethyl and Oxadiarzil from post-emergence category in transplanted wetland rice during *aman* (autumn), *aus* (summer) and *boro* (winter) growing seasons to study their effects on weed control and rice yield and found that the highest grain yield of 4.18 t ha^{-1} was contributed by weed free treatment, while the least (2.44 t ha^{-1}) was by weedy check. Among the herbicide treatments, the highest grain yield of 4.08 t ha^{-1} was obtained from Butachlor, while the lowest (2.83 t ha^{-1}) grain production was harvested in the plots receiving MCPA @ 125% of the recommended rate. Results further revealed a positive relationship between Butachlor rate and grain yield, although a declining trend was apparent at higher than the recommended rates, while a negative relationship was found in MCPA treatments.

Bhuiyan *et al.* (2010) conducted an experiment during *boro* 2006 at Gazipur and Comilla location for the control of mixed weed flora in transplanted rice (*Oryza sativa L.*) and stated that among different treatment, weed free plots produced highest grain yield followed by Oxadiargyl 400SC @ 75 g a.i. ha^{-1} which is comparable with other doses of Oxadiargyl 400SC in both locations.

Gnanavel and Anbhazhagan (2010) suggested that pre-emergence application of Oxyfluorfen 0.25 kg ha^{-1} followed by post-emergence application of bispyribac sodium 0.05 kg + metsulfuron methyl @ 0.01 kg ha^{-1} recorded higher grain yield of aromatic rice (5.32 t ha^{-1}).

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

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

Karim and Ferdous (2010) conducted an experiment at the net house of the Department of Agronomy, Bangladesh Agricultural University during the period from June to December 2008 and stated that the highest grain yield (15.09 g pot^{-1}) was found under weed free condition. Grain yield was reduced by 2.66%, 12.59%, 44.93% and 54.01% due to competition from 2, 4, 6 and 8 number of weeds of *E. indica*, whereas the yield was reduced by 57.19%, 58.98%, 82.31% and 79.26%, respectively due to competition from 2, 4, 6 and 8 number of weeds of *E. crusgalli*.

Nahar *et al.* (2010) carried out a field experiment to study the effect of spacing and weeding regime on the performance of transplant *aman* rice cv. BRRI dhan41 and reported that weed free condition produced the highest grain yield (4.35 t ha^{-1}) whereas no weeded condition produced the lowest grain yield (2.02 t ha^{-1}).

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

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

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

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.

BRRI (2006) stated that weed infestation and interference is a serious problem in rice fields that significantly decreases yield. In Bangladesh, weed infestation reduces rice grain yield by 70-80% in *aus* rice, 30-40% in transplanted *aman* rice and 22-36% for modern *boro* rice cultivars.

Manish *et al.* (2006) said that hand weeding at 15 and 30 DAT (days after transplanting) gave the highest grain yield, straw yield and harvest index.

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

Mitra *et al.* (2005) suggested two times weeding as the best practice to keep weed infestation at minimum level and to ensure higher yield in transplanted *aman* rice. Other than weed free condition, the highest grain yield (5.07 t ha^{-1}) was produced in two hand weeding and the lowest (2.46 t ha^{-1}) was in unweeded condition. One hand weeding at 25 DAT along with one mechanical weeding at around 40 DAT was also found to be effective next to two hand weeding in these regards. Pre-emergence herbicide Rifit 500 EC was not effective to keep weed infestation at minimum level and to ensure higher yield in transplanted *aman* rice.

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

Singh *et al*. (2004) reported that weed management is one of the major factors, which affect rice yield. Uncontrolled weeds cause grain yield reduction up to 76% under transplanted conditions.

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 grain yield (3.36 t ha^{-1}) and straw yield (6.53 t ha^{-1}).

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

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

Tamilselvan and Budhar (2001) studied the effects of pre-emergence herbicides Pretilachlor 0.4 kg a.i. ha^{-1}, Pretilachlor 0.4 kg a.i. ha^{-1} on rice cv. ADT 43. The herbicides were applied 8 days after sowing. The density and dry weight of weeds at 40 DAS were lower in herbicide treated plots than in unweeded and hand weeded plots. The weed control treatment had effect in increasing grain yield.

Gogoi *et al.* (2000) from Assam reported that different weed control practices significantly reduced the dry matter accumulation of weed and increased the rice yield over the unweeded control in transplanted rice. They also observed that combined weed control treatment like Oxadiazon 2.0 L ha^{-1} + 1 hand weeding increased grain yield (5.12 t ha^{-1}).

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.

Moorthy *et al.* (1999) observed the performance of the pre-emergence herbicides Pretilachlor + safener, Butachlor + safener, Butachlor, Anilofos + Ethoxysulfuron, Thiobencarb and Anilofos for their efficiency to control weeds in direct sown rice under puddled soil condition. They observed that Pretilachlor + safener (0.4 kg ha^{-1} and 0.6 kg ha^{-1}, Butachlor + safener (1.5 kg ha^{-1}) and Anilofos + Ethoxysulfuron

(0.37 + 0.04 kg ha^{-1}) produced yields comparable to those of the hand weeded control.

Sanjoy *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 and significant yield increase was observed (43%) with weed control.

Singh and Kumar (1999) reported that maximum weed dry weight and the lowest grain yield were observed in the unweeded control in the scented rice variety Pusa Basmati-1.

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

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 performance of herbicide in direct seeded puddled rice during kharif season. They observed that the highest grain yield and gross margin was obtained from the Pretilachlor (1.0 kg ha^{-1}) + two hand weeding.

Thomas *et al.* (1997) reported that rice weed competition for moisture was maximum during initial stages and yield losses from uncontrolled weeds might be as high as 74%.

Bhattacharya *et al.* (1996) reported that although the hand weeding treatment gave the highest grain yield, the results indicated that this was laborious, time consuming and costly and hand weeding could be replaced by application of Butachlor at 1.00 kg a.i. ha^{-1}.

Madhu *et al.* (1996) at Bangalore, investigated the effectiveness of four herbicides, Pendimethylin, Anilofos, Butachlor and Oxyfluorfen at 2 application rates during dry and wet seasons in puddled seeded rice field and the results showed that grain and straw yields were higher in the plots treated with Butachlor @ 1.5 kg ha^{-1}.

Mandal *et al.* (1995) reported the efficacy Pretilachlor as herbicide in comparison to hand weeding in BR11 variety. The lower doses of Pretilachlor at 1.00 L ha^{-1} failed to kill the weeds properly. The grain yield reduction due to weed infestation was 20.30%.

Kamalam and Bridgit (1993) reported that the average reduction in grain yield due to weed competition was 56 %.

BRRI (1990) stated that there was no significant difference in rice yield for using Oxadiazon as well as hand weeding. The highest grain yield was obtained from Oxadiazon @ 0.5 kg a.i. ha^{-1}.

Purushotham *et al.* (1990) observed that Oxadiazon (0.5 kg a.i. ha^{-1}) increased the grain and straw yields significantly than two manual weeding at 25 and 45 DAT.

Shivamdiah *et al.* (1987) investigated that Oxadiazon 0.75 kg ha^{-1} + one hand weeding gave significantly greater yields than herbicides alone. They also found that combination of herbicidal treatment and one hand weeding gave higher straw yield.

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%.

Chapter 3

Materials and Methods

MATERIALS AND METHODS

This chapter presents a brief description about experimental period, site description, climatic condition, crop or planting materials, treatments, experimental design and layout, crop growing procedure, fertilizer application, uprooting of seedlings, intercultural operations, data collection and statistical analysis.

3.1. Location

The field experiment was conducted at the Agronomy field laboratory, Sher-e- Bangla Agricultural University, Dhaka during the period from July to December, 2013. The location of the experimental site has been shown in Appendix I.

3.2. Soil

The soil of the experimental area belonged to the Modhupur tract (AEZ No. 28). It was a medium high land with non-calcarious dark grey soil. The pH value of the soil was 5.6. The physical and chemical properties of the experimental soil have been shown in Appendix II.

3.3. Climate

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

3.4. Treatments

The experiment consisted of three factors as mentioned below:

Factor A: Sources of Nitrogen

i. Control (N_1)
ii. Prilled urea (N_2)
iii.Urea super granules , USG (N_3)

Factor B: Varieties

i. Kalijira (V_1)
ii. BRRI dhan37 (V_2)
iii.BRRI dhan38 (V_3)

Factor C: Weed control method

i. No weeding (Control) (W_1)
i i.Two hand weeding at 20 and 40 DAT (W_2)
iii. Pre-emergence herbicide Rifit 20EC (W_3)

The description of the sources of nitrogen is given below.

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

Control (No nitrogen)

No nitrogenous fertilizer was not used in the control treatment.

Prilled Urea (PU)

Ordinary or prilled urea is the most common form of urea available in the market. It contains 46% N. The mean diameter of PU is 1.5 mm.

Urea supergranules (USG)

Urea supergranules fertilizer was manufactured from a physical modification of ordinary urea fertilizer. The International Fertilizer Development Centre (IFDC), Muscle Shoals, Alabama 35660, USA, has developed it. Its nature and properties are similar to that of urea. But its granule size is bigger and condensed with some conditions for slow hydrolysis.USG is spherical in shape containing 46% N which is similar to that of PU average diameter of the granule is 11.5mm. It is not a slow release fertilizer but can be considered as a slowly available N fertilizer. The supergranules are made by compressing prilled or granular urea in small machines with indented pocket rollers that, depending on the size of the pocket, produce individual briquettes varying in weight from 0.9 to 2.7 g. Within a week after transplanting rice, the supergranules are inserted into the puddled soil by hand, being placed to a depth of 7–10 cm in the middle of alternating squares of four hills of rice. Often refer to as urea deep placement (UDP).

Plant materials and features

Rice cv. BRRI dhan38, BRRI dhan37 and Kalijira were used as plant materials for the present study. These varieties are recommended for aman season. All of the variety had photo sensitivity. The features of these three varieties are presented below:

BRRI dhan38: BRRI dhan38 variety is grown in *aman* season. It is modern transplanted *aman* rice released by BRRI in 1997. The grain is short, thick and scented. The cultivar matures at 140 days of planting. It attains a plant height 117 cm. It is semi-photosensitive and semi-lodging tolerant. Its grain is long slender. The cultivar gives an average yield of 3.50 t ha^{-1} (BRRI, 2011).

BRRI dhan37: It is modern transplanted *aman* rice developed from a cross of Basmati (D) and BR5 and released in 1998. The grains are of medium size and slender. The color, size and scent of BRRI dhan37 rice is about Katarivog. The end point of the rice grain is slightly bended and possesses a needle like small awn. The cultivar is photosensitive. It takes about 140 days to mature. The plant height of this cultivar is about 125cm. It has the average yield potential of about 3.50 t ha^{-1} (BRRI, 2000).

Kalijira: Kalijira is a local transplanted *aman* rice. It is highly photosensitive in nature and thus only adopted in transplanted *aman* season. This cultivar matures at 130-135 days of planting. It is well known for its characteristic aroma with short grain.

The description of the weeding treatments is given below:

1) No weeding: Weeds were allowed to grow in the plots from transplanting to harvesting of the crop.

2) Two hand weeding: Two hand weedings were done at 20 and 40 DAT, respectively.

3) Rifit 20EC was applied @ 400-600 ml $acre^{-1}$ at 5 DAT in 4-5 cm standing water for 3-5 days as pre-emergence herbicide.

3.5.1. Design and layout

The experiment was laid out in a split split plot design with three replications. The size of the individual plot was 4m x 2.5 m and total numbers of plots were 81.There were 27 treatment combinations. Each block was divided into 27 unit plots. Nitrogen sources was placed along the main plot, Variety in the sub plot and weeding treatments were placed in the sub sub plot. Lay out of the experiment was done on July 25, 2012 with interplot spacing of 0.50 m and inter block spacing of 1 m.

3.5.2. Seed collection, sprouting and sowing

Seeds of BRRI dhan38 and BRRI dhan37 were collected from Bangladesh Rice Research Institute, Joydebpur, Gazipur. Seeds of Chinigura were collected from dinajpur district. Initially seed soaking was done in water for 24 hours and after wards they were kept tightly in jute sack for 3 days. When about 90% of the seeds were sprouted, they were sown uniformly in well prepared wet nursery bed on July 5, 2012. Seed bed size was 10 m long and 1.5 m wide.

3.5.3. Land preparation

The experimental field was opened by a tractor driven rotavator 15 days before transplanting. It was then ploughed well to make the soil nearly ready for transplanting. Weeds and stubble were removed and the field was leveled by repeated laddering. The experimental field was then divided into unit plots and prepared before transplantation.

3.5.4. Fertilizer application

The field was fertilized with nitrogen, phosphate, potash, sulphur and zinc at the rate of 120, 100, 70, 60 and 10 kg ha^{-1} respectively in the form of urea, triple super phosphate, muriate of potash, gypsum and zinc sulphate. The whole amount of all the fertilizers except urea were applied at the time of final land preparation and thoroughly incorporated with soil with the help of a spade. Urea was top dressed in three equal splits on 15, 30, and 45 DAT.

3.5.5. Uprooting and transplanting of seedling

The seedbeds were made wet by the application of water both in the morning and evening on the previous day before uprooting on August 1, 2012. The seedlings were then uprooted carefully to minimize mechanical injury to the roots and kept on soft mud in shade before they were transplanted. The twenty five days old seedlings were transplanted on the well puddled experimental plots on August 1, 2012 by using two seedlings $hill^{-1}$.

3.5.6. Intercultural operations

The following intercultural operations were done for ensuring the normal growth of the crop.

3.5.7. Gap filling

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

3.5.8. Weeding

Weeding was done as per the experiment treatment.

3.5.9. Irrigation and drainage

The experimental plots required two irrigations during the crop growth season and sometimes drainages were done at the time of heavy rainfall.

3.5.10. Plant protection measures

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

3.5.11. Detecting the flowering stage (50%) and observation of heading

With experience, it was felt that identifying the flowering stage should need to follow regular field observations as flowering date (50%) were recorded after visual observations. 50% flowering was observed at 10, 15 and 18 august for Kalijira, BRRI dhab38 and BRRI dhan37 respectively.

3.5.12. General observations of the experimental field

Regular observations were made to see the growth stages of the crop. In general, the field looked nice with normal green plants which were vigorous and luxuriant in the treatment plots than that of control plots. At grain maturity stage local variety Kalijira was lodged and modern variety were lodged to some exten in case of prilled urea application but incase of USG the plants remain strong and on lodging was occurred.

3.5.13. Harvest and post-harvest operation

The maturity of crop was determined when 85% to 90% of the grains become golden yellow in color. From the centre of each plot 1 m^2 area was harvested to determine yield of individual treatment and converted into t ha^{-1}. The harvested crop of each plot was bundled separately, tagged properly and brought to threshing floor. The bundles were dried in open sunshine, threshed and then grains were cleaned. The grain and straw weights for each plot were recorded after proper drying in sun. Before harvesting, ten hills were selected randomly outside the sample area of each plot and cut at the ground level for collecting data on yield contributing characters. Harvesting was done at 29th Nov, 5th and 6th December for Kalijira, BRRI dhan38 and BRRI dhan37 respectively.

3.6. Collection of data

3.6.1. Weed parameters

3.6.1.1. Weed density

The data on weed infestation as well as density were collected from each unit plot at 20 days interval up to 80 DAT. A plant quadrate of 1.0 m^2 was placed at three different spots of 10 m^2 of the plot. The middle quadrate was remained undisturbed for yield data. The infesting species of weeds within the first and third quadrate were identified and their number was counted species wise alternately at different dates.

3.6.1.2. Weed biomass

The weeds inside each quadrate for density count were uprooted, cleaned and separated species wise. The collected weeds were first dried in the sun and then kept in an electrical oven for 72 hours maintaining a constant temperature of 80^0C. After drying, weight of each species was taken and expressed to g m^{-2}.

3.6.1.3. Weed control efficiency

Weed control efficiency was calculated with the following formula developed by Sawant and Jadav (1985):

$$\text{Weed control efficiency (WCE)} = \frac{(\text{DWC} - \text{DWT})}{\text{DWC}} \times 100$$

Where,

DWC = Dry weight of weeds in unweeded treatment

DWT = Dry weight of weeds in weed control treatment

3.6.1.4. Relative weed density (%)

Relative weed density was calculated by using the following formula:

$$\text{RWD} = \frac{\text{Density of individual weed species in the community}}{\text{Total weed species in the community}} \text{X100}$$

3.7. Crop growth parameters

a. Plant height (cm) at 20 days interval up to harvest.

b. Tillers hill^{-1} at 20 days interval up to harvest.

c. Dry matter weight of plant at 20 days interval including partitioning of different parts, CGR (Crop Growth Rate), RGR (Relative Growth Rate)

d. Days to flowering

e. Days to maturity

3.8. Yield Contributing Characters

a. Effective tillers hill^{-1}

b. Length of panicle (cm)

c. Fertile spikelets (filled grains) panicle^{-1}

d. Sterile spikelets (unfilled grains) panicle^{-1}

e. Filled grain percentage (%)

f. Weight of 1000 grains (g)

3.9. Yield and harvest index

a. Grain yield (t ha^{-1})

b. Straw yield (t ha^{-1})

c. Biological yield (t ha^{-1})

d. Harvest index (%)

3.10. Procedure of sampling for growth study during the crop growth period

3.10.1. Plant height (cm)

The height of the rice plants was recorded from 15 days after transplanting (DAT) at 20 days interval up to 80 DAT, beginning from the ground level up to tip of the flag leaf was counted as height of the plant. The average height of ten hills was considered as the height of the plant for each plot.

3.10.2. Tillers hill^{-1}

Total tiller number was taken from 20 DAT at 20 days interval up to at harvest. The average number of tillers of ten hills was considered as the total tiller no hill^{-1}.

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

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

$$CGR = \frac{W_2 - W_1}{T_2 - T_1} \text{ g hill}^{-1} \text{ day}^{-1}$$

Where,

W_1= Total plant dry matter at time T_1

W_2 = Total plant dry matter at time T_2

3.11. Procedure of data collection for yield and yield components

For assessing yield parameters except the grain and straw yields data were collected from 10 randomly selected hills from each of the plots. For yield measurement, an area of 1.0 m^2 from center of each plot was harvested.

3.11.1. Plant height

Plant height was measured from the soil level to the apex of the leaf or panicle in randomly 10 hills of each plot.

3.11.2. Effective tillers hill^{-1}

The total number of tillers hill^{-1} was counted from selected samples and were grouped in effective and non-effective tillers hill^{-1}.

3.11.3. Total grains panicle^{-1}

The number of filled grains panicle^{-1} plus the number of sterile grains panicle^{-1} gave the total number of grains panicle^{-1}.

3.11.4. Number of filled grains and sterile grains panicle^{-1}

Number of filled grains and sterile grains from randomly selected 10 hills were counted and average of which gave the number of filled grains and sterile grains panicle^{-1}. Presence of any food material in the grains was considered a filled grain and lacking of any food material in the grains was considered as sterile grains.

3.11.5. Weight of 1000 grains (g)

One thousand cleaned dried grains were randomly collected from the seed stock obtained from 10 hills of each plot and were sun dried properly at 14% moisture content and weight by using an electric balance.

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

An area of 1.0 m^2 harvested for yield measurement. The crop of each plot was bundled separately, tagged properly and brought to threshing floor. The bundles were dried in open sunshine, threshed and then grains were cleaned. The grain and straw weights for each plot were recorded after proper drying in sun.

3.11.7. Biological yield (t ha^{-1})

Biological yield was calculated by using the following formula: Biological yield= Grain yield + straw yield

3.11.8. Harvest index (%)

Harvest index is the relationship between grain yield and biological yield. It was calculated by using the following formula:

$$\text{HI (\%)} = \frac{\text{Grain yield}}{\text{Biological yield}} \times 100$$

3.12. Statistical analysis

The recorded data were subjected to statistical analysis. Analysis of variance was done following two factor split plot design with the help of computer package MSTAT C. The mean differences among the treatments were adjusted by least significant difference (LSD) test at 5% level of significance.

Chapter 4

Results and Discussion

RESULT AND DISCUSSION

The experiment was conducted to evaluate the performance of different aromatic rice varieties with different nitrogen sources and weed control method. BRRI dhan37and BRRI dhan38 were considered as high yielding and Kalijira was considered as local variety and three nitrogen sources viz; control (no urea), Prilled urea and urea super granules and three weed control method viz; control (no weeding), two hand weeding and use of pre-emergence herbicide were treated to find out the results.

4.1. Infested weed species in the experimental field

It is a general observation that conditions favorable for growing aromatic *aman* rice are also favorable for exuberant growth of numerous kinds of weeds that compete with crop plants. This competition of weeds tends to increase when the weed density increases and interfere with the crop growth and development resulting poor yield. Twenty three weed species belonging to ten families were found to infest the experimental crop. Local name, common name, scientific name, family and morphological type of the weed species have been presented in Table 1. The density and dry weight of weeds varied considerably in different weed control treatments.

The most important weeds of the experimental plot were *Cyperus michelianus, Echinochloa crussgalli, Cyperus esculentus, Sagittaria guyanensis, Alternanthera sessilis, Cyperus difformis, Cyperus esculentus* and *Ludwigia octovalvis* respectively. Among the twenty species seven were aquatic, six were grasses, six were sedges, three were broad leaved and one was fern (Table 1). From a survey in BRRI farm, Bhanga, Faridpur and Burichang of Comilla district, Bangladesh, Bhuiyan *et al.* (2011) also reported that weed flora in the experimental plots observed in two agro-ecological zones comprised of grasses *Cynadon dactylon, Echinochloa crus-galli, Leptochloa chinensis,* the sedges*; Cyperus difformis, Scirpus juncoides, Fimbristylis* *miliaceae* and the broadleafs*; Monochoria vaginalis, Lindernia anagallis, Marsilea minuta andSphenoclea zeylanica.* Mamun *et al.* (2011) reported that *Echinochloa crus-galli, Scirpus maritimus, Monochoria vaginalis, Cyperus difformis, Cynodon dactylon, Marsilea minuta, Ludwigia octovalvis, Nymphaea nouchali* and *Desmodium trifolium* were important weed species of transplanted *aman* rice. The present result varied a little bit from those reports and this might be due to seasonal variation and location.

Table1. Weed species found in the experimental plots in transplanted aromatic aman rice

SL No.	Local name	Common name	Scientific name	Family	Types
1	Durba	Bermuda grass	*Cynodon dactylon*	Gramineae	Grass
2	Chanci	Sessile joyweed	*Alternanthera sessilis*	Amaranthaceae	Aquatic
3	Malancha	Alligatorweed	*Alternanthera philoxeroides*	Amaranthaceae	Aquatic
4	Boro Shama	Barnyard Grass	*Echinochloa crussgalli*	Gramineae	Grass
5	Chandmala	Duck weed	*Sagittaria guyanensis*	Alismataceae	Aquatic
6	Sushni	European waterclover	*Marsilea quadrifolia*	Marsileaceae	Fern
7	Arail	Rice grass	*Leersia hexandra*	Gramineae	Grass
8	Joyna	Fringerush	*Fimbristylis miliaceae*	Cyperaceae	Sedge
9	Mutha	Nutgrass	*Cyperus rotundus*	Cyperaceae	Sedge
10	Jhilmorich	Gooseweed	*Sphenoclea zeylanica*	Sphenocleaceae	Broadleaf
11	Chapra	Indian goosegrass	*Eleusine indica*	Gramineae	Grass
12	Nakful	Nutsedge	*Cyperus michelianus*	Cyperaceae	Sedge
13	Behua	Small flower umbrella	*Cyperus difformis*	Cyperaceae	Sedge
14	Holdemutha	Yellow nutsedge	*Cyperus esculentus*	Cyperaceae	Sedge
15	Kanai bashi	Spider wort	*Commelina benghalensis*	Commelinaceae	Aquatic
16	Moyurleja	Red sprangletop	*Leptochloa panicea*	Gramineae	Grass
17	Panilong	Willow primrose	*Ludwigia octovalvis*	Onagraceae	Broadleaf
18	Chotoshama	Jungle rice	*Echinochloa colonum*	Gramineae	Grass
19	Ghagra	Cocklebur	*Xanthium indicum*	Compositae	Aquatic
20	Keshuti	Eclipta	*Eclipta alba*	Asteraceae	Broadleaf

4.2. Weed importance according to date and variety

There are twenty weed species belonging to ten families were found to infest the experimental rice field. Weeds compete with crop plants for space, light, nutrients and water. When competition is severe, crop yield reduces drastically. There is another type of competition exists in the crop field except crop-weed competition i.e. weed-weed competition. In this experiment, several weed species were seen to be dominant at different dates and varieties i.e. weed dominance varied according to dates and variety (Table 2). In BRRI dhan38 (V_3) plots, sedge weeds were dominant (*Cyperus michelianus* and *Cyperus difformis having* 41.17% and 22.14%, respectively) at 40 DAT. On 60 DAT, sedge (*Cyperus esculentus* 22.76%), broadleaf (*Ludwigia octovalvis* and *Sphenoclea zeylanica* having 15.85% and 10.16%) and aquatic weeds (*Alternanthera sessilis* having 12.20%) showed dominance in BRRI dhan38 (V_3) plots. In case of BRRI dhan37 (V_2) plots, sedge weed (*Cyperus michelianus*) was more dominant than in BRRI dhan38 (V_3) plots having 61.9% at 40 DAT, although broadleaf weed (*Sphenoclea zeylanica*12.63%) were also present. At 60 DAT, sedge (*Cyperus esculentus* and *Cyperus difformis*), broadleaf (*Ludwigia octovalvis)*, aquatic (*Alternanthera sessilis*) and grass (*Leptochloa panicea*) weeds were severely infested the plots having 20.69%, 19.09%, 13.68%, 8.97% and 8.97% respectively. In Kalijira (V_1) plots, sedge weeds (*Cyperus difformis, Cyperus michelianus* and *Cyperus rotundus*) were dominant alone having 32.17%, 31.15% and 12.16% respectively at 40 DAT. On 60 DAT, sedge (*Cyperus esculentus* 20.97%), aquatic (*Alternanthera sessilis* 23.42%) and grass (*Echinochloa crussgalli* 9.69%) were found dominant in Kalijira (V_1) plots.

Table 2.Weed importance according to date and variety in transplanted aromatic *aman* rice

Scientific name	Type	Weed Importance according to date and variety					
		BRRI dhan38 (V_3)		BRRI dhan37 (V_2)		Kalijira (V_1)	
		40 DAT	60 DAT	40 DAT	60 DAT	40 DAT	60 DAT
Cynodon dactylon	Grass	0.44	0.00	0.37	0.00	1.80	0.00
Alternanthera sessilis	Aquatic	1.32	12.20	5.43	8.97	7.73	23.42
Alternanthera philoxeroides	Aquatic	0.00	0.00	0.00	0.00	2.07	0.00
Sagittaria guyanensis	Aquatic	3.50	2.03	3.08	0.00	1.04	0.00
Cyperus esculentus	Sedge	0.00	22.76	0.74	20.69	1.10	20.97
Eleusine indica	Grass	0.00	1.00	0.00	1.28	0.00	1.16
Cyperus michelianus	Sedge	41.17	0.00	61.9	0.00	31.15	4.65
Fimbristylis miliaceae	Sedge	2.76	9.35	2.59	9.83	0.55	1.94
Cyperus rotundus	Sedge	9.99	2.25	7.40	4.27	10.36	0.00
Sphenoclea zeylanica	Broadleaf	3.67	10.16	10.73	1.71	3.18	6.20
Ludwigia octovalvis	Broadleaf	4.41	15.85	3.34	13.68	2.07	3.88
Eclipta alba	Broadleaf	0.00	0.00	0.10	0.85	0.00	0.39
Cyperus difformis	Sedge	22.14	7.72	0.12	19.09	32.17	10.85
Echinochloa crussgalli	Grass	0.00	0.71	0.00	4.27	0.28	9.69
Leersia hexandra	Grass	0.44	3.25	0.12	1.71	0.00	1.94
Leptochloa panacea	Grass	0.00	2.44	0.00	8.97	0.00	3.88
Echinochloa colonum	Grass	0.29	3.66	0.00	0.00	0.00	6.98
Marsilea quadrifolia	Fern	4.87	4.88	0.99	2.56	0.00	1.16

4.3. Relative weed density (%)

Weed competes with another weed plants for their existence. In this experiment, several weed species were found to dominate the field at different dates (Table 3). This may be due to crop-weed competition, weed-weed competition or allelopathic effect (chemical secretion of one plant that inhibit the growth of others) of one plant to others. Although, occurrence of weed in the crop field mainly depends on various environmental factors (climate, rainfall etc.) and abiotic factors (soil types, topography of land etc.). At 20 DAT, grass and aquatic weeds dominated the field among them *Echinochloa crussgalli* (grass) scored highest (49.89% RWD) and *Sagittaria guyanensis* (aquatic) scored (27.6% RWD). Sedge weeds dominated the field at 40 DAT, & 60 DAT. At 40 DAT, *Cyperus michelianus* (52.57% RWD) *and Cyperus rotundus* (10.13% RWD) were the dominant weed species.

Table3. Relative density (%) of different weed species infested the experimental area

SL No.	Common name	Types	Relative density (%)			
			20 DAT	40 DAT	60 DAT	80 DAT
1	Bermuda grass	Grass	3.31	1.85	1.15	0.00
2	Sessile joyweed	Aquatic	6.39	8.89	28.33	0.25
3	Alligatorweed	Aquatic	1.37	0.50	0.15	0.00
4	Duck weed	Aquatic	27.6	2.01	0.00	0.00
5	Barnyard Grass	Grass	49.89	0.31	2.41	6.43
6	European waterclover	Fern	3.72	1.75	0.46	0.40
7	Nutsedge	Sedge	3.26	52.57	0.00	0.00
8	Fringerush	Sedge	0.00	1.20	11.67	10.50
9	Nutgrass	Sedge	0.00	10.13	0.00	0.00
10	Gooseweed	Broadleaf	0.00	3.81	0.18	3.49
11	Willow primrose	Broadleaf	0.00	5.17	6.05	21.88
12	Yellow nutsedge	Sedge	0.00	0.00	33.60	9.05
13	Small flower umbrella	Sedge	0.00	7.17	1.27	0.00
14	Eclipta	Broadleaf	0.00	0.00	0.48	1.58
15	Rice grass	Grass	0.00	0.29	0.73	2.65
16	Red sprangletop	Grass	0.00	0.00	5.81	9.01
17	Indian goosegrass	Grass	0.00	0.00	5.51	11.62
18	Jungle rice	Grass	0.00	0.14	1.99	3.45

Relative density of several weed species decreased at later stages (80 DAT) due to their completion of life cycle.

In this experiment, Sedge weeds dominated the crop field throughout the growing period. Grass weeds were prominent during the early and later period while broadleaf weeds were prominent during the later periods. This result is dissimilar with the findings of Hasanuzzaman *et al.* (2008) who observed that grasses and sedges were less dominating weed species. This might be due to seasonal and varietal variation.

4.4. Crop growth characters

4.4.1. Plant height

4.1.1.1. Effect of Nitrogen sources

Significant effect was observed at 20, 40, 60, 80 DAT and at harvest on plant height due to sources of nitrogen (Fig.1). Figure 1 Shows that the plants those received N from USG had always maintained higher plant heigth compared to prilled urea. It might be due to continues availability of N from the deep placed of USG that released N slowly and it enhanced the growth to crop more then urea. (N_3) USG given the highest plant height (131.3cm) and (N_1) no nitrogen provides the shorter plant height (124.1cm). The results are in agreement with those of Singh and Singh (1986) who reported that USG produced taller plants than prilled urea when applied @ 27 to 87 kgNha^{-1}

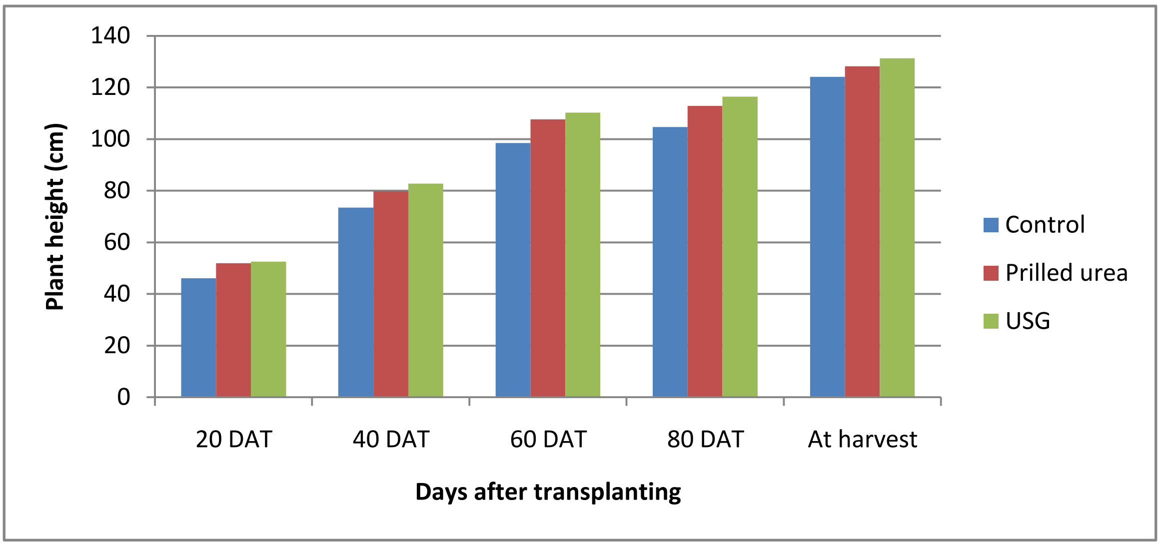

Fig.1. Effect of sources of Nitrogen on plant height (cm) of aromatic rice at different DAT (LSD $_{(0.05)}$ = 1.76, 1.18, 7.61, 6.20 and 3.16 at 20, 40, 60, 80 DAT and at harvest respectively)

4.4.1.2. Effect of variety

Plant height measured at 20, 40, 60, 80 DAT and at maturity significantly influenced by variety at all the sampling dates (Fig. 2). Figure 2 shows that irrespective of varieties, the height of rice plants increased rapidly at the early stages of growth and rate of progression in height was slow at the later stages. At harvest (V_1) Kalijira produced the taller plant (139.6cm) and BRRI dhan38 produced shortest (120.6cm). Probably the genetic make up of varieties was responsible for the variation in plant height. This result was in agreement with Bisne *et al.* (2006) who reported that plant height varies significantly among varieties.

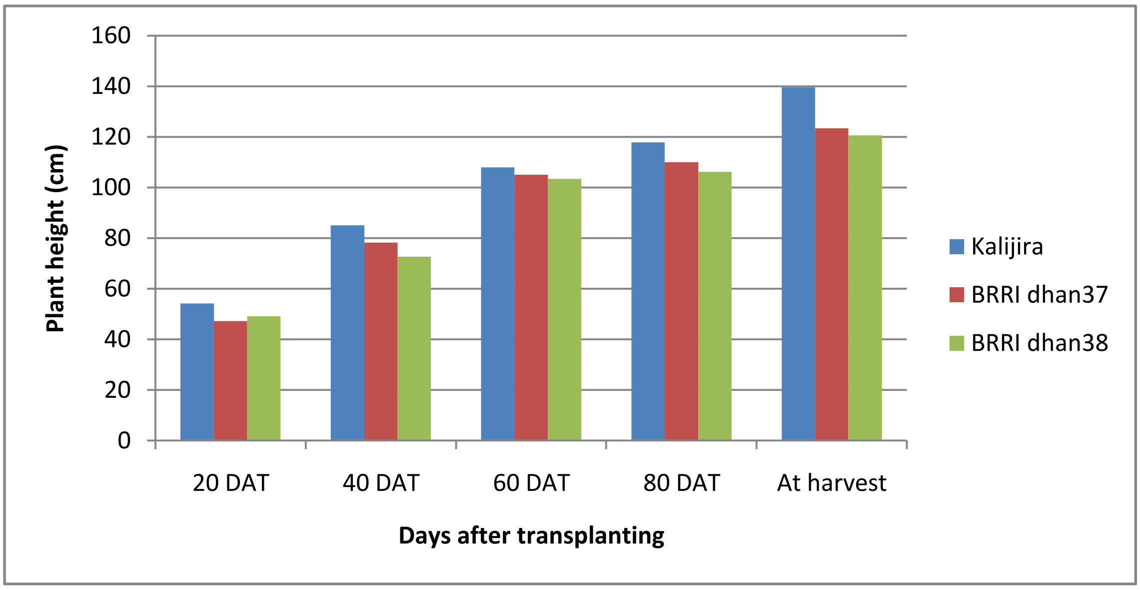

Fig.2. Effect of variety on plant height (cm) of Aromatic rice at different days after transplanting (LSD $_{(0.05)}$ = 2.46, 3.43, 2.76, 3.03 and 4.54 at 20, 40, 60, 80 DAT and at harvest respectively)

4.1.3. Effect of weed control method

There was significant variation for plant height due to different weed control treatments (Fig.3). Throughout the growing period, Pre-emergence herbicides Rifit20EC (W_3) scored the highest plant height (51.21, 81.59, 107.6, 114.0, and 131cm at 20, 40, 60, 80 DAT and at harvest, respectively) and no weeding treatment (W_1) attained the lowest (47.97, 74.73, 102.6, 108.2, and 124.5 cm at 20, 40, 60, 80 and at harvest, respectively) plant height. The results were in agreement with the findings of Khan and Tarique (2011) who found that the highest plant height was observed in completely weed free condition throughout the crop growth period with chemical weed control method and next in two hand weeding treatment whereas lowest value was observed in no weeding treatment. The results were in consistence with the findings of Hasanuzzaman *et al.* (2008) and Hasanuzzaman *et al.* (2007).

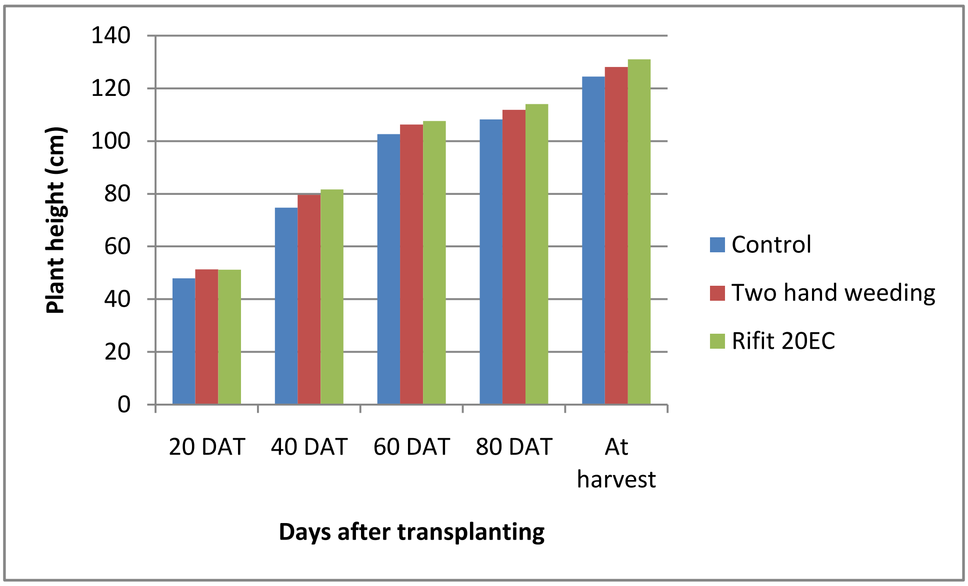

Fig.3. Effect of weed control method on plant height (cm) of aromatic rice at different DAT (LSD $_{(0.05)}$ = 2.52, 2.83, 3.55, 3.77 and 4.51 at 20, 40, 60, 80 DAT and at harvest respectively)

4.1.4. Interaction effect of Nitrogen and Variety

It was observed from the Table 4 that interaction effect of Nitrogen sources and Variety showed significant at 40 and 60DAT and not significant to the rest of the sampling dates. The maximum plant height (111.7cm) was found in combination of (N_3) USG x (V_1) Kalijira which was statistically similar with N_3XV_3, N_3XV_2, N_2XV_2 and $N_2XV_1$and minimum plant height (94.90cm) in combination of (N_1) without Nitrogen x (V_3) BRRI dhan38 which was statistically similar with N1XV2 at 60DAT. At harvest the tallest plant (143.0 cm) was found from (V_1) Kalijira with (N3) USG application which was statistically similar with the combination of same variety with rest of the other Nitrogen sources treatment and shortest plant (117.2 cm) from (V_3) BRRI Dhan38 without nitrogen N_1 (control) which was statistically similar with the combination of same variety with rest of the other Nitrogen sources treatment.

Table 4: Interaction effect of sources of nitrogen and variety on plant height (cm) at different days after transplanting

Treatment Combination	Plant height (cm) at different days after transplanting				
	20 DAT	**40 DAT**	**60 DAT**	**80 DAT**	**At harvest**
N_1V_1	49.74 bc	80.57 bc	105.0 c	114.7 b	136.0 a
N_1V_2	42.33 d	72.57 de	95.56 d	101.6 d	119.3 bc
N_1V_3	46.07 cd	67.30 e	94.90 d	97.70 d	117.2 c
N_2V_1	55.89 a	84.48 ab	107.3 a-c	116.9 ab	139.7 a
N_2V_2	48.96 bc	80.52 bc	109.7 a-c	112.8 bc	124.2 bc
N_2V_3	50.81 b	74.25 d	106.1 bc	109.0 c	120.7 bc
N_3V_1	56.81 a	90.04 a	111.7 a	121.8 a	143.0 a
N_3V_2	50.52 b	81.74 bc	110.1 ab	115.6 b	126.6 b
N_3V_3	50.30 bc	76.42 cd	109.1 a-c	112.0 bc	124.1 bc
LSD(0.05)	4.262	5.941	4.777	5.24	7.86
CV (%)	8.27	7.35	4.41	4.58	5.99

N_1=Control, N_2=Prilled Urea, N_3=USG (Urea Super Granules), V_1=Kalijira, V_2=BRRI dhan37, V_3=BRRI dhan38

4.1.5. Interaction effect of Nitrogen and Weed control method

Interaction effect of Nitrogen Sources and weed control method on plant height was found significant at different date of sampling (Table 5). At harvest tallest plant (134.10 cm) was found from the combination of (N_3) USG (Urea Super Granules) with (W_3) Pre-emergence herbicides Rifit 20EC which was statistically similar with the combination of N_2W_3 and N_1W_3 and shortest plant (119.50 cm) was found from the combination of without nitrogen fertilizer (N_1) (control) with no weeding (W_1) (control) which was statistically similar with the combination of N_2XW_1.

Table 5: Interaction effect of sources of nitrogen and weed control method on plan height (cm) at different days after transplanting

Treatment Combination	Plant height (cm) at different days after transplanting				
	20 DAT	40 DAT	60 DAT	80 DAT	At harvest
N_1W_1	43.63 c	69.24 e	96.04 e	101.8 e	119.5 c
N_1W_2	47.00 bc	74.77 d	98.79 e	104.4 e	124.9 bc
N_1W_3	47.52 bc	76.42 cd	100.7 de	107.9 de	128.0 ab
N_2W_1	50.44 ab	76.07 cd	106.0 b-d	111.1 cd	125.4 bc
N_2W_2	53.04 a	80.64 bc	107.9 a-c	112.7 b-d	128.3 ab
N_2W_3	52.19 a	82.54 ab	109.2 a-c	114.9 a-c	130.9 ab
N_3W_1	49.85 ab	78.88 b-d	105.8 cd	111.7 cd	128.5 ab
N_3W_2	53.85 a	83.52 ab	112.0 ab	118.4 ab	131.1 ab
N_3W_3	53.93 a	85.80 a	113.1 a	119.4 a	134.1 a
$LSD_{(0.05)}$	4.361	4.901	6.146	6.532	7.803
CV (%)	9.09	6.52	6.09	6.14	6.38

N_1=Control, N_2=Prilled Urea, N_3=USG (Urea Super Granules), W_1=control, W_2=Two hand weeding and W_3=Pre-emergence herbicides Rifit 20EC

4.1.6. Interaction effect of Variety and Weed control method

Interaction effect of Variety and Weed control method on plant height was found significant at different date of sampling (Table 6). At harvest tallest plant (142.50 cm) found from (Table 6) the combination of (V_1) Kalijira with (W_3) Pre-emergence herbicides Rifit 20EC which was statistically similar with the combination of V_1XW_1, V_1XW_2 and the shortest plant (118.2cm) was found from the combination of (V_3) BRRI dhan38 with no weeding W_1 (control) which was statistically similar with the combination of V_2XW_1, V_2XW_2, V_2XW_3, V_3XW_2,V_3XW_3. This result was similar with the findings of Gnanavel and Anbhazhagan (2010) who observed that Pre-emergence application of oxyfluorfen 0.25 kg ha^{-1} followed by post-emergence application of bispyribac sodium 0.05 kg + metsulfuron methyl @ 0.01 kg ha^{-1} recorded the least weed count (11.00 m^{-2}) in transplanted aromatic basmati rice.

Table 6: Interaction effect of variety and weed control method on plant height (cm) at different days after transplanting

Treatment	Plant height (cm) at different days after transplanting				
	20 DAT	40 DAT	60 DAT	80 DAT	At harvest
V_1W_1	50.52 b	81.37 bc	105.6 ab	115.4 a-c	136.4 a
V_1W_2	55.41 a	86.06 ab	108.2 a	117.8 ab	139.8 a
V_1W_3	56.52 a	87.67 a	110.2 a	120.2 a	142.5 a
V_2W_1	45.59 c	73.96 e	101.6 b	105.8 ef	118.8 c
V_2W_2	47.96 bc	79.29 cd	106.0 ab	110.7 c-e	123.4 bc
V_2W_3	48.26 bc	81.57 bc	107.8 a	113.5 b-d	127.9 b
V_3W_1	47.81 bc	68.86 f	100.7 b	103.4 f	118.2 c
V_3W_2	50.52 b	73.59 ef	104.5 ab	107.0 d-f	121.0 bc
V_3W_3	48.85 bc	75.52 de	104.9 ab	108.4 d-f	122.7 bc
LSD(0.05)	4.361	1.059	6.146	6.532	7.803
CV (%)	8.89	6.52	6.09	6.14	6.38

V_1=Kalijira, V_2=BRRI dhan37, V_3=BRRI dhan38, W_1=control, W_2=Two hand weeding and W_3=Pre-emergence herbicides Rifit 20EC

4.1.7. Interaction effect of variety, Nitrogen sources and Weed control method

From the interaction of variety, Sources of Nitrogen and Weed control method at different date of sampling (Table 7), it was found that plant height was significant at all sampling dates. At harvest tallest plant height (142.5cm) obtained from (V_1) Kalijira x (N_3) USG x (W_3) Pre-emergence Herbicides Rifit 20EC which was statistically similar with same varietal combination irrespective of Nitrogen sources and Weed control method except $N_2V_1W_1$ and Shortest plant (112.30cm) was observed from BRRI dhan37 x PU x W1 which was also statistically similar with same varietal combination irrespective of source of N. and Weed control method except $N_1XV_2XW_3$ and $N_3XV_2XW_3$.

Table 7: Interaction effect of nitrogen sources, variety and weed control method on plant height (cm) at different days after transplanting

Treatments	Plant height at different days after sowing				
	20 DAT	40 DAT	60 DAT	80 DAT	At harvest
$N_1V_1W_1$	46.00 e-h	77.05d-k	103.8a-e	113.6a-e	136.4a-e
$N_1V_1W_2$	50.22 c-f	81.72c-h	104.8a-d	113.7a-e	139.8ab
$N_1V_1W_3$	53.00 a-e	82.94b-g	106.6a-c	116.9a-e	142.5a
$N_1V_2W_1$	41.44 h	67.67lm	91.00 f	96.33ij	118.8f-h
V_2W_2	42.22 gh	73.75h-l	96.56c-f	101.3f-j	123.4e-h
$N_1V_2W_3$	43.33 f-h	76.28e-k	99.11b-f	107.2e-i	127.9b-f
$N_1V_3W_1$	43.44 f-h	63.00m	93.33ef	95.55j	118.2f-h
$N_1V_3W_2$	48.56 e-h	68.84k-m	95.04d-f	98.11h-j	121.0f-h
$N_1V_3W_3$	46.22 e-h	70.06k-m	96.33c-f	99.45g-j	122.7f-h
$N_2V_1W_1$	53.00 a-e	81.67c-h	105.8a-c	115.3a-e	127.21b-f
$N_2V_1W_2$	57.67 a-c	85.11a-d	106.4a-c	116.0a-e	137.0a-d
$N_2V_1W_3$	57.00 a-d	86.67a-c	109.5ab	119.2a-c	138.4a-c
$N_2V_2W_1$	47.00 e-h	75.66f-l	108.3ab	111.0c-f	112.3h
$N_2V_2W_2$	49.89 d-f	81.89c-h	109.6ab	113.0b-e	119.3f-h
$N_2V_2W_3$	50.00 d-f	84.00b-f	111.4a	114.4a-e	126.2c-g
$N_2V_3W_1$	51.33 b-e	70.89j-m	103.9a-e	106.9e-i	113.7gh
$N_2V_3W_2$	51.55 b-e	74.93g-l	107.8ab	109.2c-h	118.3f-h
$N_2V_3W_3$	49.55 d-g	76.95d-k	106.6a-c	110.9c-f	119.4f-h
$N_3V_1W_1$	52.56 a-e	85.39a-d	107.3ab	117.2a-e	137.3a-d
$N_3V_1W_2$	58.33 ab	91.33 ab	113.4 a	123.7 ab	139.4a-c
$N_3V_1W_3$	59.56 a	93.41 a	114.4 a	124.4 a	142.3 a
$N_3V_2W_1$	48.33 e-h	78.55c-j	105.3a-d	110.1c-g	121.0f-h
$N_3V_2W_2$	51.78 b-e	82.22c-h	112.0a	117.9a-e	124.1d-h
$N_3V_2W_3$	51.44 b-e	84.44b-e	112.9a	118.9a-d	127.4b-f
$N_3V_3W_1$	48.67 e-h	72.70i-l	104.9a-d	107.7d-h	117.9f-h
$N_3V_3W_2$	51.44 b-e	77.00d-k	110.7 a	113.7a-e	121.2f-h
$N_3V_3W_3$	50.78 b-f	79.56c-i	111.9 a	114.8a-e	122.9f-h
$LSD_{(0.05)}$	7.554	8.49	10.64	11.31	13.52
CV (%)	9.09	6.52	6.09	6.14	6.38

V_1=Kalijira, V_2=BRRI dhan37, V_3=BRRI dhan38, N_1=Control, N_2=Prilled Urea, N_3=USG (Urea Super Granules), W_1=control, W_2=Two hand weeding and W_3=Pre-emergence herbicides Rifit 20EC

4.4.2. Number of total tiller hill^{-1}

4.4.2.1. Effect of Nitrogen sources

Sources of N fertilizer affected tiller production significantly at all observations of crop growth (Fig.4). Figure 4 shows that irrespective of all sampling dates the USG applied plants always produced higher number of total tiller hill^{-1}. Increased number of tillers in USG than PU might be due to uniform and steady N supply through USG. Maximum (17.53) tillers hill^{-1} was observed in USG at 60 DAT. Mirzeo and Reddy (1989) and Singh and Singh (1986), also reported similar results. On the other hand Peng *et al.* (1996) reported that N supply controlled the tiller production of rice plant unless other factors such as spacing or light became limiting.

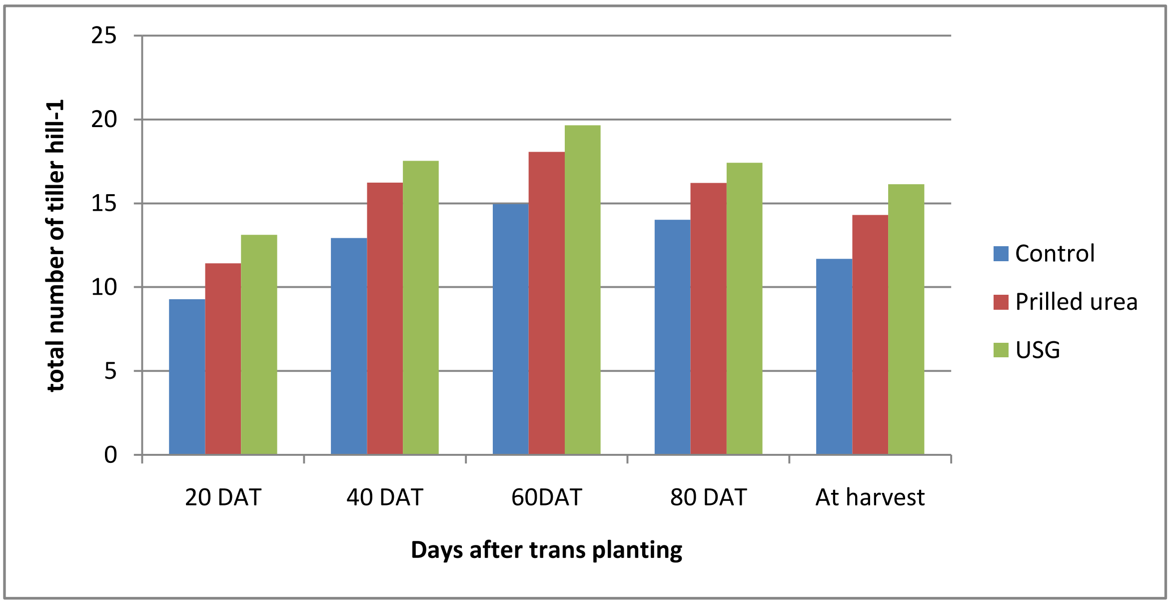

Fig.4. Effect of Nitrogen sources on total tiller hill^{-1} of aromatic rice varieties at different days after transplanting (LSD $_{(0.05)}$ = 0.59, 1.54, 1.69, 1.26 and 2.55 at 20, 40, 60, 80 DAT and at harvest respectively)

4.4.2.2. Effect of Variety

The number of total tillers hill^{-1} was significantly influenced by variety at all stages of crop growth (Fig. 5). Varietal effects on the formation of total number of tillers are shown in Figure 4. BRRI dhan38 (V_3) was achieved maximum (19.11) tiller at 60 DAT, then with advancement to age it declined up to maturity, where as in the case of BRRI dhan37 (V_2) maximum (17.64) tiller production was observed around stage at 60 DAT and Kalijira (V_1) maximum (15.93) tiller production was observed around stage at 60 DAT also then with advancement to age it declined up to maturity. The value decreased because some of the last emerged tillers died due to their failure in competing for light and nutrients. This revealed that during the reproductive and ripening phases the rate of tiller mortality exceeded the tiller production rate (Roy and Satter, 1992). Variable effect of variety on number of total tillers hill^{-1} was also reported by Hussain *et al*. (1989) who noticed that number of total tillers hill^{-1} differed among the varieties.

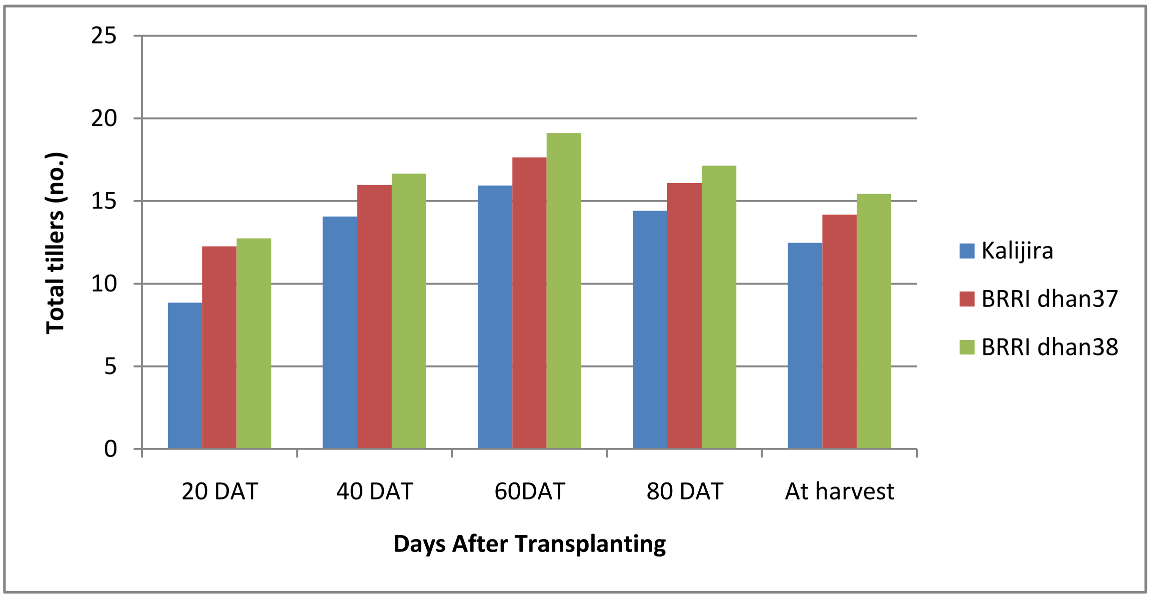

Fig.5. Effect of variety on total tiller hill^{-1} of Aromatic rice varieties at different days after transplanting (LSD $_{(0.05)}$ = 0.74, 0.97, 1.11, 0.81 and 0.81 at 20, 40, 60, 80 DAT and at harvest respectively)

4.4.2.3 Effect of Weed control method

The number of total tillers hill^{-1} was significantly influenced by weed control method at all stages of crop growth (Fig. 6). Weed control effects on the formation of total number of tillers are shown in Figure 6. Weed control by (W_3) pre-emergence herbicide Rifit 20EC was achieved maximum tiller at harvest (15.11) and (W_1) Control treatment gave lowest (12.84) tiller at harvest. (W_2) Two hand weeding provided (14.15) tiller at harvest. this result was in agreement with the findings of Al-Mamun *et al.* (2011), Bhuiyan *et al.* (2011), Mamun *et al.* (2011), Ali *et al.* (2010), Gnanavel and Anbhazhagan (2010) and Kabir *et al.* (2008).

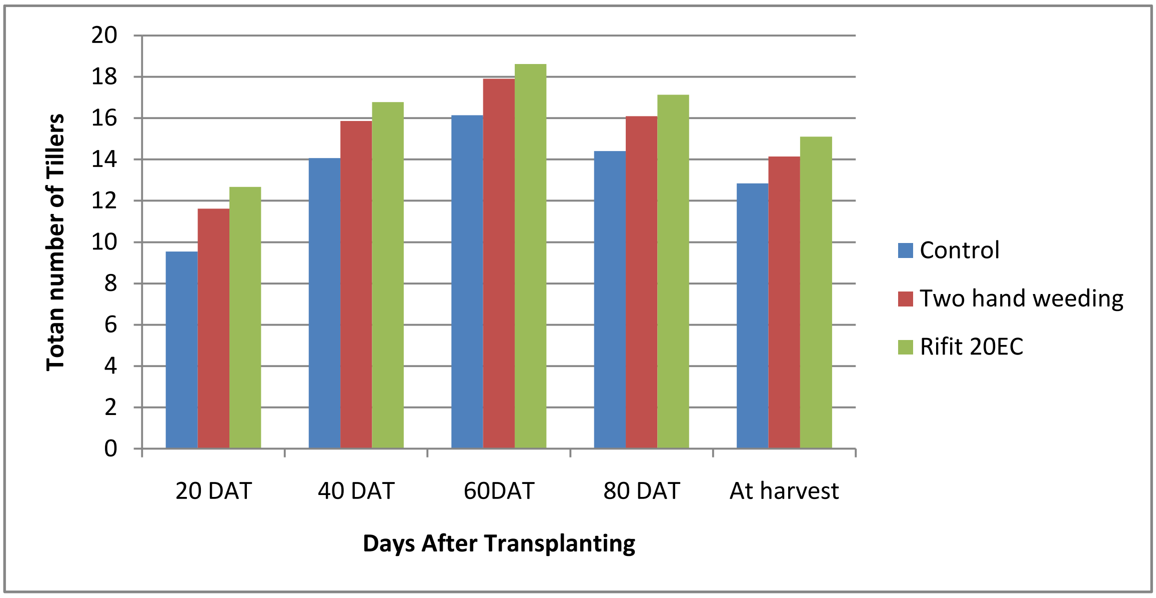

Fig.6. Effect of Weed control method on total tiller hill^{-1} of Aromatic rice at different days after transplanting (LSD $_{(0.05)}$ = 0.69, 1.04, 1.01, 1.28 and 0.88 at 20, 40, 60, 80 DAT and at harvest respectively)

4.4.2.4. Interaction effect of Nitrogen sources and Variety

The effect application of Nitrogen from different sources such as Control, USG and PU and variety were statistically significant at 20, 40, 60, 80 DAT and at harvest (Table 8) The maximum number of total tillers hill^{-1} was obtained from BRRI dhan38 (V_3) with USG (N_3) application at all sampling dates. By the interaction of variety and sources of nitrogen fertilizer maximum tillers hill^{-1} (21.07) in N_3XV_3 was counted at 60 DAT. At harvest maximum tiller was obtained from N_3XV_3 treatment which was statistically similar with the treatment of N_3V_2 and lowest number of tiller was obtained from N_1XV_1 treatment which was statistically similar with N_1XV_2.

Table 8: Interaction effect of sources of nitrogen and variety on number of tiller $hill^{-1}$ at different days after transplanting

Treatment combination	Number of tiller $hill^{-1}$ at different days after transplanting				
	20 DAT	40 DAT	60 DAT	80 DAT	At harvest
N_1V_1	7.112 f	12.00 e	13.00 d	12.70 e	10.26 g
N_1V_2	10.19 d	13.22 de	14.78 d	14.37 d	11.52 fg
N_1V_3	10.56 d	13.58 de	17.07 c	15.00 b-d	13.26 de
N_2V_1	8.668 e	14.22 d	17.00 c	14.74 cd	12.48 ef
N_2V_2	12.52 c	16.96 bc	18.04 bc	16.22 b	14.63 cd
N_2V_3	13.11 bc	17.52 a-c	19.19 ab	17.67 a	15.78 bc
N_3V_1	10.78 d	15.96 c	17.78 bc	15.78 bc	14.70 c
N_3V_2	14.04 ab	17.74 ab	20.11 a	17.70 a	16.38 ab
N_3V_3	14.56 a	18.89 a	21.07 a	18.74 a	17.30 a
LSD(0.05)	1.285	1.68	1.92	1.395	1.394
CV (%)	11.09	10.51	10.65	8.55	9.67

V_1=Kalijira, V_2=BRRI dhan37, V_3=BRRI dhan38, N_1=Control, N_2=Prilled Urea, N_3=USG (Urea Super Granules)

4.4.2.5. Interaction effect of Nitrogen sources and weed control method

Interaction effect of Nitrogen source and application of different weed control method such as Control, two hand weeding and Pre-emergence herbicides Rifit 20EC were statistically significant at all sampling dates (Table 9). The maximum number of total tillers $hill^{-1}$ was obtained from USG (N_3) with Rifit 20EC (W_3) application at all sampling dates. By the interaction of form of nitrogen fertilizer and Weed control method maximum (20.85) tillers $hill^{-1}$ in N_3XW_3 was counted at 60 DAT. At harvest maximum tiller (17.22) was obtained from N_3XV_3 treatment which was statistically similar with the treatment of N_3XW_2 and lowest number of tiller was obtained from N_1XW_1 treatment which was statistically similar with N_1XW_2.

Table 9: Interaction effect of sources of nitrogen and weed control method on number of tiller hill^{-1} at different days after transplanting

Treatment combination	Number of tiller hill^{-1} at different days after transplanting				
	20 DAT	**40 DAT**	**60 DAT**	**80 DAT**	**At harvest**
N_1W_1	7.742 g	11.35 e	14.22 e	12.63 d	10.33 f
N_1W_2	9.556 f	13.07 de	15.07 de	14.26 cd	11.74 ef
N_1W_3	10.56 ef	14.37 cd	15.56 de	15.18 bc	12.96 de
N_2W_1	9.408 f	14.78 cd	16.15 d	14.41 cd	13.30 d
N_2W_2	11.93 cd	16.70 b	18.63 bc	16.85 ab	14.44 cd
N_2W_3	12.96 bc	17.22 ab	19.44 a-c	17.37 ab	15.15 bc
N_3W_1	11.48 de	16.07 bc	18.07 c	16.37 a-c	14.89 bc
N_3W_2	13.37 ab	17.82 ab	20.04 ab	17.56 a	16.27 ab
N_3W_3	14.52 a	18.70 a	20.85 a	18.30 a	17.22 a
$LSD_{(0.05)}$	1.189	1.797	1.75	2.221	1.525
CV (%)	11.02	12.07	10.42	14.63	11.37

N_1=Control, N_2=Prilled Urea, N_3=USG (Urea Super Granules), W_1=control, W_2=Two hand weeding and W_3=Pre-emergence herbicides Rifit 20EC

4.4.2.6. Interaction effect of Variety and Weed control method

Interaction effect of Variety and application of different weed control method such as Control, two hand weeding and Pre-emergence herbicides Rifit 20EC were statistically significant at all sampling dates (Table 10) The maximum number of total tillers hill^{-1} was obtained from BRRI dhan38 (V_3) with Rifit 20EC (W_3) application at all sampling dates. By the interaction of Variety and Weed control method maximum tillers hill^{-1} (19.89) obtained in V_3XW_3 was counted at 60 DAT. At harvest maximum tiller (16.52) was obtained from V_3W_3 treatment which was statistically similar with the treatment of V_3XW_2 and lowest number of tiller was obtained from V_1XW_1 treatment which was statistically similar with V_1XW_2.

Table 10: Interaction effect of variety and weed control method on number of tiller hill^{-1} at different days after transplanting

Treatment combination	Number of tiller hill^{-1} at different days after transplanting				
	20 DAT	40 DAT	60 DAT	80 DAT	At harvest
V_1W_1	6.964 e	12.70 d	14.11 f	12.74 d	11.33 d
V_1W_2	9.223 d	14.15 cd	16.45 de	15.19 bc	12.67 cd
V_1W_3	10.37 cd	15.34 bc	17.22 c-e	15.29 bc	13.44 c
V_2W_1	10.52 c	14.44 b-d	16.22 e	14.81 cd	13.07 c
V_2W_2	12.74 b	16.19 ab	17.96 b-e	16.19 a-c	14.09 bc
V_2W_3	13.48 ab	17.30 a	18.74 a-c	17.30 ab	15.37 ab
V_3W_1	11.15 c	15.06 bc	18.11 b-d	15.85 bc	14.11 bc
V_3W_2	12.89 b	17.26 a	19.33 ab	17.30 ab	15.70 a
V_3W_3	14.19 a	17.67 a	19.89 a	18.26 a	16.52 a
$LSD_{(0.05)}$	1.189	1.797	1.75	2.221	1.525
CV (%)	11.02	12.07	10.42	14.63	11.37

V_1=Kalijira, V_2=BRRI dhan37, V_3=BRRI dhan38, W_1=control, W_2=Two hand weeding and W_3=Pre-emergence herbicides Rifit 20EC

4.4.2.7. Interaction effect of Nitrogen sources, variety and weed control method

From the interaction of variety, Sources of Nitrogen and Weed control method at different date of sampling (Table 11), it was found that total number of tiller hill^{-1} was insignificant at 20, 40, 60, 80 DAT and at harvest. At harvest maximum tiller number hill^{-1} (18.44) obtained from (V_3) BRRI dhan38 x (N_3) USG x (W_3) Pre-emergence Herbicides Rifit 20EC which was statistically similar with $N_3XV_3XW_2$, $N_3XV_2XW_2$, $N_2V_3W_2$ and $N_2XV_3XW_3$ and lowest (8.887) tiller hill^{-1} was observed from (N_1) control x(V_1) Kalizira x (W_1) Control which was also statistically similar with $N_1XV_1XW_2$, $N_1XV_1XW_3$, $N_1XV_2XW_1$ and $N_1XV_2XW_2$.

Table 11: Interaction effect of sources of N, variety and weed control method on number of tiller hill^{-1} at different days after transplanting

Treatment Combination	Number of tillers hill^{-1} at different days after sowing				
	20 DAT	**40 DAT**	**60 DAT**	**80 DAT**	**At harvest**
$N_1V_1W_1$	5.337 n	10.10 k	11.89 m	11.44 f	8.887 j
$N_1V_1W_2$	7.667 lm	12.11 i-k	13.11 lm	12.89 d-f	10.44 ij
$N_1V_1W_3$	8.333 k-m	13.79 h-j	14.00 k-m	13.76 d-f	11.44 h-j
$N_1V_2W_1$	8.557 j-l	11.78 jk	13.33 lm	12.89 d-f	10.55 ij
$N_1V_2W_2$	10.67 f-i	13.00 h-k	15.33 i-l	14.67 c-f	11.44 h-j
$N_1V_2W_3$	11.33 e-h	14.89 e-i	15.67 h-l	15.56 b-e	12.55 g-i
$N_1V_3W_1$	9.333 h-l	12.19 i-k	17.45 d-j	13.55 d-f	11.55 hi
$N_1V_3W_2$	10.33 g-k	14.11 g-j	16.78 f-k	15.22 b-f	13.33 f-h
$N_1V_3W_3$	12.00 d-g	14.45 f-j	17.00 e-k	16.22 b-d	14.89 d-g
$N_2V_1W_1$	6.447 mn	13.22 h-j	14.45 j-m	12.00 ef	11.33 h-j
$N_2V_1W_2$	9.000 i-l	14.33 f-j	18.00 c-i	16.22 b-d	12.67 g-i
$N_2V_1W_3$	10.56 g-j	15.11 d-i	18.56 b-h	16.00 b-d	13.44 f-h
$N_2V_2W_1$	10.33 g-k	15.45 c-h	16.55 f-k	15.00 b-f	13.56 e-h
$N_2V_2W_2$	13.67 b-d	17.44 a-f	18.00 c-i	16.00 b-d	14.56 d-g
$N_2V_2W_3$	13.56 b-d	18.00 a-e	19.55 a-f	17.67 a-c	15.78 b-f
$N_2V_3W_1$	11.44 e-g	15.67 c-h	17.44 d-j	16.22 b-d	15.00 d-g
$N_2V_3W_2$	13.11 c-e	18.33 a-c	19.89 a-e	18.33 a-c	16.11 a-e
$N_2V_3W_3$	14.78 a-c	18.56 a-c	20.22 a-d	18.44 a-c	16.22 a-d
$N_3V_1W_1$	9.110 i-l	14.78 f-j	16.00 g-l	14.78 c-f	13.78 d-h
$N_3V_1W_2$	11.00 f-i	16.00 b-h	18.22 c-i	16.44 a-d	14.89 d-g
$N_3V_1W_3$	12.22 d-g	17.11 a-g	19.11 b-f	16.11 b-d	15.44 b-f
$N_3V_2W_1$	12.67 d-f	16.11 b-h	18.78 b-g	16.56 a-d	15.11 c-g
$N_3V_2W_2$	13.89 a-d	18.11 a-d	20.55 a-c	17.89 a-c	16.26 a-d
$N_3V_2W_3$	15.55 ab	19.00 ab	21.00 a-c	18.67 ab	17.78 ab
$N_3V_3W_1$	12.67 d-f	17.33 a-f	19.44 a-f	17.78 a-c	15.78 b-f
$N_3V_3W_2$	15.22 ab	19.33 a	21.33 ab	18.33 a-c	17.67 a-c
$N_3V_3W_3$	15.78 a	20.00 a	22.45 a	20.11 a	18.44 a
$LSD_{(0.05)}$	2.059	3.112	3.031	3.847	2.642
CV (%)	11.02	12.07	10.42	14.63	11.37

V_1=Kalijira, V_2=BRRI dhan37, V_3=BRRI dhan38, N_1=Control, N_2=Prilled Urea, N_3=USG (Urea Super Granules), W_1=control, W_2=Two hand weeding and W_3=Pre-emergence herbicides Rifit 20EC.

4.4.3. Total dry matter production

4.4.3.1. Effect of Nitrogen Sources

The TDM production was affected significantly at 20, 40, 60 and 80 DAT by the forms of N fertilizer (Fig. 7). Figure 7 indicates that at each sampling dates, USG applied plants gave higher TDM compared to prilled urea and control (without nitrogen) treatment. Maximum TDM (123.9g) found from the (N_3) USG application at harvest. At the same time it could also be noticed that the difference between treatments for TDM was much slower at early growth stages but became must higher in later stages. This might be due to the fact that USG receiving plants got continuous supply of N and plants could better utilize it and growth parameters were positively responded to it. Rao *et al.* (1986) from their study concluded that USG was the most effective in increasing TDM than split application of urea.

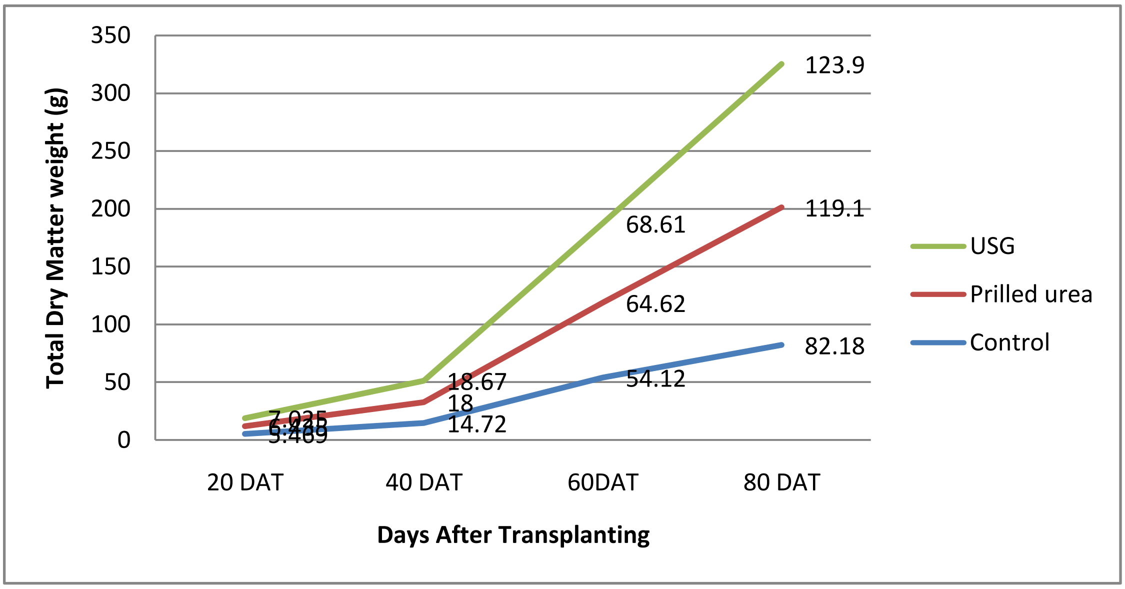

Fig.7. Effect of nitrogen sources on total dry matter production of Aromatic rice varieties at different days after transplanting (LSD $_{(0.05)}$ = 0.60, 1.21, 3.14, and 9.94 at 20, 40, 60 and 80 DAT respectively)

4.4.3.2. Effect of variety

Dry matter is the material which was dried to a constant weight. Total dry matter (TDM) production indicates the production potential of a crop. A high TDM production is the first perquisite for high yield. TDM of roots, leaves, leaf sheath + stem and or panicles of all varieties were measured at 20, 40, 60 and 80 DAT. It was evident from Figure 8 that irrespective of varieties TDM of all the varieties increased steadily for all sampling dates. BRRI dhan384 (V_3) achieved the highest dry matter throughout the growing period (6.988, 18.77, 64.55 and 112.2 g hill^{-1} at 20, 40, 60 and at 80 DAT respectively). Lower amount of dry matter production was observed in Kalijira (V_1) throughout the growing period. This may be due to the highest number of tiller mortality. Dissimilar results were reported by Amin *et al.* (2006) who stated that traditional varieties accumulated higher amount of vegetative dry matter than the modern variety.

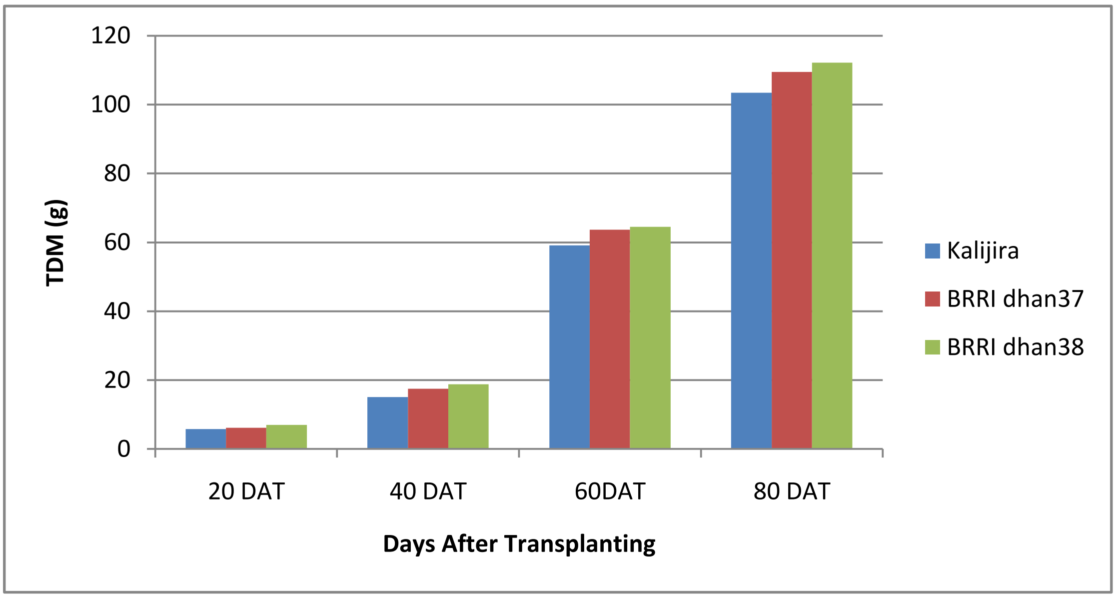

Fig.8: Effect of variety on total dry matter production of aromatic rice varieties at different days after transplanting (LSD $_{(0.05)}$ = 0.31, 0.80, 1.8 and 6.20 at 20, 40, 60 and 80 DAT respectively)

4.4.3.3. Effect of weed control method

Total dry matter (TDM) increased exponentially with time. TDM was significantly affected by different weed control treatments (Fig.9). From the early stages distinct differences were not visible among the weed control treatments in TDM production. The lowest TDM throughout the growing period was observed in unweeded treatment (W_1). Among all the weed control treatments, Rifit 20EC (W_3) achieved the highest TDM throughout the growing period. Similar results were observed by Bhuiyan *et al.* (2011).

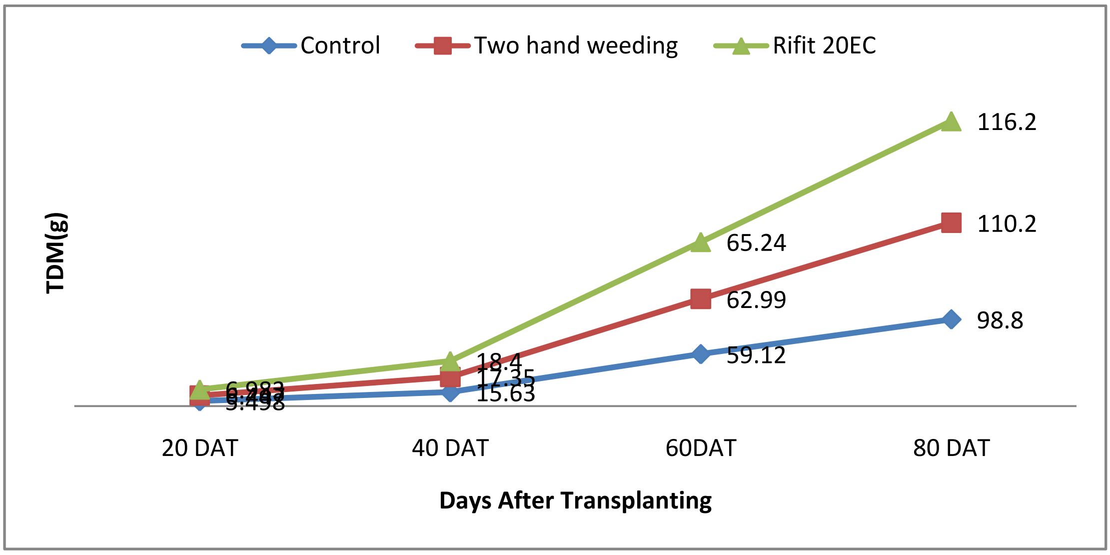

Fig.9: Effect of effect of weed control method on total dry matter production of aromatic rice varieties at different days after transplanting (LSD $_{(0.05)}$ = 0.52, 0.61, 2.51 and 5.79 at 20, 40, 60 and 80 DAT respectively)

4.4.3.4. Interaction effect of Nitrogen sources and Variety

Table 12 revealed that interaction of urea source and variety on TDM production significantly affected at 20DAT. At 20 DAT significantly maximum (7.54 g hill^{-1}) TDM found from the combination of BRRI dhan38 with USG which was statistically similar with N_3XV_2 and N_2XV_3 and the minimum (4.68 g hill^{-1}) from the combination of Kalijira with no nitrogen

Table 12: Interaction effect of sources of nitrogen and variety on total dry matter at different days after transplanting

Treatment	TDM at different day after transplanting			
Combination	**20DAT**	**40DAT**	**60DAT**	**80DAT**
N_1V_1	4.684 d	12.15 f	51.54 f	76.94 c
N_1V_2	5.412 c	15.85 e	54.96 e	82.72 c
N_1V_3	6.309 b	16.14 e	55.86 e	86.87 c
N_2V_1	6.252 b	16.44 e	59.89 d	113.5 b
N_2V_2	5.938 bc	17.87 cd	66.98 bc	121.4 ab
N_2V_3	7.116 a	19.68 ab	67.00 bc	122.6 ab
N_3V_1	6.457 b	16.70 de	65.97 c	120.0 ab
N_3V_2	7.079 a	18.81 bc	69.09 ab	124.4 a
N_3V_3	7.540 a	20.49 a	70.78 a	127.3 a
$LSD_{(0.05)}$	0.5445	1.378	3.118	10.74
CV (%)	8.4	7.83	8.77	8.57

V_1=Kalijira, V_2=BRRI dhan37, V_3=BRRI dhan38, N_1=Control, N_2=Prilled Urea, N_3=USG (Urea Super Granules),

4.4.3.5. Interaction effect of Nitrogen sources and Weed control method

The interaction effect of Nitrogen sources and Weed control method varied significantly for TDM production in all sampling dates. At 80 DAT maximum (129.9g $hill^{-1}$) TDM was found from the combination of BRRI dhan38 X USG which was statistically similar with N_3XW_3, N_3XW_2 and N_2XW_2 and minimum (73.68 g $hill^{-1}$) from the (N_1) no nitrogen with (W_1) without weeding which was statistically similar with N_1W_2 (Table 13).

Table 13: Interaction effect of sources of nitrogen and weed control method on total dry matter at different days after transplanting

Treatment Combination	TDM at different day after transplanting			
	20DAT	**40DAT**	**60DAT**	**80DAT**
N_1W_1	4.353 d	13.74 d	50.02 d	73.68 e
N_1W_2	5.702 c	14.27 d	54.65 c	83.22 de
N_1W_3	6.35 bc	16.13 c	57.69 bc	89.63 d
N_2W_1	5.824 c	16.16 c	60.53 b	105.8 c
N_2W_2	6.537bc	18.48 b	65.65 a	121.7 ab
N_2W_3	6.944ab	19.35ab	67.69 a	129.9 a
N_3W_1	6.317bc	16.98 c	66.81 a	116.9 b
N_3W_2	7.103 b	19.29 ab	68.68 a	125.8 ab
N_3W_3	7.656 a	19.73 a	20.85 a	129.0 a
$LSD_{(0.05)}$	0.903	1.059	4.36	10.02
CV (%)	14.97	6.47	7.75	9.72

N_1=Control, N_2=Prilled Urea, N_3=USG (Urea Super Granules), W_1=control, W_2=Two hand weeding and W_3=Pre-emergence herbicides Rifit 20EC

4.4.3.6. Interaction effect of Variety and Weed control method

It was observed from the (Table 14) that interaction effect of Nitrogen sources and Variety showed significant in TDM production at all sampling dates. At 80 DAT maximum (120.2g $hill^{-1}$) TDM was found from the combination of BRRI dhan38 with (W_3) Rifit 20EC which was statistically similar with V_2XW_3,V_3XW_2, V2XW2 and V_1XW_3 and minimum (92.91 g $hill^{-1}$) from the (V_1) Kalijira with (W_1) without weeding (Table 14) which was statistically similar with V_2XW_1.

Table 14: Interaction variety and weed control method on total dry matter at different days after transplanting

Treatment Combination	TDM at different day after transplanting 20DAT	40DAT	60DAT	80DAT
V_1W_1	5.192 e	13.73 f	54.74 c	92.91 e
V_1W_2	5.902 de	15.39 e	59.84 b	106.8 b-d
V_1W_3	6.299b-d	16.17 de	62.82 ab	110.7 a-c
V_2W_1	5.238 e	16.30 de	60.45 b	100.4 de
V_2W_2	6.302b-d	17.54 c	64.13 ab	110.4 a-d
V_2W_3	6.889 ac	18.69 b	66.46 a	117.6 a
V_3W_1	6.064 c-e	16.85 cd	62.17 ab	103.1 cd
V_3W_2	7.138 ab	19.11 b	65.01 a	113.4 ab
V_3W_3	7.762 a	20.34 a	19.89 a	120.2 a
$LSD_{(0.05)}$	0.903	1.059	4.36	10.02
CV (%)	14.97	6.47	7.75	9.72

V_1=Kalijira, V_2=BRRI dhan37, V_3=BRRI dhan38, W_1=control, W_2=Two hand weeding and W_3=Pre-emergence herbicides Rifit 20EC

4.4.3.7. Interaction effect of Nitrogen sources, Variety and Weed control method

It was observed from the (Table 15) that interaction effect of Nitrogen sources, Variety and weed control method showed significant variation in TDM production at all sampling dates. At 80 DAT maximum TDM (133.6g $hill^{-1}$) was found from the combination of USG (N_3) X BRRI dhan38 (V_3) X (W_3) Rifit 20EC which was statistically similar with $N_3V_3W_3$, $N_2V_3W_3$, $N_3V_3W_1$, $N_3V_2W_2$, $N_2V_2W_3$, $N_3V_1W_2$, $N_3V_1W_3$, $N_2V_2W_2$, $N_2V_1W_3$ and $N_2V_1W_1$ and minimum (68.33 g $hill^{-1}$) from the (V_1) Kalijira with no Nitrogen (N_1) and (W_1) without weeding (Table 15) which was statistically similar with $N_1V_1W_2$, $N_1V_1W_3$, $N_1V_2W_1$ and $N_1V_3W_1$.

Table 15: Interaction effect of sources of N, variety and weed control method on total dry matter at different days after transplanting

Treatment Combination	TDM at different days after sowing			
	20 DAT	40 DAT	60 DAT	80 DAT
$N_1V_1W_1$	3.837 k	10.51 m	46.59 j	68.33 i
$N_1V_1W_2$	4.933 h-k	12.29 lm	51.93 h-j	78.17 g-i
$N_1V_1W_3$	5.283 g-k	13.65 kl	56.11 g-i	84.33 f-i
$N_1V_2W_1$	4.373 jk	15.32 i-k	50.23 ij	75.67 hi
$N_1V_2W_2$	5.577 f-j	15.49 ij	55.85 g-i	83.33 f-i
$N_1V_2W_3$	6.287 c-i	16.75 f-j	58.79 e-h	89.17 f-h
$N_1V_3W_1$	4.850 i-k	15.38 i-k	53.24 h-j	77.04 hi
$N_1V_3W_2$	6.597 b-g	15.04 jk	56.18 g-i	88.17 f-h
$N_1V_3W_3$	7.480 a-d	18.00 d-f	58.15 f-h	95.40 e-g
$N_2V_1W_1$	5.757 e-j	15.11 jk	53.42 h-j	96.78 d-f
$N_2V_1W_2$	6.300 b-i	16.73 f-j	61.42 d-g	119.2 a-c
$N_2V_1W_3$	6.700 a-g	17.47e-g	64.83 b-f	124.4 a-c
$N_2V_2W_1$	5.237 g-k	15.73 g-j	63.13 c-g	107.4 c-e
$N_2V_2W_2$	6.053 c-i	18.22 d-f	68.00 a-d	123.2 a-c
$N_2V_2W_3$	6.523 b-g	19.67b-d	69.81 a-c	133.6 a
$N_2V_3W_1$	6.480 b-h	17.65 ef	65.05 b-f	113.3 b-d
$N_2V_3W_2$	7.257 a-e	20.48 a-c	67.52 a-d	122.6 a-c
$N_2V_3W_3$	7.610 a-c	20.90 ab	68.43 a-d	131.9 a
$N_3V_1W_1$	5.983 d-i	15.57 h-j	64.20 b-f	113.6 b-d
$N_3V_1W_2$	6.473 b-h	17.14 e-i	66.17 a-e	122.9 a-c
$N_3V_1W_3$	6.913 a-f	17.39e-h	67.53 a-d	123.4 a-c
$N_3V_2W_1$	6.103 c-i	17.86 d-f	67.99 a-d	118.2 a-c
$N_3V_2W_2$	7.277 a-e	18.92 c-e	68.53 a-d	124.8 ab
$N_3V_2W_3$	7.857 ab	19.66b-d	70.76 ab	130.1 ab
$N_3V_3W_1$	6.863 a-f	17.52e-g	68.23 a-d	118.9 a-c
$N_3V_3W_2$	7.560 a-c	21.81 a	71.33 ab	129.6 ab
$N_3V_3W_3$	8.197 a	22.13 a	72.77 a	133.3 a
$LSD_{(0.05)}$	1.564	1.834	7.552	17.36
CV (%)	14.97	6.47	7.75	9.72

V_1=Kalijira, V_2=BRRI dhan37, V_3=BRRI dhan38, N_1=Control, N_2=Prilled Urea, N_3=USG (Urea Super Granules), W_1=control, W_2=Two hand weeding and W_3=Pre-emergence herbicides Rifit 20EC

4.4. Crop growth rate (CGR)

4.4.4.1. Effect of sources of nitrogen

At 20-40 DAT, USG (N_3) scored the highest CGR (0.5815 g $hill^{-1}$ day^{-1}) which was statistically similar (0.5785 g $hill^{-1}$ day^{-1}) with Prilled Urea (N_2) (Fig.10) The lowest CGR (0.4678 g $hill^{-1}$ day^{-1}) was observed from control (N_1). On 40-60 DAT, From USG (N_3) the highest CGR (2.497 g $hill^{-1}$ day^{-1}) was recorded and lowest (1.971 g $hill^{-1}$ day^{-1} from control (N_1) without urea. On 60-80 DAT the highest CGR (2.763 g $hill^{-1}$ day^{-1}) was obtained from Urea Super Granules (N_3) and lowest (1.403 g $hill^{-1}$ day^{-1}) from (N_1.)

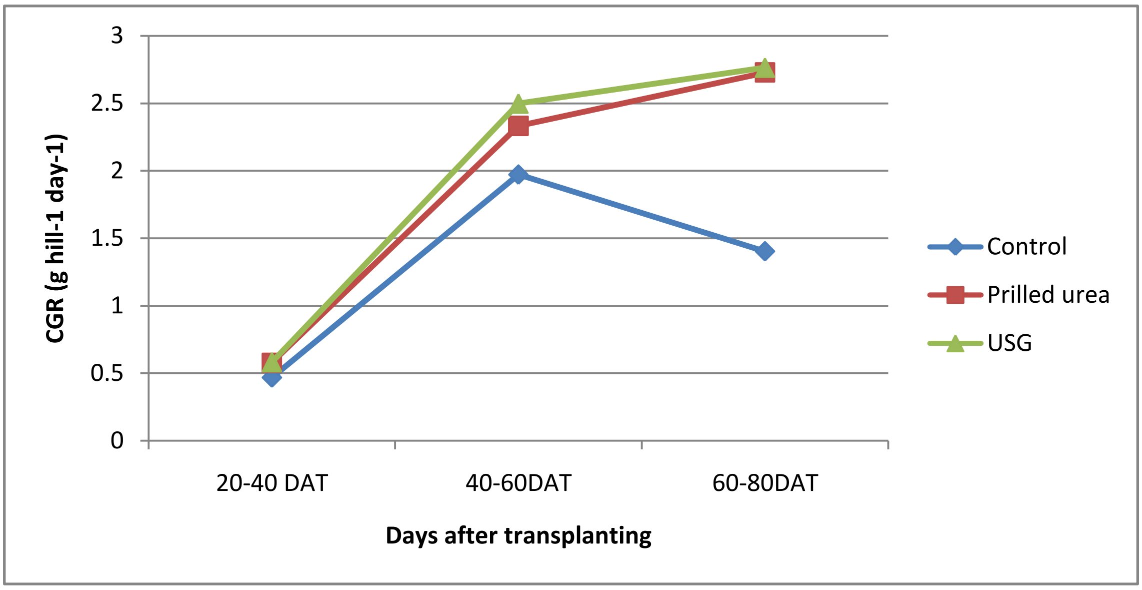

Fig.10: Effect of sources of nitrogen on crop growth rate (g $hill^{-1}$ day^{-1}) of aromatic rice (LSD $_{(0.05)}$ = 0.07, 0.13, 0.62 at 20-40, 40-60 and 60-80 DAT respectively)

4.4.4.2. Effect of variety

Crop growth rate is a measure of the increase in size, mass or number of crops over a period of time. The increase can be plotted as a logarithmic or exponential curve in many cases. It varied significantly due to variety in 20-40 DAT shown in Figure11 BRRI dhan38 (V_3) scored the highest CGR (0.5893 g $hill^{-1}$ day^{-1}) which was statistically similar with BRRI dhan37 (V_2) (0.5681 g $hill^{-1}$ day^{-1}). The lowest CGR was observed from Kalizira (V_1) (0.47 g $hill^{-1}$$day^{-1}$). On 40-60 DAT, BRRI dhan38 (V_3) was recorded the highest CGR (2.309 g hill^{-1} day^{-1}) and which was statistically similar with BRRI dhan37 and kalizira. In case of 60-80 DAT, the highest CGR (2.384 ghill^{-1}day^{-1}) was recorded by BRRI dhan38 (V_3) which was statistically similar (2.291 and 2.217 g hill^{-1} day^{-1}) with BRRI dhan37 (V_2) and Kalizira respectively.

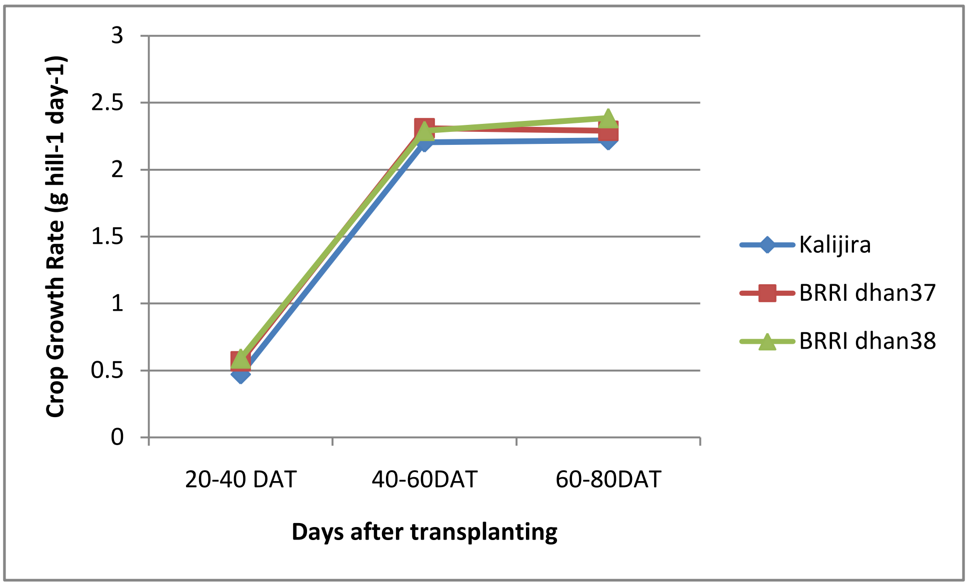

Fig.11: Effect of variety on crop growth rate (g hill^{-1}day^{-1}) of aromatic rice (LSD $_{(0.05)}$ = 0.04, 0.17 and 0.35 at 20-40, 40-60 and 60-80 DAT respectively)

4.4.4.3. Effect of weed control method

The growth rate of rice crop was significantly influenced by different weed control treatments over time (Fig.12). No weeding treatment (W_1) showed the lowest CGR throughout the growing period. It revealed that severe weed infestation might hamper the growth and development of rice plants drastically (Figure 13). Treatment (W_3) Rifit 20EC gave the highest CGR (0.5711 g hill^{-1} day^{-1}), 2.343 and 2.547 g hill^{-1} day^{-1} at 20-40, 40-60 and 60-80 DAT respectively. The lowest CGR was obtained with (W_1) no weeding treatment for all sampling dates. From the results, it was seen that the higher CGR was obtained from 60-80 DAT and then it declined. It might be due to the late season weed infestation which put adverse impact onCGR.

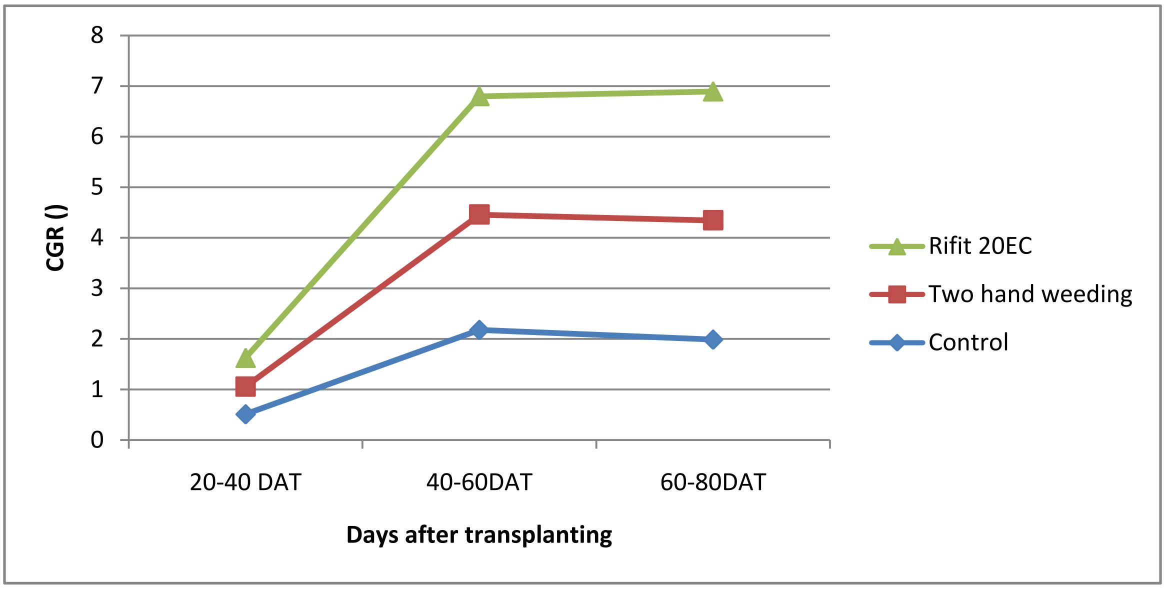

Fig.12: Effect of weed control method on crop growth rate (g hill^{-1} day^{-1}) of aromatic rice (LSD $_{(0.05)}$ = 0.04, 0.13 and 0.33 at 20-40, 40-60 and 60-80 DAT respectively)

4.4.4.4. Interaction effect of nitrogen sources and variety

Interaction effect of Nitrogen sources and Variety showed significant in CGR (g hill^{-1}day^{-1}) at all sampling dates (Table 16). At 60-80 DAT maximum CGR (2.823 g hill^{-1} day^{-1}) was found from the combination of USG (N_3) with BRRI dhan38 which was statistically similar with N_2V_1, N_2V_2, N_2V_3, N_3V_1 and N_3V_2 and minimum (1.271 g hill^{-1} day^{-1}) from (N_1) without Nitrogen with (V_1) Kalijira which was statistically similar with N_1V_2.

Table 16: Interaction effect of sources of nitrogen and variety on crop growth rate at different days after transplanting

Treatment combination	CGR at different dates after transplanting		
	20-40 DAT	40-60DAT	60-80DAT
N_1V_1	0.3889 d	1.970 c	1.271 b
N_1V_2	0.5222 bc	1.957 c	1.388 b
N_1V_3	0.4922 c	1.986 c	1.550 b
N_2V_1	0.5100 c	2.172 bc	2.680 a
N_2V_2	0.5967 a	2.457 ab	2.720 a
N_2V_3	0.6289 a	2.368 ab	2.780 a
N_3V_1	0.5122 c	2.463 ab	2.701 a
N_3V_2	0.5856 ab	2.514 a	2.764 a
N_3V_3	0.6467 a	2.514 a	2.823 a
$LSD_{(0.05)}$	0.06496	0.2977	0.6137
CV (%)	12.82	10.43	25.68

V_1=Kalijira, V_2=BRRI dhan37, V_3=BRRI dhan38, N_1=Control, N_2=Prilled Urea, N_3=USG (Urea Super Granules).

4.4.4.5. Interaction effect of sources of N and weed control method

Interaction effect of Nitrogen sources and weed control method showed significantly on CGR (g hill^{-1} day^{-1}) at 20-40DAT (Table 17). At 20-40 DAT Maximum (0.6211 g hill^{-1} day^{-1}) CGR was found from the combination of USG (N_3) with Rifit 20EC (W_3) which was statistically similar with N_2W_2 and N_3W_2 and minimum (0.4300 g hill^{-1} day^{-1}) from the (N_1) without Nitrogen and two hand weeding (W_2) which was statistically similar with N_1W_1 and N_2W_1 (Table 17). The table indicates that for all sampling dates N_3W_3 showed highest CGR followed by N_3W_2, N_2W_3 and N_2W_2.

Table 17: Interaction effect of sources of nitrogen and weed control method on crop growth rate at different days after transplanting

Treatment combination	CGR at different dates after transplanting		
	20-40 DAT	40-60DAT	60-80DAT
N_1W_1	0.4844 cd	1.814 d	1.183 d
N_1W_2	0.4300 d	2.019 cd	1.428 d
N_1W_3	0.4889 cd	2.079 c	1.598 d
N_2W_1	0.5167 c	2.219 bc	2.263 c
N_2W_2	0.5978 ab	2.360 ab	2.803 a-c
N_2W_3	0.6033 a	2.418 ab	3.113 a
N_3W_1	0.5333 bc	2.492 a	2.504 bc
N_3W_2	0.6078 a	2.469 a	2.854 ab
N_3W_3	0.6211 a	2.531 a	2.930 ab
$LSD_{(0.05)}$	0.0676	0.2262	0.564
CV (%)	12.82	10.43	25.68

N_1=Control, N_2=Prilled Urea, N_3=USG (Urea Super Granules), W_1=control, W_2=Two hand weeding and W_3=Pre-emergence herbicides Rifit 20EC

4.1.4.6. Interaction effect of variety and weed control method

Interaction effect of variety and weed control method exerted significant effect on CGR (g $hill^{-1}$ day^{-1}) at all different sampling dates (Table 18). At 60-80 DAT Maximum CGR (2.688 g $hill^{-1}$ day^{-1}) was found from the combination of BRRI dhan38 (V_3) with Rifit 20EC (W_3) which was statistically similar with all other combination except V_1W_1, V_2W_1 and V_3W_1 and minimum CGR(1.908 g $hill^{-1}$ day^{-1}) from the (V_1) Kalizira and without weeding (W_1).

Table 18: Interaction effect of variety and weed control method on crop growth rate at different days after transplanting

Treatment combination	CGR at different dates after transplanting		
	20-40 DAT	40-60DAT	60-80DAT
V_1W_1	0.4422 e	2.050 b	1.908 c
V_1W_2	0.4756 de	2.222 ab	2.348 a-c
V_1W_3	0.4933 c-e	2.333 a	2.397 a-c
V_2W_1	0.5533 bc	2.209 ab	2.000 bc
V_2W_2	0.5611 b	2.330 a	2.316 a-c
V_2W_3	0.5900 ab	2.389 a	2.557 ab
V_3W_1	0.5389 b-d	2.267 ab	2.043 bc
V_3W_2	0.5989 ab	2.296 a	2.422 a-c
V_3W_3	0.6300 a	2.306 a	2.688 a
$LSD_{(0.05)}$	0.0676	0.2262	0.564
CV (%)	12.82	10.43	25.68

V_1=Kalijira, V_2=BRRI dhan37, V_3=BRRI dhan38, W_1=control, W_2=Two hand weeding and W_3=Pre-emergence herbicides Rifit 20EC

4.4.4.7. Interaction effect of sources of nitrogen, variety and weed control method

Interaction effect of Nitrogen sources, variety and weed control method showed significant on CGR (g hill^{-1} day^{-1}) at all different sampling dates. At 60-80 DAT Maximum CGR (3.187 g hill^{-1} day^{-1}) was found from the combination of prilled urea (N_2), BRRI dhan37 (V_2) with Rifit 20 EC (W_3) followed by $N_3V_3W_3$ and $N_3V_2W_3$ and minimum (1.087 g hill^{-1} day^{-1}) from the control (N_1) X (V_1) Kalizira X without weeding (W_1) (Table 19).

Table 19: Interaction effect of sources of nitrogen, variety and weed control method on crop growth at different days of transplanting of aromatic rice

Treatment Combination	CGR at different dates of transplanting		
	20-40 DAT	40-60DAT	60-80DAT
$N_1V_1W_1$	0.3800 kl	1.803 h	1.087 h
$N_1V_1W_2$	0.3700 l	1.980 f-h	1.313 f-h
$N_1V_1W_3$	0.4167 j-l	2.127 b-h	1.413 f-h
$N_1V_2W_1$	0.5467 d-h	1.747 h	1.273 f-h
$N_1V_2W_2$	0.4967 f-k	2.020 e-h	1.373 f-h
$N_1V_2W_3$	0.5233 f-j	2.103 c-h	1.517 e-h
$N_1V_3W_1$	0.5267 f-j	1.893 gh	1.190 gh
$N_1V_3W_2$	0.4233 i-l	2.057 d-h	1.597 d-h
$N_1V_3W_3$	0.5267 f-j	2.007 e-h	1.863 c-h
$N_2V_1W_1$	0.4667 h-l	1.913 gh	2.167 b-g
$N_2V_1W_2$	0.5233 f-j	2.237 a-g	2.893 ab
$N_2V_1W_3$	0.5400 e-i	2.367 a-f	2.980 ab
$N_2V_2W_1$	0.5267 f-j	2.373 a-e	2.213 a-f
$N_2V_2W_2$	0.6067 a-f	2.490 a-c	2.760 a-c
$N_2V_2W_3$	0.6567 a-e	2.507 ab	3.187 a
$N_2V_3W_1$	0.5567 c-h	2.370 a-f	2.410 a-e
$N_2V_3W_2$	0.6633 a-d	2.353 a-f	2.757 a-c
$N_2V_3W_3$	0.6667 a-c	2.380 a-e	3.173 a
$N_3V_1W_1$	0.4800 g-l	2.433 a-d	2.470 a-e
$N_3V_1W_2$	0.5333 f-j	2.450 a-c	2.837 a-c
$N_3V_1W_3$	0.5233 f-j	2.507 ab	2.797 a-c
$N_3V_2W_1$	0.5867 b-g	2.507 ab	2.513 a-d
$N_3V_2W_2$	0.5800 b-h	2.480 a-c	2.813 a-c
$N_3V_2W_3$	0.5900 b-g	2.557 a	2.967 ab
$N_3V_3W_1$	0.5333 f-j	2.537 a	2.530 a-d
$N_3V_3W_2$	0.7100 a	2.477 a-c	2.913 ab
$N_3V_3W_3$	0.6967 ab	2.530 a	3.027 ab
$LSD_{(0.05)}$	0.1171	0.3919	0.9769
CV (%)	12.82	10.43	25.68

V_1=Kalijira, V_2=BRRI dhan37, V_3=BRRI dhan38, N_1=Control, N_2=Prilled Urea, N_3=USG (Urea Super Granules), W_1=control, W_2=Two hand weeding and W_3=Pre-emergence herbicides Rifit 20EC

4.5. Yield contributing characters

4.5.1. Panicle length

4.5.1.1. Effect of Nitrogen sources

Panicle length was statistically significant by sources of nitrogen (Fig.13). The Longest panicle (28.22 cm) was produced due to application of USG which was statistically similar to application of PU (27.39 cm) and shortest (25.32cm) was produced in control (no urea). A similar finding was reported by Hasan *et al.* (2002). Sen and Pandey (1990) also found similar panicle length by applying 38.32 kg N ha^{-1} either in the form of USG or prilled urea.

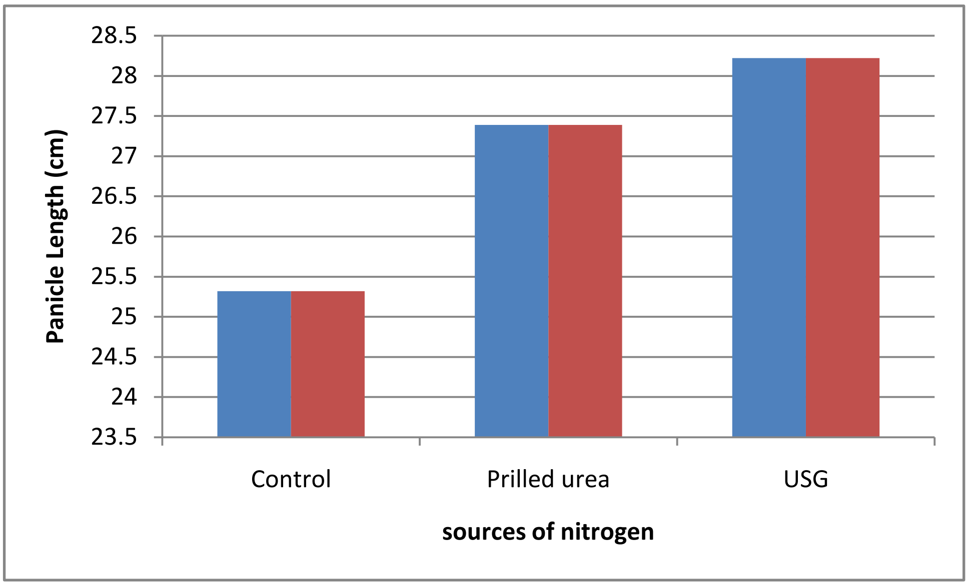

Fig.13: Effect of sources of nitrogen on panicle length (cm) of aromatic rice ($LSD_{(0.05)}$ = 1.824)

4.5.1.2. Effect of variety

The panicle length varied significantly due to variety shown in (Fig.14). It was observed that BRRI Dhan38 produced longer (28.67cm) panicle than BRRI dhan37 (26.77cm) and Kalijira (25.29cm). This confirms the report of Ahmed *et al.* (1997) and Idris (1990) who showed that panicle length was differed due to variety.

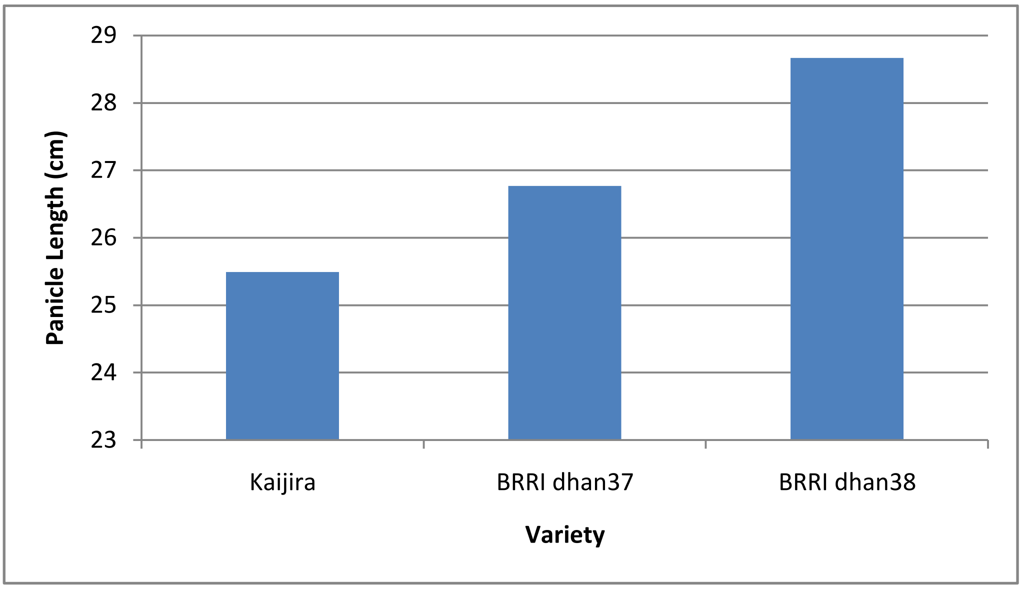

Fig.14: Effect of variety on panicle length (cm) of aromatic rice (LSD (0.05) = 0.82)

4.5.1.3. Effect of weed control method

The panicle length varied significantly due to weed control treatments shown in Figure 15. It was observed that the longest panicle (27.76 cm) was observed from the treatment (W_3) Rifit 20EC. The shortest (25.97cm) panicle length was observed from control treatment (W_1). This confirms the report of Khan and Tarique (2011) and Hasanuzzaman *et al.* (2008) who observed that panicle length was differed due to different weed control treatments.

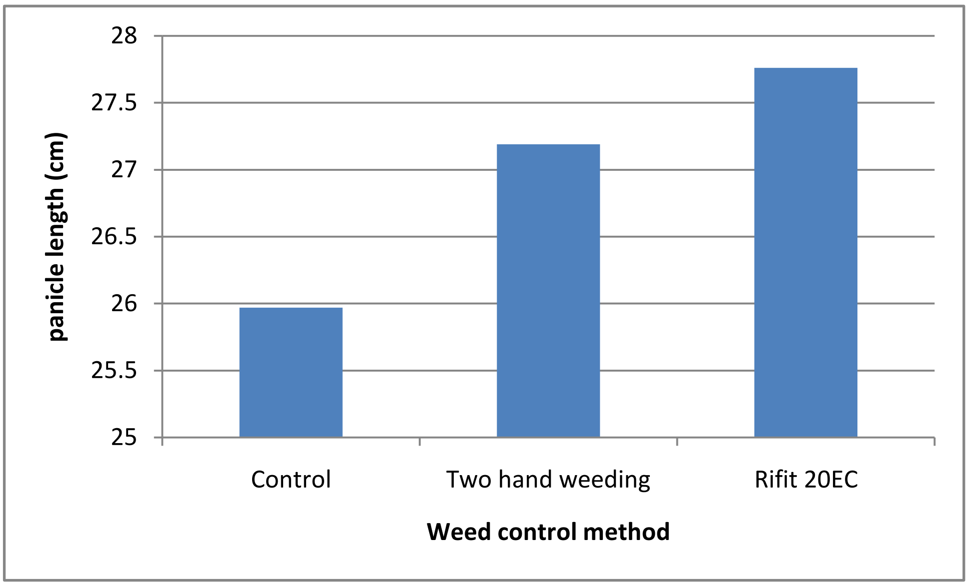

Fig.15: Effect of weed control method on panicle length (cm) of aromatic rice (LSD $_{(0.05)}$ = 0.95)

4.5.1.4. Interaction effect of sources of nitrogen and variety

Panicle length was statistically significant by the interaction of variety and forms of nitrogen. Longest panicle (29.64cm) obtained from N_3V_3 which is statistically similar with N_2V_2 and shortest panicle (23.09cm) obtained from N_1V_1 (Table 20).

4.4.5.5. Interaction effect of sources of nitrogen and weed control method

Panicle length was statistically significant by the interaction of variety and sources of nitrogen. Longest panicle (28.85cm) obtained from N_3W_3 which is statistically similar with N_3W_2, N_3W_1, N_2W_3 and N_2W_2 and shortest panicle (24.36cm) obtained from N_1V_1 which was statistically similar with N_1W_2(Table 21).

4.5.1.6. Interaction effect of variety and weed control method

Panicle length was statistically significant by the interaction of variety and weed control method. The longest panicle length obtained from the interaction of V_3W_3 and shortest panicle was obtained from interaction of V_1W_1 (Table 22).

4.5.1.7. Interaction effect of sources of nitrogen, variety and weed control method

Panicle length was statistically significant by the interaction of sources of nitrogen, variety and weed control method. The longest panicle (30.45cm) was obtained from $N_3V_3W_3$ which is statistically similar with $N_3V_3W_2$, $N_3V_3W_2$, $N_3V_2W_3$, $N_3V_2W_2$, $N_3V_1W_3$, $N_3V_1W_2$, $N_2V_3W_2$, $N_2V_3W_3$, $N_2V_3W_1$ and $N_2V_2W_3$ and the shortest panicle (21.41cm) obtained from $N_1V_1W_1$ which was statistically similar with $N_1V_1W_2$ (Table 23).

4.5.2 Effective tiller hill^{-1}

4.5.2.1. Effect of Sources of Nitrogen

Nitrogen in the form of USG ($N_{3)}$ produced significantly higher (14.01) productive tillers hill^{-1} compared to urea split application (Fig.16) and lowest productive tillers hill^{-1} (9.63) produced in Control (N_1) without Nitrogen. It is in agreement with Rama *et a1.* (1989), who reported that USG produced higher numbers of panicle m^{-2} than splits application of urea. Adequacy of nitrogen and uniform supply through USG probably favoured the cellular activities during panicle formation and development which lead to increase number of effective tillers hill^{-1}. Thakur (1991b) also agreed to this view.

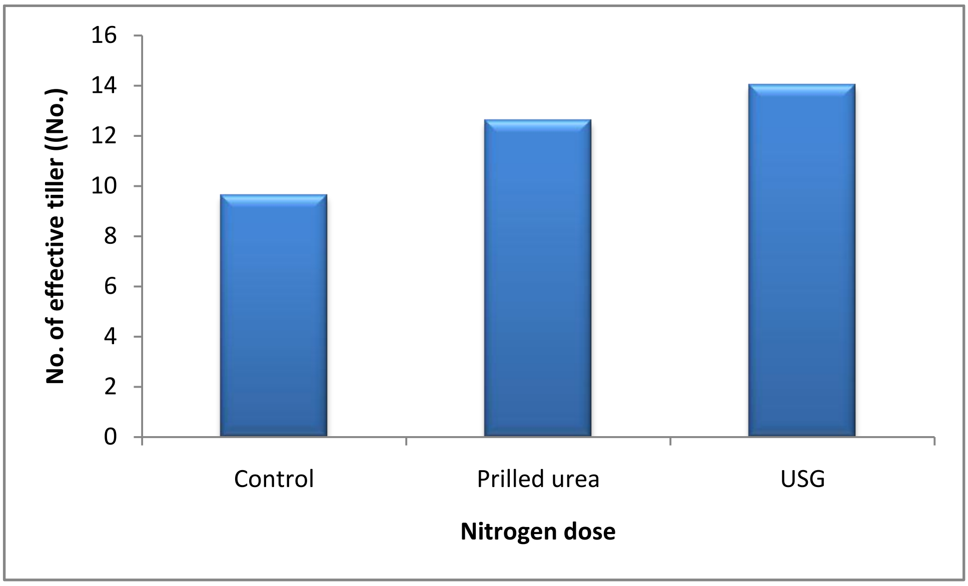

Fig.16. Effect of sources of nitrogen on effective tiller hill^{-1} on aromatic rice (LSD $_{(0.05)}$ = 0.50)

4.5.2.2. Effect of variety

Productive tillers unit area^{-1} determined the final yield of rice. This is why it is said that the higher the effective tillers, the higher the yield. It was evident from (Fig.17) that variety had significant effect on numbers of effective tiller. BRRI Dhan38 (V_3) produced higher number (13.76) and Kalijira (V_1) produced lower number (10.35) of productive tiller. Similar results were observed by Jones *et al.* (1996). Although Kalijira produced higher number of tiller but a high tiller number also increased tiller abortion rate as was observed in this study. The same result was reported by Peng *et al.* (1996). He found a negative correlation between maximum tiller number and percentage of productive tillers.

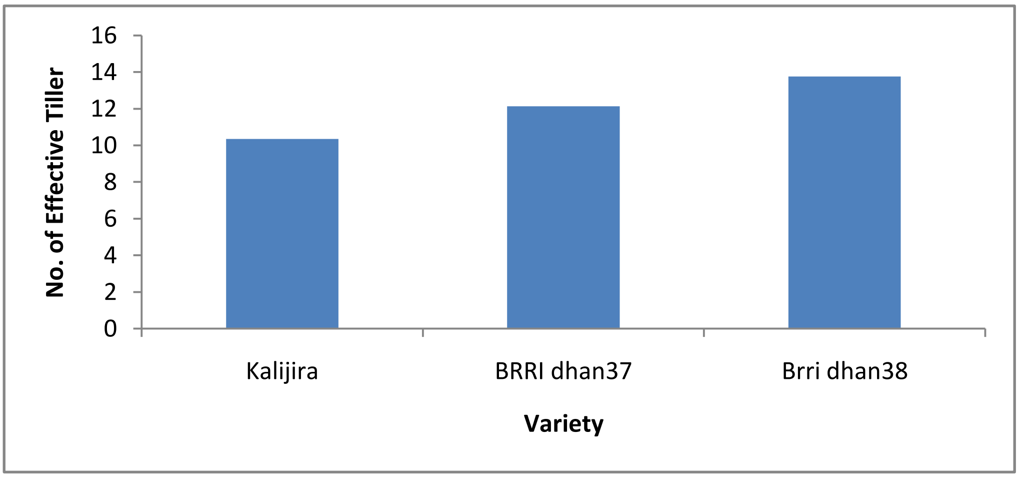

Fig.17: Effect of variety on effective tiller hill^{-1} on aromatic rice (LSD $_{(0.05)}$ = 0.42)

4.5.2.3. Effect of weed control method

Weed control by Rifit 20EC (W_3) gave the highest effective tiller (13.23) (Fig.18). No weeding (W_1) in the field gave the lowest effective tiller (10.70). These results were similar to the findings of Hasanuzzaman *et al.* (2008) and Raju *et al.* (2003) who stated that use of weedicide (Ronstar 25 EC, Safener and Butachlor) gave the highest effective tiller.

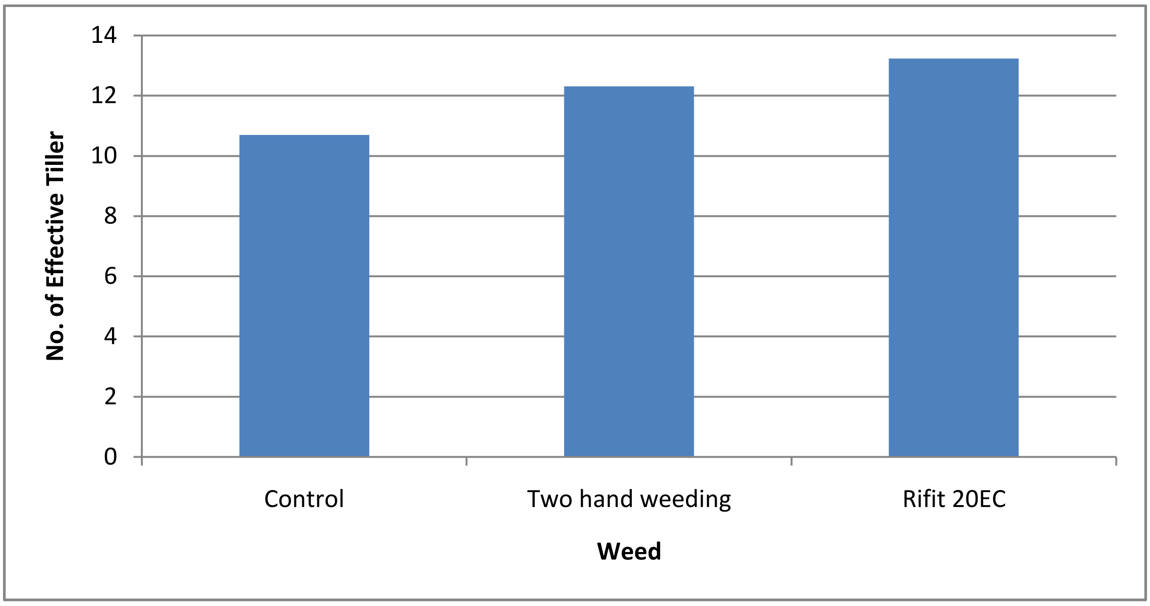

Fig.18: Effect of weed control method on effective tiller hill^{-1} of aromatic rice (LSD $_{(0.05)}$ = 0.57)

4.5.2.4. Interaction effect of nitrogen sources and variety

The effect of interaction between variety and source of N was found significant in respect of number of productive tillers hill^{-1}. Combination of BRRI Dhan38 with USG produced highest (15.50) number of productive tillers hill^{-1} (Table20). It was also observed that in case of all varieties USG receiving plants produced higher productive tillers hill^{-1} than split urea receiving plants and minimum in without urea.

4.5.2.5. Interaction effect of nitrogen sources and weed control method

The effect of interaction between source of N and weed control method exerted significant effect in respect of number of productive tillers hill^{-1} (Table 21) Combination of USG and Pre-emergence herbicide Rifit 20EC produced highest (15.21) number (Table 20) and minimum effective tillers hill^{-1} (8.149) in combination with no urea (control) x without weeding (control) treatment.

4.5.2.6. Interaction effect of variety and weed control method

Effective tiller was significantly affected by the interaction of variety and weed control (Table 22). The highest effective tiller (15.04) was obtained from the combination BRRI dhan38 with Rifit 20EC (V_3W_3). Second highest effective tiller (13.86) was obtained from the combination of V_3W_2 which was statistically similar with V_2W_3 (13.18). The lowest (8.867) was found from the combination Kalijira with no weeding (V_1W_1). Similar findings were reported by Khan and Tarique (2011), Hassan *et al.* (2010) and Ashraf *et al.* (2006) who stated that effective tillers hill^{-1} varied due to various varieties and weed control treatments.

4.5.2.7. Interaction effect of sources of nitrogen, variety and weed control method

Effective tiller was significantly affected by the interaction of sources of nitrogen, variety and weed control method (Table 23). The highest effective tiller (16.78) was obtained from the combination USG x BRRI dhan38 x Rifit 20EC ($N_3V_3W_3$) which was statistically similar with the treatment of $N_3V_3W_2$, $N_2V_3W_3$ and $N_2V_3W_2$. Second highest effective tiller (15.67) was obtained from the combination of $N_2V_3W_3$ which was statistically similar with $N_2V_3W_2$, $N_3V_2W_2$, $N_3V_2W_3$, $N_3V_2W_2$ and $N_3V_3W_2$. The lowest (8.30) was found from the combination with Control (no urea) x Kalijira x no weeding ($N_1V_1W_1$). Similar findings were reported by Khan and Tarique (2011), Hassan *et al.* (2010) and Ashraf *et al.* (2006) who stated that effective tillers hill^{-1} varied due to various varieties and weed control treatments.

4.5.3 Number of filled grains panicle^{-1}

4.5.3.1. Effect of sources of nitrogen

There observed a significant variation in number of filled grains panicle^{-1} due to soueces of N fertilizer (Fig.19). Results showed that higher number of filled grains panicle^{-1} was obtained with USG (100.7) than urea (94.90) and control (81.53). Rama *et al.* (1989) found significantly higher filled grains panicle^{-1} with 40, 80 or 120 kg N ha^{-1} applied as USG over split application of urea. The present results supported by the present results.

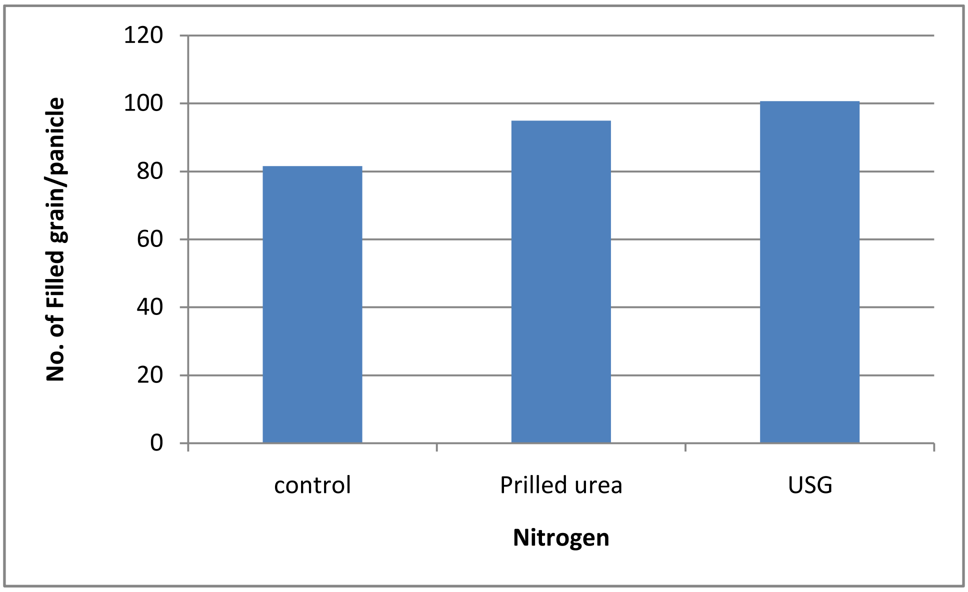

Fig.19: Effect of sources of nitrogen on number of grains panicle^{-1} of aromatic rice (LSD $_{(0.05)}$ = 20.43)

4.5.3.2. Effect of variety

Significant variation was observed in filled grain due to the effect of variety shown in Figure 20. The highest filled grain (99.87) was found in Kalijira (V_1). The lowest filled grain (85.01) was gained from BRRI dhan38 (V_3). Kalijira produced 17.48% more filled grain than BRRI dhan38. These results were in agreement with Ahmed *et al.* (1997) who reported that percent filled grain was the highest in Nizersail (a local variety) followed by BR25 and the lowest in BR11 and BR23.

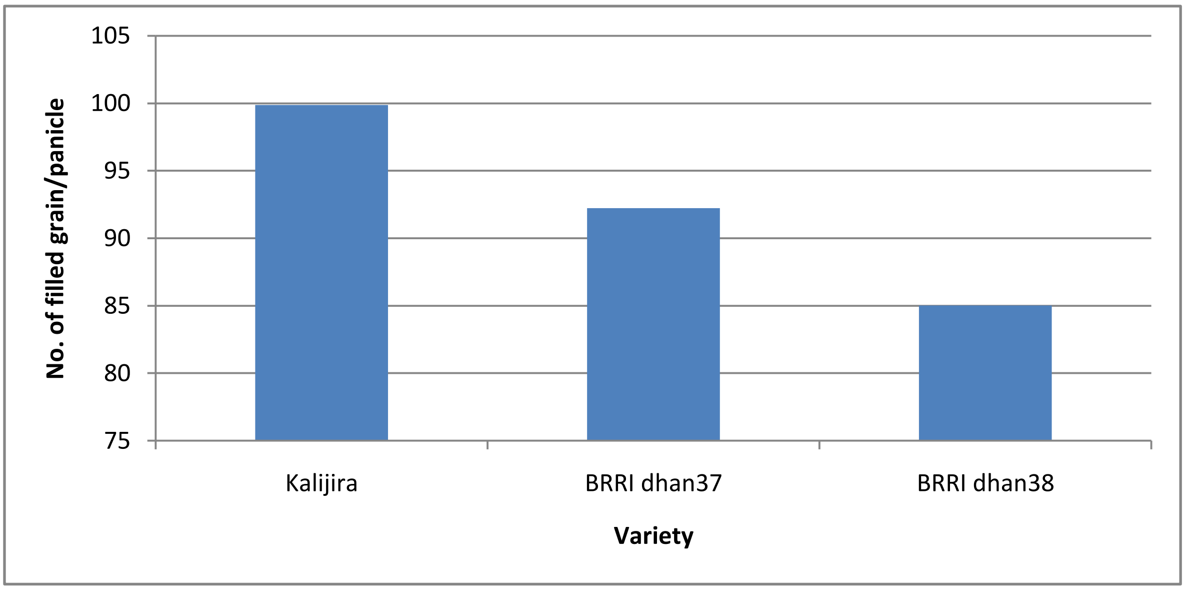

Fig.20: Effect of variety on number of grains panicle^{-1} of aromatic rice (LSD $_{(0.05)}$ = 11.26)

4.5.3.3. Effect of weed control method

Significant variation was found in filled grain due to the effect of weed control method (Fig.21). The highest filled grain (98.96) was obtained from the effect of Rifit 20EC (W_3). The lowest filled grain (85.40) was obtained from no weeding treated plot (W_1). This result supports the findings of Hasanuzzaman *et al.* (2008) and Salam *et al.* (2010) who showed that application of herbicide contributed mainly increasing the number of grain panicle^{-1}. But dissimilar findings were stated by Karim and Ferdous (2010) who revealed that the number of filled grains panicle^{-1} was negatively related to weed density.

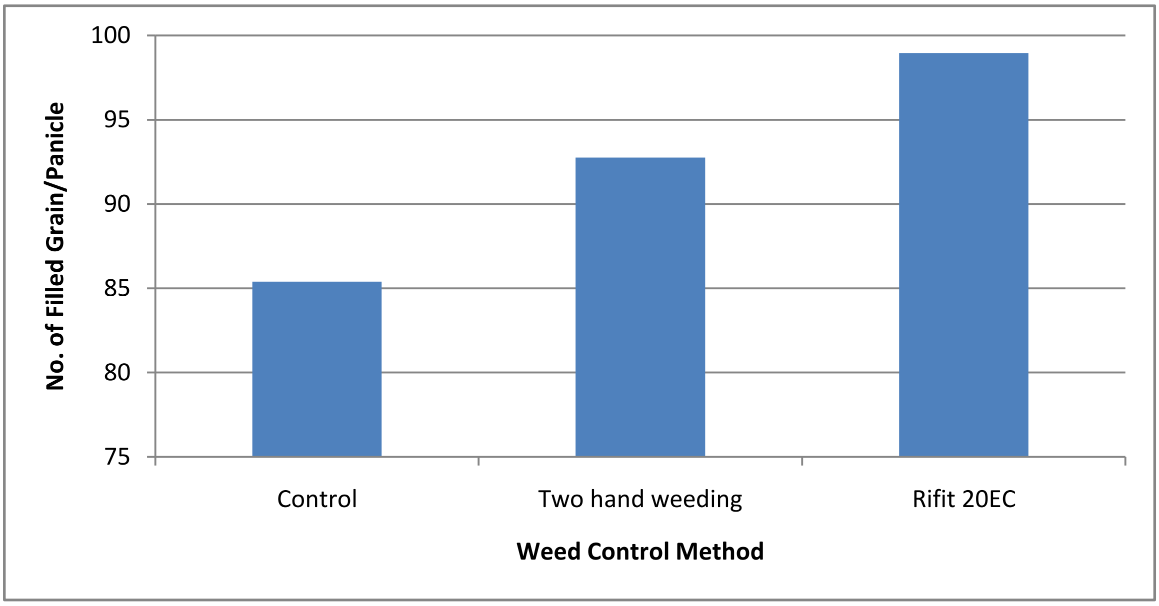

Fig.21: Effect of weed control method on number o grains panicle^{-1} of aromatic rice (LSD $_{(0.05)}$ = 10.55)

4.5.3.4. Interaction effect of sources of nitrogen and variety

Interaction effect of sources of N fertilizer and weed control method was found significant on filled grains panicle^{-1} (Table 20). From the results of it was observed that the highest (108.7) filled grains panicle^{-1} was found from the combination of Kalijira with USG which was statistically similar with the combination of N_2V_1 and N_3V_2 and the lowest (73.81) in BRRI dhan38 with Control (no urea) which was statistically similar with the combination of N_1V_2.

4.5.3.5. Interaction effect of sources of nitrogen and weed control method

Interaction effect of sources of N fertilizer and weed control method was found significant on filled grains panicle^{-1}. From the results of Table 21 it was observed that highest filled grains panicle^{-1} (107.2) was found from the combination of USG with Rifit 20EC which was statistically similar with the combination of N_3W_2 and N_2W_3 and the lowest (75.49) in Control (no urea) with no weeding treatment which was statistically similar with the combination of N_1W_2 (80.84).

4.5.3.6. Interaction effect of variety and weed control method

Interaction effect of variety and weed control method was found significant on filled grains panicle^{-1}. From the results of Table 22 it was observed that highest (105.4) filled grains panicle^{-1} was found from the combination of Kalijira X Rifit 20EC which was statistically similar with the combination of V_1W_2 and V_2W_3 and lowest (77.55) in BRRI dhan38 X Control (without weeding) which was statistically similar with the combination of V_3W_2 and V_2W_1.

4.5.3.7. Interaction effect of nitrogen sources, variety and weed control method

Number of grains panicle^{-1} was significantly affected by the interaction of sources of nitrogen, variety and weed control method (Table 23). The highest number of grains panicle^{-1} (117.2) was obtained from the combination USG x Kalijira x Rifit 20EC ($N_3V_1W_3$) which was statistically similar with the treatment of $N_3V_1W_2$, $N_2V_2W_3$, $N_2V_1W_2$ and $N_2V_1W_3$. The lowest (66.19) was found from the combination with Control (no urea) x BRRI dhan38 x no weeding ($N_1V_3W_1$) which was statistically similar with the treatment of $N_1V_3W_2$, $N_1V_3W_3$, $N_1V_2W_2$, $N_1V_2W_2$ and $N_2V_3W_1$.

4.5.4 Number of unfilled grains panicle^{-1}

4.5.4.1. Effect of sources of nitrogen

Number of unfilled grains panicle^{-1} was statistically influenced from the N source (Fig.22) siginificantly the highest unfilled grain panicle^{-1} (22.04) was observed in (N_1) without nitrogen and minimum number was obtained from the application of USG. But the result was dissimilar with Hasan *et al.* (2002) who observed that unfilled grains panicle^{-1} was unaffected by the application of USG and PU.

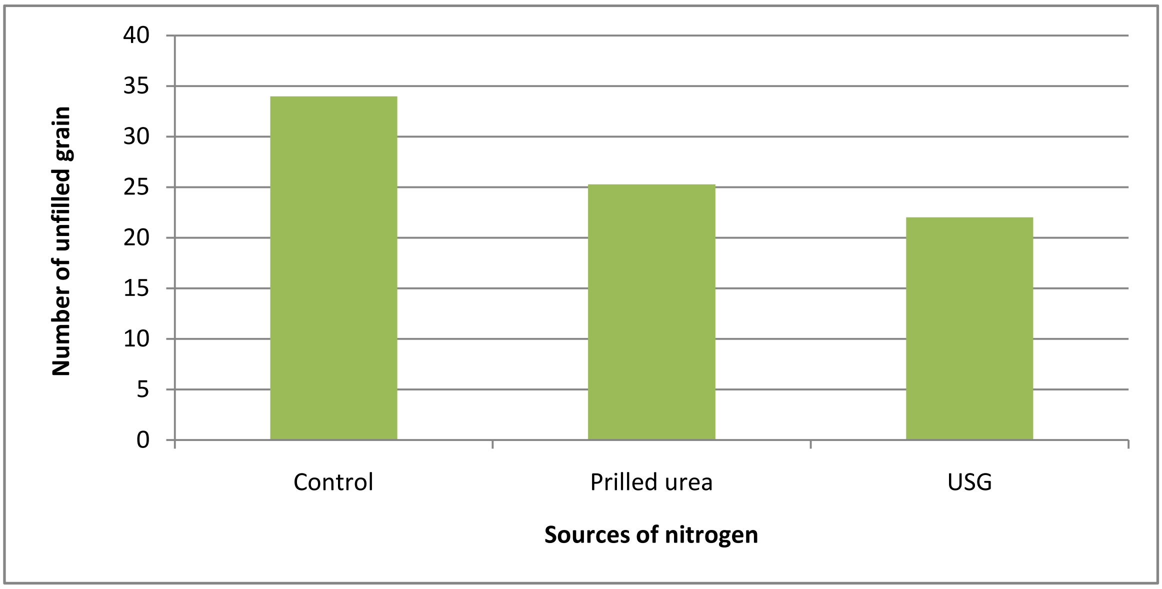

Fig.22: Effect of sources of nitrogen on number of unfilled grain panicle^{-1} on aromatic rice (LSD $_{(0.05)}$ = 1.41)

4.5.4.2. Effect of variety

Significant variation was obtained in unfilled grain panicle^{-1} due to the effect of variety (Figure 23). BRRI dhan38 (V_3) produced highest unfilled grain panicle^{-1} (33.72). The second highest unfilled grain panicle^{-1} (30.25) was obtained from BRRI dhan37 (V_2) and lowest unfilled grain panicle^{-1} (17.34) from Kalijira (V_1). BRRI dhan38 produced 48.58% highest unfilled grain panicle^{-1} than Kalijira. Similar findings were reported by Ahmed *et al*. (1997).

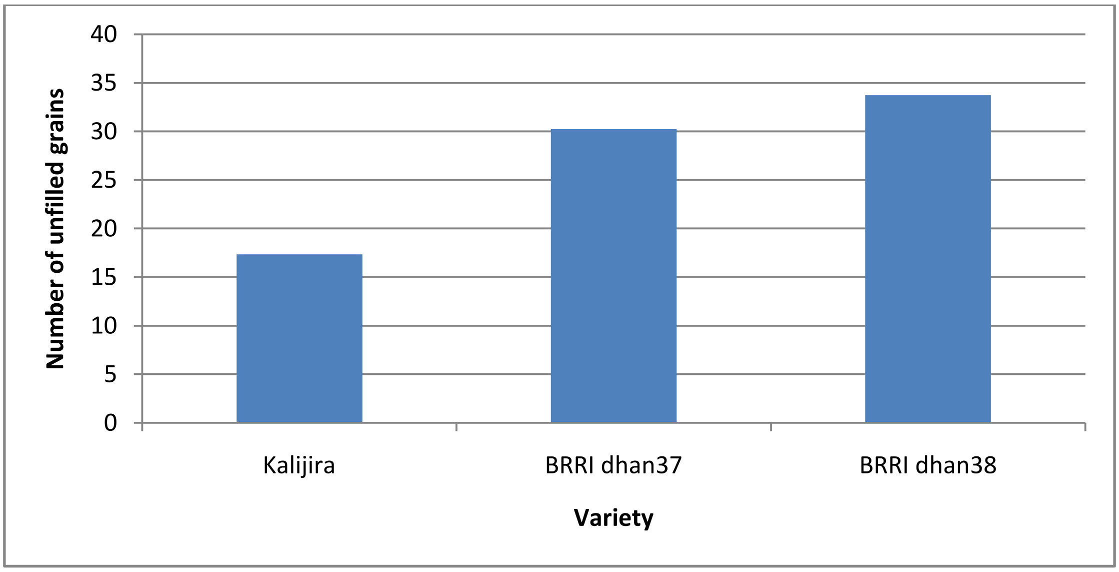

Figure 23: Effect of variety on number of unfilled grain panicle^{-1} of aromatic rice (LSD $_{(0.05)}$ = 1.45)

4.5.4.3. Effect of weed control method

Effect of weeding showed significant variation in unfilled grain (Fig.24). No weeding (W_1) gave highest unfilled grain (34.03). The lowest unfilled grain (21.59) was obtained from Rifit 20EC (W_3). No weeding (W_1) produced 57.62% higher unfilled grain than Rifit 20EC (W_3).

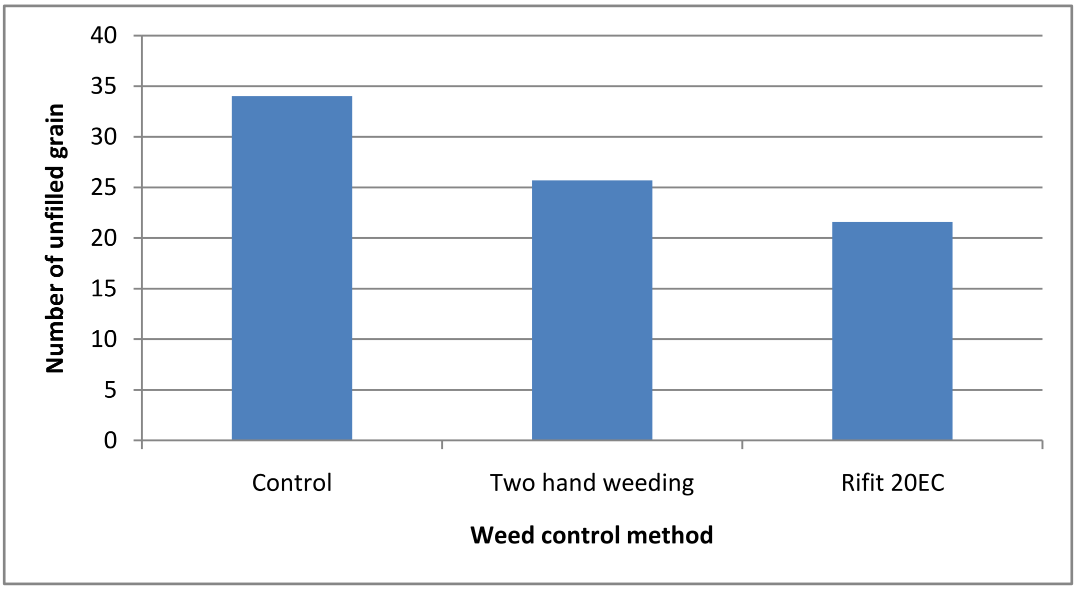

Fig.24: Effect of weed control method on number of unfilled grain panicle^{-1} of aromatic rice (LSD $_{(0.05)}$ = 1.66)

4.5.4.4. Interaction effect of nitrogen sources and variety

Significant variation was obtained in unfilled grain due to the effect of sources of nitrogen and variety (Table 20). Minimum unfilled grains panicle^{-1} (13.47) was obtained from the application of USG with combination of Kalijira. And the highest (40.55) was produced from the combination of control (no urea) and BRRI dhan38. But the result was dissimilar with Hasan *et al.* (2002) also observed that unfilled grains panicle^{-1} was unaffected by the application of USG and PU.

4.5.4.5. Interaction effect of nitrogen sources and weed control method

Significant variation was obtained in unfilled grain due to the effect of sources of nitrogen and weed control method (Table 21). Minimum (17.33) unfilled grains panicle^{-1} was obtained from the application of USG with combination of Rifit 20EC which was statistically similar with N2W2. The highest (42.31) was produced from the combination of control (no urea) and no weeding treatment.

4.5.4.6. Interaction effect of variety and weed control method

Ssignificant variation was obtained in unfilled grain due to the interaction effect of variety and weed control method shown in Table 22. Interaction effect of BRRI dhan38 X no weeding (V_3W_1) gave highest unfilled grain (41.84). The lowest unfilled grain (12.30) was found from the interaction effect of Kalijira X Rifit 20EC (V_1W_3).

4.5.4.7. Interaction effect of sources of nitrogen, variety and weed control method

Significant variation was obtained in unfilled grain due to the interaction effect of sources of nitrogen, variety and weed control method shown in Table 31. Interaction effect of control (no urea), BRRI dhan38 X no weeding ($N_1V_3W_1$) gave the highest unfilled grain (48.26). The lowest unfilled grain (10.00) was found from the interaction effect of USG X Kalijira X Rifit 20EC ($N_3V_1W_3$) which was statistically similar with $N_3V_1W_2$ (12.53).

4.5.5. 1000-grain weight

4.5.5.1. Effect of sources of nitrogen

There was significant variation in 1000-seed weight due to different sources of N (Fig.25). The weight of 1000-seed were 14.41g, 13.17g and 11.93g for USG, PU and control (without urea) respectively. But it was dissimilar with the result of (Yoshida, 1981). The 1000-grain weight of rice is more or less a stable genetic character and N management strategy could not increase the grain weight in this case. Hasan *et al.* (2002) also reported that the effect of application method of USG and PU was not significant in respect of 1000-grain weight.

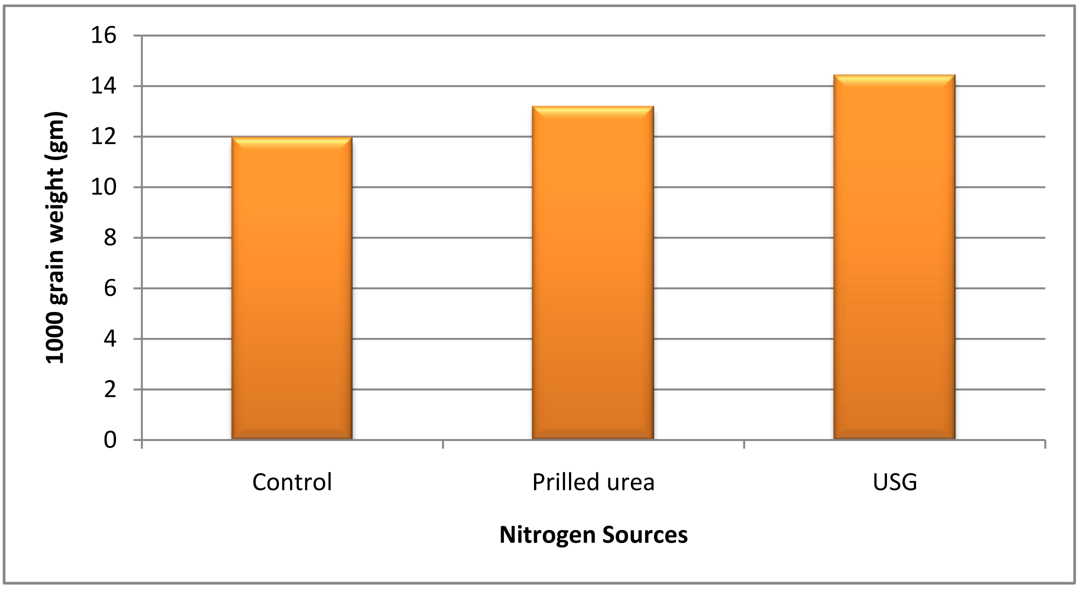

Fig.25: Effect of sources of nitrogen on 1000 grain weight (gm) of aromatic rice (LSD $_{(0.05)}$ = 0.93)

4.5.5.2. Effect of variety

Weight of 1000 grains showed significant variation among the different varieties. BRRI dhan38 produced highest 1000 grain weight (15.42g). The lowest 1000 grain weight (10.48 g) was obtained from Kalijira (Fig.26). Similar findings were reported by Hossain *et al.* (2007).

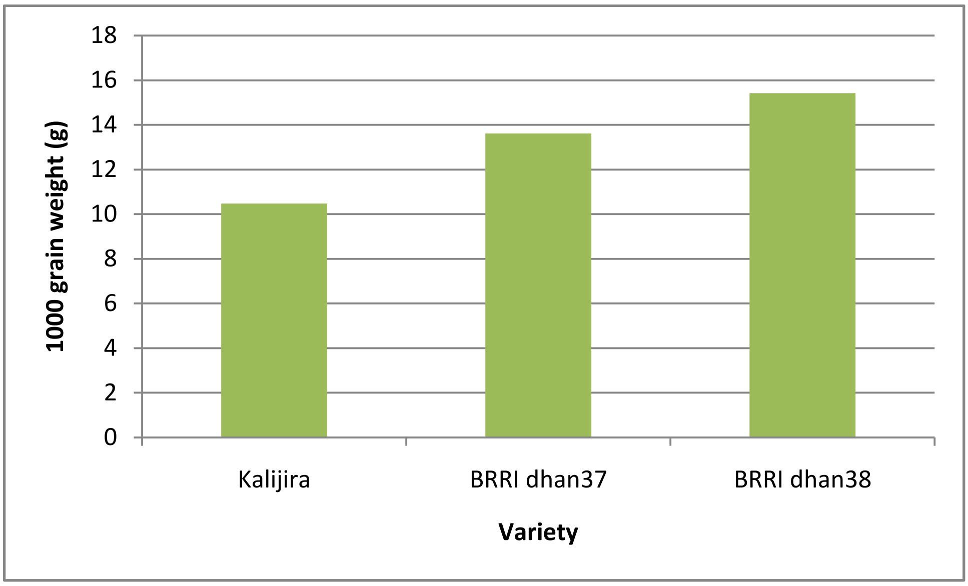

Fig.26: Effect of variety on 1000 grain weight (gm) of aromatic aman rice (LSD (0.05) = 0.75)

4.5.5.3. Effect of weed control method

Different weed control method showed significant variation in 1000 grain weight aromatic rice. Rifit 20EC (W_3) gave the highest 1000 grain weight (113.93 g) which was statistically similar with two hand weeding (W_2) (Fig.27). The lowest 1000 grain weight (12.10 g) was found from no weeding (W_1). This finding was in agreement with Khan and Tarique (2011), Hassan *et al.* (2010) and Raju *et al.* (2003) who showed that weeding regime had significant effect on 1000 grain weight. But this result was dissimilar with the findings of Nahar *et al.* (2010) and Karim and Ferdous (2010) who observed that 1000 grain weight was negatively related to weed density.

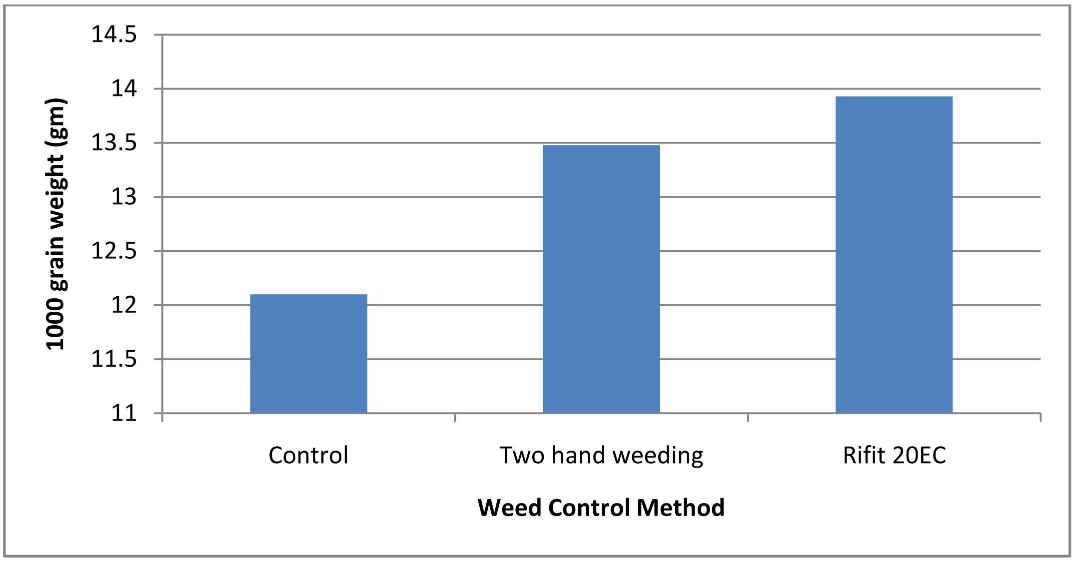

Figure 26: Effect of weed control method on 1000 grain weight (gm) of aromatic rice (LSD $_{(0.05)}$ = 0.55)

4.5.5.4. Interaction effect of sources of nitrogen and variety

Interaction of variety and different sources of N was significant on 1000-grain weight (Table 20). Heaviest with USG (16.11g) 1000-grain weight was obtained from USG with BRRI dhan 38 which was statistically similar with N_3V_2 and N_2V_3 and the lowest (8.813 g) was obtained from control (without nitrogen) and Kalijira.

4.5.5.5. Interaction effect of sources of nitrogen and weed control method

Interaction of different sources of N and weed control method was affected significantly on 1000-grain (Table 21). Heaviest (15.27 g) 1000-grain weight was obtained from USG with Rifit 20EC which was statistically similar with N3W2 and lowest (11.12 g) was obtained from control (without nitrogen) and without weeding.

4.5.5.6. Interaction effect of variety and weed control method

Interaction of variety and weed control method gave significant on 1000-grain weight (Table 22). Heaviest seed (16.47 g) 1000-grain weight was obtained from BRRI dhan38 X Rifit 20EC which was statistically similar with V_3W_2 and lowest was obtained from Kalijira X without weeding (9.619 g).

4.5.5.7. Interaction effect of sources of N, variety and weed control method

Interaction of sources of N, variety and weed control method was showed significant on 1000-grain (Table 23). Heaviest seed1000-grain weight (17.28 g) was obtained from combination of USG X BRRI dhan38 X Rifit 20EC which was statistically similar with $N_3V_3W_2$, $N_2V_3W_2$ and $N_2V_3W_3$ and the lowest (8.30 g) was obtained from combination of control (without nitrogen), Kalijira and without weeding which was statistically similar with $N_1V_1W_3$ and $N_1V_1W_2$.

Table 20: Interaction effect of sources of nitrogen and variety on yield contributing characters of aromatic rice

Treatment	Panicle Length (cm)	Effective Tillers/hill (no.)	Filled Grains/Panicle (no.)	Unfilled grains/Panicle (no.)	1000 Grain weight (g)
N_1V1	23.09 f	8.149 g	87.62 cd	22.11 d	8.813 f
N_1V_2	25.49 e	9.740 f	83.16 de	39.30 a	12.44 d
N_1V_3	27.37 cd	11.00 e	73.81 e	40.55 a	14.55 bc
N_2V_1	26.11 de	10.38 ef	103.3 ab	16.44 e	10.39 e
N_2V_2	27.05 cd	12.64 d	94.10 bc	27.52 c	13.50 cd
N_2V_3	29.01 ab	14.78 b	87.34 cd	31.90 b	15.61 ab
N_3V_1	27.26 cd	12.52 d	108.7 a	13.47 f	12.22 d
N_3V_2	27.77 bc	14.01 c	99.45 ab	23.94 d	14.90 ab
N_3V_3	29.64 a	15.50 a	93.89 bc	28.71 c	16.11 a
LSD(0.05)	1.415	0.7034	10.68	2.215	1.3
CV (%)	5.67	5.67	11.26	9.03	8.47

V_1=Kalijira, V_2=BRRI dhan37, V_3=BRRI dhan38, N_1=Control, N_2=Prilled Urea, N_3=USG (Urea Super Granules),

Table 21: Interaction effect of sources of nitrogen and weed control method on yield contributing characters of aromatic rice

Treatment	Panicle Length (cm)	Effective Tillers/hill (no.)	Filled Grains/Panicle (no.)	Unfilled grains/Panicle (no.)	1000 Grain weight (g)
N_1W_1	24.36 d	8.149 f	75.49 e	42.31 a	11.12 e
N_1W_2	25.38 cd	9.927 e	80.84 de	32.08 b	11.98 de
N_1W_3	26.21 bc	10.81 de	88.25 cd	27.58 c	12.70 cd
N_2W_1	26.30 bc	11.20 d	88.68 cd	31.88 b	12.03 de
N_2W_2	27.63 ab	12.93 c	94.54 bc	24.11 d	13.64 bc
N_2W_3	28.23 a	13.68 bc	101.5 ab	19.87 ef	13.83 b
N_3W_1	27.26 ab	12.74 c	92.03 c	27.90 c	13.14 bc
N_3W_2	28.56 a	14.08 b	102.9 ab	20.89 e	14.83 a
N_3W_3	28.85 a	15.21 a	107.2 a	17.33 f	15.27 a
LSD(0.05)	1.645	0.9843	9.313	2.873	0.9522
CV (%)	6.38	8.52	10.55	11.09	7.56

N_1=Control, N_2=Prilled Urea, N_3=USG (Urea Super Granules), W_1=control, W_2=Two hand weeding and W_3=Pre-emergence herbicides Rifit 20EC

Table 22: Interaction effect variety and weed control method on yield contributing characters of aromatic rice

Treatment	Panicle Length (cm)	Effective Tillers/hill (no.)	Filled Grains/Panicle (no.)	Unfilled grains/Panicle (no.)	1000 Grain weight (g)
V_1W_1	23.85 e	8.867 f	93.52 bc	23.85 e	9.619 e
V_1W_2	15.87 f	10.70 e	100.7 ab	15.87 f	10.91 d
V_1W_3	12.30 g	11.48 de	105.4 a	12.30 g	10.90 d
V_2W_1	36.39 b	10.84 e	85.13 cd	36.39 b	12.54 c
V_2W_2	29.85 cd	12.37 cd	92.36 bc	29.85 cd	13.88 b
V_2W_3	24.52 e	13.18 bc	99.22 ab	24.52 e	14.42 b
V_3W_1	41.84 a	12.39 cd	77.55 d	41.84 a	14.14 b
V_3W_2	31.36 c	13.86 b	85.23 cd	31.36 c	15.65 a
V_3W_3	27.96 d	15.04 a	92.25 bc	27.96 d	16.47 a
LSD(0.05)	2.873	0.9843	9.313	2.873	0.9522
CV (%)	6.38	8.52	10.55	11.09	7.56

V_1=Kalijira, V_2=BRRI dhan37, V_3=BRRI dhan38, W_1=control, W_2=Two hand weeding and W_3=Pre-emergence herbicides Rifit 20EC

Table 23: Interaction effect of sources of nitrogen, variety and weed control method on yield contributing characters of aromatic rice.

Treatment combination	Panicle Length (cm)	Effective Tillers/hill (no)	Filled Grains/Panicle (no)	Unfilled grains/Panicle (no)	1000 Grain weight (g)
$N_1V_1W_1$	21.41 j	6.670 l	82.67 g-k	32.89 ef	8.300 m
$N_1V_1W_2$	23.09 ij	8.667 k	88.89 c-k	19.33 j-l	9.163l m
$N_1V_1W_3$	24.78 g-i	9.110 jk	91.29 c-j	14.11 m-o	8.977 m
$N_1V_2W_1$	24.91 g-i	8.553 k	77.61 j-l	45.77 ab	11.29 ij
$N_1V_2W_2$	25.47 f-i	10.00 h-k	80.31 i-l	37.91 cd	12.37 hi
$N_1V_2W_3$	26.10 e-h	10.67 h-j	91.56 c-j	34.22 d-f	13.66 f-h
$N_1V_3W_1$	26.75 c-h	9.223 i-k	66.19 l	48.26 a	13.77 f-h
$N_1V_3W_2$	27.58 b-g	11.11 f-h	73.33 kl	38.99 cd	14.40 d-f
$N_1V_3W_3$	27.76 a-f	12.67 d-f	81.89 h-l	34.40 de	15.47 b-d
$N_2V_1W_1$	24.54 hi	8.600 k	98.44 b-g	20.78 i-k	9.457 k-m
$N_2V_1W_2$	26.89 c-h	10.89 g-i	103.6 a-c	15.76 l-n	11.02 i-k
$N_2V_1W_3$	26.88 c-h	11.67 e-h	107.8 ab	12.80 no	10.70 j-l
$N_2V_2W_1$	26.26 d-h	11.22 f-h	86.23 d-k	34.07 d-f	12.53 g-i
$N_2V_2W_2$	26.95 c-h	13.00 de	94.83 b-i	27.22 gh	13.85 d-h
$N_2V_2W_3$	27.94 a-f	13.70 cd	101.2 a-e	21.27 i-k	14.11 d-g
$N_2V_3W_1$	28.11 a-f	13.77 cd	81.37 h-l	40.80 bc	14.11 d-g
$N_2V_3W_2$	29.06 a-d	14.89 bc	85.23 e-k	29.36 fg	16.05 a-c
$N_2V_3W_3$	29.85 ab	15.67 ab	95.41 b-i	25.53 g-i	16.67 ab
$N_3V_1W_1$	26.00 f-h	11.33 e-h	99.44 b-f	17.89 k-m	11.10 i-k
$N_3V_1W_2$	27.93 a-f	12.55 d-g	109.6 ab	12.53 no	12.55 g-i
$N_3V_1W_3$	27.84 a-f	13.67 cd	117.2 a	10.00 o	13.02 f-h
$N_3V_2W_1$	26.87 c-h	12.73 d-f	91.57 c-j	29.33 fg	13.79 e-h
$N_3V_2W_2$	28.18 a-f	14.11 b-d	101.9 a-d	24.42 g-i	15.42 b-e
$N_3V_2W_3$	28.25 a-f	15.18 a-c	104.9 a-c	18.07 k-m	15.49 b-d
$N_3V_3W_1$	28.90 a-e	14.16 b-d	85.07 f-k	36.47 c-e	14.53 c-f
$N_3V_3W_2$	29.57 a-c	15.57 ab	97.13 b-h	25.72 g-i	16.51 ab
$N_3V_3W_3$	30.45 a	16.78 a	99.46 b-f	23.93 h-j	17.28 a
$LSD_{(0.05)}$	2.849	1.705	16.13	4.976	1.649
CV (%)	6.38	8.52	10.55	11.09	7.56

V_1=Kalijira, V_2=BRRI dhan37, V_3=BRRI dhan38, N_1=Control, N_2=Prilled Urea, N_3=USG (Urea Super Granules), W_1=control, W_2=Two hand weeding and W_3=Pre-emergence herbicides Rifit 20EC

4.6 Yield

4.6.1 Grain yield

4.6.1.2. Effect of nitrogen sources

Grain yield affected significantly due to the sources of N-fertilizer (Table 24). Higher grain yield (3.33 t ha^{-1}) by urea super granules indicated its superiority over split application of urea (3.0 t ha^{-1}). Placement of nitrogen fertilizer in the form of USG @ 58 kg N ha^{-1} in the present experiment produced the highest number of effective tillers $hill^{-1}$, filled grains $panicle^{-1}$ which ultimately gave higher grain yield than split application of urea and control treatment (with out urea). This result is in agreement with those of BRRI (2000) that USG gave 18% yield increase over the recommended prilled urea. In the present experiment it 18.87% higher grain yield was found in USG over urea. Similar results were reported by Mishra *et al.* (2000) and Raju *et al.* (1987) who observed that among all the forms of N, urea super granules recorded the highest grain yield and proved significantly superior to other sources.

4.6.1.2. Effect of variety

Grain yield varied significantly for different varieties shown in Table 24. The highest grain yield (3.29 t ha^{-1}) was recorded by BRRI dhan38 (V_3). The second highest grain yield (3.02 t ha^{-1}) was recorded from BRRI dhan37 (V_2). The lowest grain yield (2.15 t ha^{-1}) was recorded from Kalijira (V_1). This result was similar with Franje *et al.* (1992) who found that yields of modern cultivars improved with increased weeding while yields of traditional cultivars did not. Dissimilar results were found by Reza *et al.* (2010) who stated that Pajam (a local variety) produced the higher grain yield (4.0 t ha^{-1}) than BRRI dhan28 (2.79 t ha^{-1}).

4.6.1.3. Effect of weed control method

Significant variation was observed for grain yield due to different weed control treatments (Table24). The highest yield (3.26 t ha^{-1}) was recorded from Rifit 20EC (W_3) and the lowest yield (2.2 t ha^{-1}) was obtained from no weeding treatment (W_1). Similar findings were reported by Al-Mamun *et al.* (2011), Bhuiyan *et al.* (2011), Khan and Tarique (2011), Mamun *et al.* (2011), and Shultana *et al.*(2011). Who observed that application of chemical herbicides significantly increases grain yield of rice.

4.6.1.4. Interaction effect of sources of nitrogen and variety

Interaction of variety and sources of nitrogen significantly affected the grain yield (Table 25). In case of all varieties superior grain yield was found by the application of USG. Significant highest grain yield (3.82 t ha^{-1}) was found from the combination of BRRI dhan38 X USG which was statistically similar with N_3V_2 and N_2V_3 and lowest (1.45 t ha^{-1}) from Kalijira X control (without nitrogen).

4.6.1.5. Interaction effect of sources of nitrogen and weed control method

Interaction of sources of nitrogen and weed control method significantly affected the grain yield of aromatic rice. In case of all varieties higher grain yield was found by the application of USG in combination with Rifit 20EC. Significant highest grain yield (3.83 t ha^{-1}) was found from the combination of USG X Rifit 20EC (Table 26) which was statistically similar with N_3W_2 and N_2W_3 and the lowest (1.60 t ha^{-1}) from control (without nitrogen) X no weeding.

4.6.1.6. Interaction effect of variety and weed control method

The grain yield varied significantly due to different varietal and weed control treatment combinations (Table 27). The highest grain yield (3.71 t ha^{-1}) was recorded from BRRI dhan38 X Rifit 20EC combination (V_3W_3). The lowest grain yield (1.60 t ha^{-1}) was recorded from Kalijira X no weeding treatment combination (V_1W_1). This result is in agreement with Al-Mamun *et al.* (2011) who reported that the highest grain yield (6.96 t ha^{-1}) was obtained from Surjamoni when treated with Bouncer 10WP @ 150 g ha^{-1}, which was 49% higher than control. BRRI dhan29 also produced the highest grain yield when treated with same treatment, which was 37% higher than control.

4.6.1.7. Interaction effect of sources of N, variety and weed control method

Interaction of sources of N, variety and weed control method showed significant on grain yield (Table 28). Highest grai yield (4.28 t ha^{-1}) was obtained from combination of USG X BRRI dhan38 X Rifit 20EC which was statistically similar with $N_3V_3W_2$ and $N_2V_3W_3$ and the lowest (0.98 t ha^{-1}) was obtained from combination of control (without nitrogen), Kalijira and without weeding which was statistically similar with $N_1V_1W_2$ and $N_2V_1W_1$.

4.6.2 Straw yield

4.3.2.1. Effect of sources of nitrogen

Straw yield of rice varied significantly affected due to the sources of N fertilizer. Straw yield was the highest (5.364 t ha^{-1}) in urea super granules and lowest (4.09 t ha^{-1}) was obtained from without nitrogen. Mirzeo and Reddy (1989) also observed that urea super granules in rice gave higher straw yield than split application of prilled urea.

4.6.2.2. Effect of variety

There observed significant variation for straw yield due to varietal variation (Table 24). Kalijira (V_1) recorded the highest straw yield (5.62 t ha^{-1}) and BRRI dhan37 (V_2) recorded the lowest straw yield (4.44 t ha^{-1}) which was statistically similar with BRRI dhan38. Similar findings were also reported by Hassan *et al.* (2010).

4.3.2.3. Effect of weed control method

Significant variation was observed due to different weed control treatments (Table 24). Highest straw yield (5.21 t ha^{-1}) was recorded from Rifit 20EC (W_3) and the lowest (4.45 t ha^{-1}) was recorded from no weeding (W_1) treatment. This result was in agreement with the findings of Khan and Tarique (2011), Salam *et al.* (2010), Manish *et al.* (2006) and Chandra and Solanki (2003) who revealed that weeding had significant variation on straw yield of rice.

4.3.2.4. Interaction effect of sources of N and variety

Interaction effect of variety and sources of N fertilizer was observed significant on straw yield (Table 25). Highest straw yield (6.30 t ha^{-1}) was found from the combination of Kalijira X USG and lowest (3.80 t ha^{-1}) from the combination of BRRI dhan38 X no nitrogen.

4.3.2.5. Interaction effect of sources of nitrogen and weed control method

Interaction effect of sources of N fertilizer and variety was observed significant on straw yield. Highest (5.86 t ha^{-1}) straw yield was found from the combination of USG X Rifit 20EC and the lowest (3.35 t ha^{-1}) from the combination of no nitrogen X without weeding (Table 26).

4.6.2.6. Interaction effect of variety and weed control method

The straw yield varied significantly due to different varietal and weed control treatment combinations. The highest straw yield (6.34 t ha^{-1}) was obtained from the combination of Kalijira with Rifit 20EC (V_1W_3). The lowest (3.99 t ha^{-1}) was found from the combination BRRI dhan37 with no weeding (V_2W_1) which was similar to V_3W_1 and V3W3 (Table27). This result was similar to the findings of Salam *et al.* (2010) who stated that the highest straw yield (7.37 t ha^{-1}) were found due to application of Machete 5G @ 25 kg ha^{-1} in *boro* rice (BINA dhan5). Similar results were also observed by Hassan *et al.* (2010).

4.6.2.7. Interaction of nitrogen sources, variety and weed control method

There was significant effect on straw yield (Table 28). Highest syraw yield (7.14 t ha^{-1}) was obtained from combination of USG X Kalijira X Rifit 20EC which was statistically similar with $N_2V_1W_3$ and $N_3V_1W_1$ and the lowest (3.17 t ha^{-1}) was obtained from combination of control (without nitrogen) X BRRI dhan38 X without weeding which was statistically similar with $N_1V_1W_2$, $N_1V_3W_3$, $N_2V_2W_1$ and $N_2V_3W_3$.

4.3.3 Biological yield

4.3.3.1. Effect of sources of nitrogen

Biological yield was significantly affected by the sources of N fertilizer. Maximum biological yield (8.694 t ha^{-1}) was observed from the USG treated plots than PU treated plots (8.03 t ha^{-1}) and control (6.22 t ha^{-1}) plots (Table 24).

4.3.3.2. Effect of variety

The biological yield varied significantly due to variety shown in Table 24. It was observed that BRRI dhan38 (V_3) produced significantly highest biological yield (7.76 t ha^{-1}) and the lowest biological yield (7.72 t ha^{-1}) was recorded from Kalijira (V_1) was statistically similar with BRRI dhan37.

4.3.3.3. Effect of weed control method

The biological yield varied significantly due to different weed control treatments shown Table 24. Weeds controlled by Rifit 20EC (W_3) gave the highest biological yield (8.47 t ha^{-1}). No weeding (W_1) treatment gave the lowest biological yield (6.67 t ha^{-1}).

4.3.3.4. Interaction effect of sources of nitrogen and variety

It was found that biological yield was affected significantly due to the interaction of variety and form of nitrogen fertilizer (Table 25). Maximum biological yield (8.99 t ha^{-1}) was obtained from the combination of USG X BRRI dhan38 which was similar to N_3V_1 and N_2V_1 and the minimum (5.75 t ha^{-1}) from Kalijira with control (without nitrogen) which was statistically similar to N_1V_2 and N_1V_3.

4.3.3.5. Interaction effect of sources of N and weed control method

It was found that biological yield was affected significantly due to the interaction of sources of nitrogen fertilizer (Table 26). Maximum biological yield (9.69 t ha^{-1}) was obtained from the combination of USG X Rifit 20EC and minimum (4.95 t ha^{-1}) from control (without nitrogen) X without weeding.

4.3.3.6. Interaction effect of variety and weed control method

Biological yield was significantly affected by the interaction of variety and weed control method. The highest biological yield (8.93 t ha^{-1}) was obtained from the combination Kalijira X Rifit 20EC (V_1W_3). The lowest biological yield (6.44t ha^{-1}) was found from the combination BRRI dhan37 X no weeding (V_2W_1). This result was similar to the findings of Salam *et al.* (2010) who stated that the highest grain yield (7.15 t ha^{-1}) and straw yield (7.37 t ha^{-1}) were found due to application of Machete 5G @ 25 kg ha^{-1}.

4.6.3.7. Interaction effect of sources of N, variety and weed control method

It was found that biological yield was affected significantly due to the interaction of sources of nitrogen fertilizer X variety X weed control method (Table 28). Maximum (10.52 t ha^{-1}) biological yield was obtained from the combination of USG X BRRI dhan38 X Rifit 20EC and the minimum (4.52 t ha^{-1}) from control (without nitrogen) X Kalizira X without weeding.

4.3.4 Harvest Index

4.3.4.1. Effect of sources of nitrogen

Forms of nitrogen fertilizer had significant variation on harvest index (Table 24) and it was 40.35% in urea super granules and 38.12% in prilled urea and 34% in control treatment Ali (2005) was reported that N management strategy did not influence HI. On the other hand Miah *et al.* (2004) also reported that forms of nitrogen fertilizer had exerted very little variation on harvest index.

4.3.4.2. Effect of variety

Variety showed significant variation in harvest index (Table24). BRRI dhan38 (V_3) showed the highest harvest index (43.00%) whereas lowest harvest index (28.59%) in Kalijira (V_1).

4.3.4.3. Effect of weed control method

Significant variation was observed in harvest index due to the effect of weeding (Table 24). The highest harvest index (39.91%) was found due to the effect of Rifit 20EC (W_3) which was statistically similar with two hand weeding treatment (W_2) (38.48%). No weeding (W_1) gave the lowest harvest index (34.08%). Similar findings were observed by Manish *et al.* (2006) who stated that weeding had significant variation on harvest index.

4.6.4.4. Interaction effect of sources of nitrogen and variety

There was observed significant effect on harvest index by the interaction of variety and nitrogen source (Table25). Maximum (44.80%) harvest index was found from the combination of BRRI Dhan38 with Prilled urea which was statistically similar of same variety with USG and the minimum (25.23%) was found from the combination of Kalijira with control (no nitrogen) which was also statistically similar to same variety with Prilled urea

4.6.4.5. Interaction effect of sources of N and weed control method

Significant effect on harvest index by the interaction of urea source and weed control method. Maximum harvest index (43.24%) was found from the combination of N_3 X W_2 which was statistically similar with N_3W_2, N_2W_3 and N_2W_2 and minimum (32.19%) was found from the combination of N_1 X W_1 which was also statistically similar to N_1W_2, N_2W_1 and N_3W_1.

4.6.4.6. Interaction effect of variety and weed control method

There was significant effect on harvest index by the interaction of variety and weed control method (Table25). In numerically maximum harvest index (46.86%) was found from the combination of V_3 X W_3 and the minimum (24.13%) was found from the combination of V1 X W1.

4.6.4.7. Interaction effect of sources of nitrogen, variety and weed control method

There was significant effect on harvest index by the interaction of variety and weed control method (Table 26). In numerically maximum harvest index (50.77%) was found from the combination of N_2 X V_3 X W_3 which was statistically similar with $N_2V_2W_2$, $N_2V_2W_3$, $N_3V_2W_2$, $N_2V_2W_3$, $N_3V_3W_2$ and $N_3V_3W_3$ and minimum (21.96%) was found from the combination of N_1 X V_1 X W_1 which was statistically similar with $N_1V_1W_1$, $N_2V_1W_1$, $N_2V_1W_3$ and $N_3V_1W_1$.

Table 24: Effect of sources of nitrogen, variety and weed control method on yield and harvest index of aromatic rice

Treatment	Grain Yield ($t\ h^{-1}$)	Straw Yield ($t\ h^{-1}$)	Biological Yield ($t\ h^{-1}$)	Harvest Index (%)
Factor A				
N_1	2.125 c	4.090 b	6.216 c	34.00 b
N_2	2.959 b	5.073 a	8.032 b	38.12 a
N_3	3.329 a	5.364 a	8.694 a	40.35 a
CV (%)	12.09	8.03	5.36	11.23
$LSD_{(0.05)}$	0.2563	0.2936	0.9362	3.181
Factor B				
V_1	2.105 c	5.619 a	7.724 a	28.59 b
V_2	3.020 b	4.441 b	7.461 a	40.88 a
V_3	3.288 a	4.468 b	7.756 a	43.00 a
CV(%)	11.88	15.68	11.05	10.74
$LSD_{(0.05)}$	0.1976	0.4504	0.6318	2.387
Factor C				
W_1	2.224 c	4.450 b	6.674 c	34.08 b
W_2	2.927 b	4.869 a	7.795 b	38.48 a
W_3	3.262 a	5.210 a	8.472 a	39.91 a
CV(%)	15.50	13.47	11.17	11.37
$LSD_{(0.05)}$	0.2710	0.3598	0.4635	2.354

V_1=Kalijira, V_2=BRRI dhan37, V_3=BRRI dhan38, N_1=Control, N_2=Prilled Urea, N_3=USG (Urea Super Granules), W_1=control, W_2=Two hand weeding and W_3=Pre-emergence herbicides Rifit 20EC

Table 25: Interaction effect of sources of nitrogen and weed control method on on yield and harvest index of aromatic rice

Treatment Combination	Grain Yield (t h^{-1})	Straw Yield (t h^{-1})	Biological Yield (t h^{-1})	Harvest Index (%)
N_1V_1	1.45 e	4.300 cd	5.751 c	25.23 c
N_1V_2	2.374 cd	4.172 cd	6.547 c	36.05 b
N_1V_3	2.550 c	3.799 d	6.349 c	40.73 a
N_2V_1	2.183 d	6.253 a	8.437 ab	27.18 c
N_2V_2	3.193 b	4.538 b-d	7.731 b	42.39 a
N_2V_3	3.499 ab	4.429 b-d	7.928 b	44.80 a
N_3V_1	2.680 c	6.303 a	8.983 a	33.36 b
N_3V_2	3.492 ab	4.613 bc	8.106 b	44.20 a
N_3V_3	3.816 a	5.177 b	8.992 a	43.49 a
$LSD_{(0.05)}$	0.3422	0.7795	0.8679	4.174
CV (%)	11.88	15.68	11.05	10.74

V_1=Kalijira, V_2=BRRI dhan37, V_3=BRRI dhan38, N_1=Control, N_2=Prilled Urea, N_3=USG (Urea Super Granules),

Table 26: Interaction effect of sources of nitrogen and weed control method on yield and harvest index of aromatic rice

Treatment Combination	Grain Yield (t h^{-1})	Straw Yield (t h^{-1})	Biological Yield (t h^{-1})	Harvest Index (%)
N_1W_1	1.604 f	3.349 d	4.953 d	32.19 e
N_1W_2	2.219 e	4.426 c	6.644 c	32.91 de
N_1W_3	2.552 de	4.497 c	7.049 c	36.90 b-d
N_2W_1	2.339 de	4.772 bc	7.111 c	34.17 de
N_2W_2	3.132 bc	5.171 b	8.303 b	39.30 a-c
N_2W_3	3.404 ab	5.277 ab	8.681 b	40.89 ab
N_3W_1	2.730 cd	5.228 b	7.958 b	35.87 c-e
N_3W_2	3.429 ab	5.009 bc	8.438 b	43.24 a
N_3W_3	3.829 a	5.857 a	9.686 a	41.94 a
$LSD_{(0.05)}$	0.4693	0.6233	0.8169	4.076
CV (%)	15.50	13.47	11.05	11.40

N_1=Control, N_2=Prilled Urea, N_3=USG (Urea Super Granules), W_1=control, W_2=Two hand weeding and W_3=Pre-emergence herbicides Rifit 20EC

Table 27: Interaction effect of variety and weed control method on yield and harvest index of aromatic rice

Treatment Combination	Grain Yield (t h^{-1})	Straw Yield (t h^{-1})	Biological Yield (t h^{-1})	Harvest Index (%)
V_1W_1	1.601 e	5.267 b	6.868 de	24.13 e
V_1W_2	2.124 d	5.249 b	7.373 cd	31.14 d
V_1W_3	2.589 cd	6.341 a	8.930 a	30.49 d
V_2W_1	2.453 cd	3.991 d	6.444 e	38.16 c
V_2W_2	3.118 b	4.396 cd	7.513 cd	42.11 bc
V_2W_3	3.489 ab	4.937 bc	8.426 ab	42.37 b
V_3W_1	2.619 c	4.091 d	6.710 de	39.95 bc
V_3W_2	3.538 ab	4.961 bc	8.499 ab	42.20 bc
V_3W_3	3.708 a	4.352 cd	8.060 bc	46.86 a
$LSD_{(0.05)}$	0.4693	0.6233	0.8169	4.076
CV (%)	15.50	13.47	11.05	11.37

V_1=Kalijira, V_2=BRRI dhan37, V_3=BRRI dhan38, N_1=Control, W_1=control, W_2=Two hand weeding and W_3=Pre-emergence herbicides Rifit 20EC

Table 28: Interaction effect of sources of nitrogen, variety and weed control method on yield and harvest index of aromatic rice

Treatment	Grain Yield ($t\ h^{-1}$)	Straw Yield ($t\ h^{-1}$)	Biological Yield ($t\ h^{-1}$)	Harvest Index (%)
$N_1V_1W_1$	0.9833 l	3.53 ijk	4.520 j	21.96 i
$N_1V_1W_2$	1.483 kl	4.560e-i	6.043hi	24.58 hi
$N_1V_1W_3$	1.887 i-k	4.803 d-h	6.690 gh	29.14 gh
$N_1V_2W_1$	1.807 jk	3.343 jk	5.150 ij	35.11 fg
$N_1V_2W_2$	2.430 f-j	4.400 e-j	6.830 f-h	35.39 fg
$N_1V_2W_3$	2.887 d-g	4.773 d-h	7.660 d-g	37.65 ef
$N_1V_3W_1$	2.023 h-k	3.167 k	5.190 ij	39.51 c-f
$N_1V_3W_2$	2.743 e-h	4.317 f-j	7.060 f-h	38.76 d-f
$N_1V_3W_3$	2.883 d-g	3.913 h-k	6.797 gh	43.92 a-e
$N_2V_1W_1$	1.790 j-l	5.730 b-d	7.520 d-g	24.02 hi
$N_2V_1W_2$	2.263 g-k	5.950 bc	8.213 c-f	30.05 gh
$N_2V_1W_3$	2.497 f-j	7.080 a	9.577 a-c	27.46 hi
$N_2V_2W_1$	2.477 f-j	4.160 g-k	6.637 gh	38.54 d-f
$N_2V_2W_2$	3.343 b-e	4.457 e-i	7.800 d-g	44.20 a-e
$N_2V_2W_3$	3.760 a-c	4.997 c-g	8.757 b-d	44.42 a-e
$N_2V_3W_1$	2.750 e-h	4.427 e-i	7.177 e-h	39.97 b-f
$N_2V_3W_2$	3.790 a-c	5.107 c-g	8.897 b-d	43.65 b-e
$N_2V_3W_3$	3.957 ab	3.753 h-k	7.710 d-g	50.77 a
$N_3V_1W_1$	2.030 h-k	6.533 ab	8.563 b-e	26.41 hi
$N_3V_1W_2$	2.627 e-i	5.237 c-g	7.863 d-g	38.79 d-f
$N_3V_1W_3$	3.383 b-e	7.140 a	9.673 ab	34.88 fg
$N_3V_2W_1$	3.077 c-f	4.470 e-i	7.547 d-g	40.83 b-f
$N_3V_2W_2$	3.580 a-d	4.330 f-j	7.910 d-g	46.73 ab
$N_3V_2W_3$	3.820 a-c	5.040 c-g	8.860 b-d	45.05 a-d
$N_3V_3W_1$	3.083 c-f	4.680 d-h	7.763 d-g	40.37 b-f
$N_3V_3W_2$	4.080 ab	5.460 b-e	9.540 a-c	44.21 a-e
$N_3V_3W_3$	4.283 a	5.390 c-f	10.52 a	45.88 a-c
$LSD_{(0.05)}$	0.8129	1.08	1.415	7.06
CV (%)	14.97	6.47	7.75	11.37

V_1=Kalijira, V_2=BRRI dhan37, V_3=BRRI dhan38, N_1=Control, N_2=Prilled Urea, N_3=USG (Urea Super Granules), W_1=control, W_2=Two hand weeding and W_3=Pre-emergence herbicides Rifit 20EC

Chapter 5

Summary and conclusion

SUMMARY AND CONCLUSION

A field experiment was conducted at the Agronomy field, Sher-e-Bangla Agricultural University (SAU), during July through December, 2012 with view to finding out the performance of modern and traditional of aromatic *aman* rice as affected by the sources of nitrogen and weed control method. The experiment was laid out in a split split plot design with three replications. The size of the individual plot was 4 m x 2.5 m and total numbers of plots were 81. There were 27 treatment combinations. Sources of Nitrogen viz: (N_1) control, (N_2) prilled urea and (N_3) USG (urea super granules) was placed along the main plot and Variety (V_1) Kalijira, (V_2) BRRI dhan37 and (V_3) BRRI dhan38 were placed along the sub plot. The weeding treatments were placed along the sub sub plot. Weed control methods viz: no weeding (W_1), two hand weedings at 20 DAT and 40 DAT (W_2), Pre-emergence herbicides Rifit 20EC @ 900 ml ha^{-1} (W_3) was applied at 5 DAT in 4-5 cm standing water for 3-5 days. Twenty five days old seedlings of BRRI dhan37, BRRI dhan38 and Kalijira were transplanted on the well puddled experimental plots on August 1, 2012 by using two seedlings $hill^{-1}$. Sources of nitrogen fertilizer was significantly differed all growth characters. Highest plant height (131.3cm) was recorded from application of USG at harvest and lowest one (124.1cm) from control treatment at harvest. Highest number of tiller $hill^{-1}$ (16.13) was recorded from USG treatment at harvest and TDM (123.9g) and CGR (2.76 gm^{-2} d^{-1}) were recorded from application of USG at 80 DAT. Among the yield contributing parameters effective tillers $hill^{-1}$, filled grains $panicle^{-1}$, unfilled grain $panicle^{-1}$ and 1000 grain weight was affected significantly. The highest effective tillers $hill^{-1}$, filled grains $panicle^{-1}$ and 1000 grain weight were recorded 14.01, 100.7 and 14.41g respectively from USG treatment. Grain yield, straw yield as well as biological yield and harvest index significantly increased. Highest grain yield (3.33 t ha^{-1}) was recorded from USG treatmenr. 13.61% higher mean yield was found in USG over urea.

Variety showed significant effect on all growth characters as well as yield. Highest plant height (139.6cm) was recorded from Kalijira at harvest and lowest one (120.6cm) in BRRI dhan38 at harvest. Highest number of tiller $hill^{-1}$ (15.44) was recorded in BRRI dhan38 at harvest and TDM (112.2g) was recorded in BRRI dhan38 at 80 DAT. Among the yield contributing parameters effective tillers $hill^{-1}$, filled grains $panicle^{-1}$, unfilled grain $panicle^{-}$

^{1} and 1000 grain weight was affected significantly. The highest effective tillers hill^{-1} (13.76) was recorded in BRRI dhan38 and filled grains panicle^{-1} (99.87) was recorded in Kalijira. Highest 1000 grain weight (15.42g) was recorded in BRRI dhan38. Grain yield, straw yield as well as biological yield and harvest index significantly increased. Highest grain yield (3.26 t ha^{-1}) was recorded in BRRI dhan38 and the lowest grain yield (2.1 t ha^{-1}) in Kalijira.

Weed control methods were significantly differed all growth characters. Highest plant height (131.0cm) was recorded from application of Rifit 20EC and the lowest one (124.5cm) from control treatment (no weeding) at. Highest number of tiller hill^{-1} (15.11) was recorded fromRifit 20EC herbicide treatment at harvest and TDM (116.2g) were recorded from application of Rifit 20EC at 80 DAT. Among the yield contributing parameters effective tillers hill^{-1}, filled grains panicle^{-1}, unfilled grain panicle^{-1} and 1000 grain weight was affected significantly. The highest effective tillers hill^{-1} (13.23) and filled grains panicle^{-1} (98.96) were recorded from Rifit 20 EC treatment. Grain yield, straw yield as well as biological yield and harvest index significantly increased. Highest grain yield (3.30 t ha^{-1}) was recorded from Rifit 20EC treatment and the lowest (2.22 t ha^{-1}) was recorded in control (no weeding) treatment.

Interaction effect of sources of nitrogen fertilizer and variety was affected significantly in plant height, number of total tiller hill^{-1} and TDM in all sampling dates. Among the yield contributing characters are also significantly influenced by the interaction of sources of nitrogen and variety. The highest plant height (124.1cm) and number of tillers hill^{-1} (17.30) were recorded from USG X BRRI dhan38 at harvest. Grain yield, straw yield, biological yield even harvest index significantly influenced. Highest grain yield (3.82 t ha^{-1}) was recorded from USG X BRRI Dhan38 and the lowest grain yield (1.45 t ha^{-1}) was recorded from without urea X Kalijira (1.45 t ha^{-1}).

Interaction effect of sources of nitrogen fertilizer and weed control method was affected significantly in plant height, number of total tiller hill^{-1} and TDM in all sampling dates. Among the yield contributing characters are also significantly influenced by the interaction of sources of nitrogen and weed control methods. The highest plant height (134.1cm) and number of tillers hill^{-1} (17.22) were recorded from USG X Rifit 20EC at harvest. Grain yield, straw yield, biological yield even harvest index significantly influenced. Highest grain yield (3.83 t ha^{-1}) was recorded from USG X Rifit 20EC and the lowest grain yield (1.60 t ha^{-1}) was recorded from without urea X control (no weeding) treatment.

Interaction effect of variety and weed control method was observed significant on all growth characters as well as yield. Highest plant height and number of tiller $hill^{-1}$ 122.7cm and 16.52 respectively were recored from the combination of BRRI dhan38 X Rifit 20EC at harvest. Highest grain yield (3.71 t ha^{-1}) was recorded from the combination of BRRI dhan38 X Rifit 20EC and the lowest grain yield (1.60 t ha^{-1}) was recorded from Kalijira X control (no weeding) treatment.

Interaction of sources of nitrogen, variety and weed control methods exerted significant effect on all growth parameters as well as yield. Highest plant height and number of tiller $hill^{-1}$ 142.5cm and 18.44 respectively were recored from the combination of sources of nitrogen X BRRI dhan38 X Rifit 20EC at harvest. Highest grain yield (4.28 t ha^{-1}) was recorded from the combination of sources of nitrogen X BRRI dhan38 X Rifit 20EC and the lowest grain yield (1.45 t ha^{-1}) was recorded from control (without nitrogen) X Kalijira X control (no weeding) treatment.

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

1. As sources of nitrogen super granules was found to be a promising practice for good yield.
2. BRRI dhan38 response much in USG application but BRRI dhan37 and Kalijira also provide a good response.
3. Pre-emergence herbicide Rifit 20EC showed best weed control efficiency on BRRI dhan38.
4. The interaction of USG, BRRI dhan38 and Rifit 20EC showed best result on all growth as well as yield characters.

However, to reach a specific conclusion and recommendation, more research work on modern and traditional variety, sources of Nitrogen fertilizer and weed control method should be done over different Agro-ecological zones of the country.

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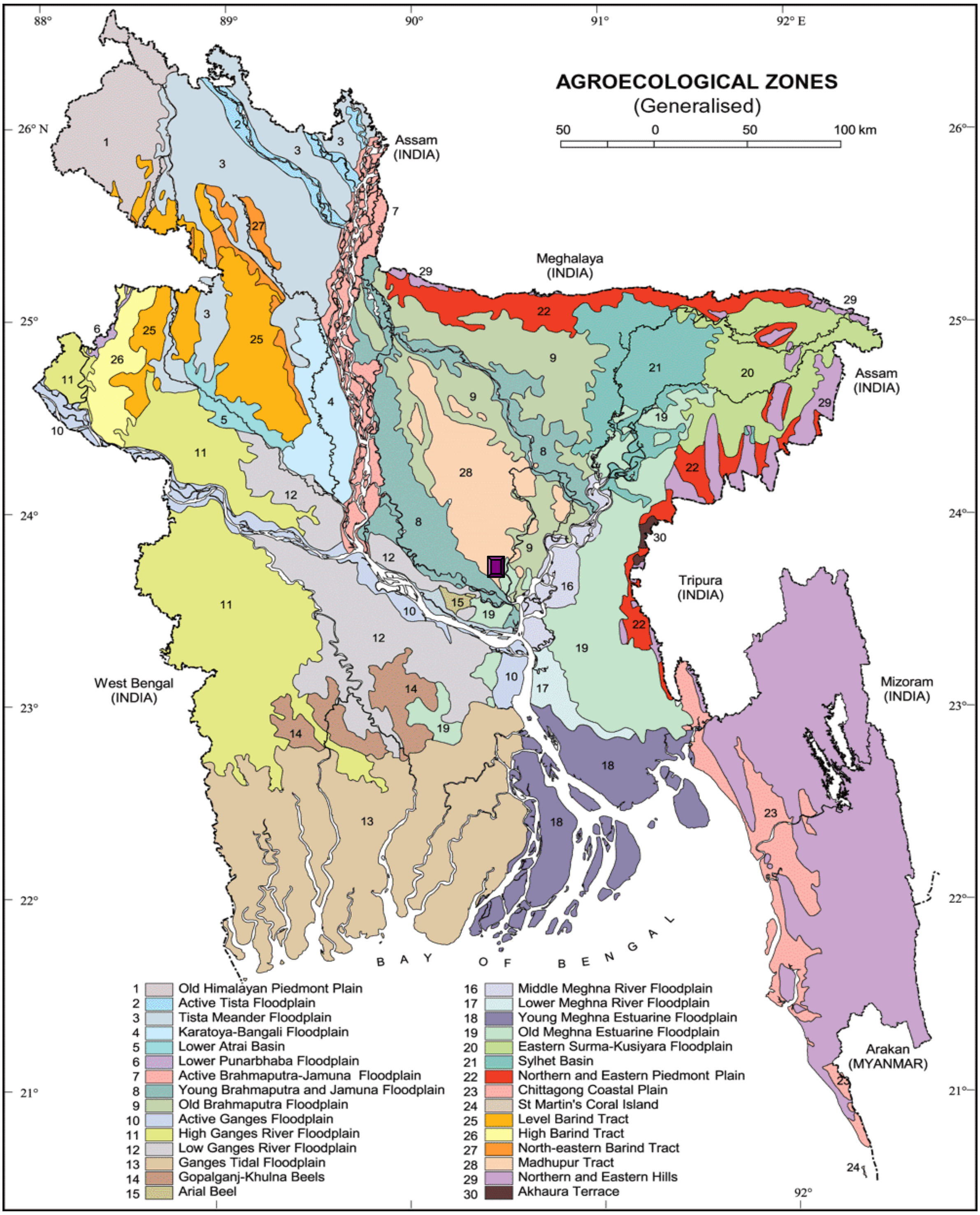
Appendices

APPENDICES

Appendix I. Map showing the experimental site under study



Appendix II: Physical and chemical properties of experimental soil analyzed at Soil Resources Development Institute (SRDI), Farmgate, Dhaka.

Characteristics	*Value*
Partical size analysis	
% Sand	27
%Silt	43
% Clay	30
Textural class	Silty-clay
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	45

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

Appendix III: Weather data, 2013, Dhaka

		Average Temperature (ºC)		Total	Average
Month	**Average**	**Min.**	**Max.**	**Rainfall**	**Sunshine hours**
June	83	26.5	34.2	619	4.8
July	81	25.2	31.8	761	4.3
August	80	26.7	33.5	514	4.7
September	79	24.4	31	183	3.6
October	78	22.8	31.3	341	4.9
November	73	18.9	28.6	107	5.8
December	69	16.6	23.2	0	5.6

Source: Bangladesh Meterological Department (Climatic Division), Agargaon, Dhaka-1207

Appendix IV. Means square values for plant height (cm) of T. *aman* aromatic rice at different days after transplanting

Sources of variation	DF	Means square values at different days after transplanting				
		20	40	60	80	At harvest
Replication	2	12.171	3.863	2.207	31.133	21.067
Sources of N fertilizer (N)	2	345.172**	602.590**	1039.102*	988.187*	343.339**
Error (a)	4	5.403	2.450	101.420	67.218	17.449
Variety (V)	2	343.817**	1036.668**	147.379*	933.289**	2829.782**
N x V	4	9.399*	14.517**	94.622**	68.534*	1.340*
Error (b)	12	17.217	33.457	21.633	26.029	58.563
Weed control method (W)	2	96.766**	337.092**	180.286*	234.997*	291.107**
N x W	4	4.002*	0.786*	14.326*	19.197*	7.887*
V x W	4	15.469*	1.049*	4.146*	7.093*	11.987*
N x V x W	8	3.606*	2.157*	3.959*	4.579*	5.599*
Error (c)	36	20.810	26.284	41.320	46.680	66.620

*Significant at 5% level

**Significant at 1% level

Appendix V. Means square values for total tiller number of T. *aman* aromatic rice at different days after transplanting

Sources of variation	DF	Means square values at different days after transplanting				
		20	40	60	80	At Harvest
Replication	2	1.719	0.157	4.317	6.118	2.304
Form of N fertilizer (N)	2	99.981**	151.679**	154.730**	79.536**	135.061*
Error (a)	4	0.610	4.127	5.016	2.773	11.376
Variety (V)	2	120.952**	49.083**	68.582**	51.265**	59.689**
N x V	4	0.655*	2.361*	2.773*	0.529*	0.760*
Error (b)	12	1.566	2.676	3.500	1.845	1.843
Weed control metho (W)	2	68.671**	50.919*	43.700**	43.918**	35.122**
N x W	4	0.450*	0.379*	2.656*	1.082*	0.365*
V x W	4	0.335*	0.517*	1.157*	0.989*	0.280*
N x V x W	8	0.723*	0.413*	1.133*	1.090*	0.403*
Error (c)	36	1.546	3.531	3.351	5.398	2.545

*Significant at 5% level **Significant at 1% level

Appendix VI. Means square values for total dry matter weight (g $hill^{-1}$) of T. *aman aromatic* rice at different days after transplanting

*Significant at 5% level

Sources of variation	DF	Means square values at different days after transplanting			
		20	40	60	80
Replication	2	1.487	4.784	22.699	18.990
Form of N fertilizer (N)	2	16.676**	120.690**	1513.376**	14070.820**
Error (a)	4	0.622	2.545	10.120	269.393
Variety (V)	2	10.127**	94.046**	228.100**	544.158*
N x V	4	0.919*	3.310*	11.720*	10.711*
Error (b)	12	0.281	1.800	29.999	86.336
Weed control method(W)	2	15.273**	52.955*	259.006**	2105.720**
N x W	4	0.516*	2.609*	12.886*	89.377*
V x W	4	0.249*	1.069*	8.323*	11.550*
N x V x W	8	0.103*	1.948*	5.223*	18.895*
Error (c)	36	0.892	1.227	23.455	110.939

**Significant at 1% level

*Significant at 5% level

Appendix VII. Means square values for grain yield, straw yield, biological yield and harvest index of T. *aman* aromatic rice

Sources of variation	DF	Means square values			
		Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
Replication	2	0.153	0.269	0.367	0.930
Form of N fertilizer (N)	2	10.268**	12.034**	44.452**	280.138*
Error (a)	4	0.115	0.151	0.168	17.717
Variety (V)	2	10.394**	12.204**	0.707*	1635.260**
N x V	4	0.045*	2.248*	2.183*	42.944*
Error (b)	12	0.111	0.576	0.714	16.201
Weed control method (W)	2	7.568*	3.916**	22.260**	249.445**
N x W	4	0.028*	1.093*	1.032*	29.314*
V x W	4	0.098*	1.712*	2.404*	23.772*
N x V x W	8	0.081*	0.451*	0.514*	9.074*
Error (c)	36	0.241	0.425	0.730	18.180

*Significant at 5% level

**Significant at 1% level

PLATES

LIST OF PLATES

Plate no. 1. Photograph showing general view of experimental plot

Plate no. 2. Photograph showing growth performance of aromatic rice varieties of treatment USG X BRRI dhan38 X Rifit 20EC

Plate no. 3. Photograph showing highest plant height of aromatic rice for the treatment of USG X Kalijira X Rifit 20EC

Plate no. 4. Photograph showing flowering stage of aromatic rice for the treatment interaction of USG X Rifit 20EC

Plate no. 5. Photograph showing lodging of Kalijira rice

Plate no. 6. Photograph showing panicle of Kalijira rice

Plate no.7. Photograph showing growth and yield performance of aromatic rice of treatment USG X BRRI dhan38 X Rifit 20EC

Plate 8. Photograph showing urea super granules

Plate no. 9. Photograph showing application of USG on experimental plots