EFFECT OF NPK ON THE GROWTH, YIELD AND NUTRIENTS CONTENT OF TWO CULTIVARS OF AROMATIC RICE

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CERTIFICATE

This is to certify that the thesis entitled, "EFFECT OF NPK ON THE GROWTH, YIELD AND NUTRIENTS CONTENT OF TWO CULTIVARS OF AROMATIC RICE" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in the partial fulfillment of the requirements for the degree of MASTER OF SCIENCE (M.S.) IN AGRICULTURAL CHEMISTRY, embodies the result of a piece of bona fide research work carried out by MD. MOKUL ARFAN, Registration No. 08-02892 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.

Dated:
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Dedicated to
My
Beloved Parents

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ABSTRACT

A field experiment was conducted at the Agronomy field, Sher-e-Bangla Agricultural University (SAU), during July to December, 2014 to study the effect of NPK on the growth and yield of aromatic rice cultivars. Two varities are BRRI dhan38 (V_1) and *Chinigura* (V_2) and four NPK fertilizers doses: 0% recommended fertilizer dose of NPK (T_0), 75% recommended fertilizer dose of NPK (T_1), 100% recommended fertilizer dose of NPK (T_2) and 125% recommended fertilizer dose of NPK (T_3) are included in the experiment. Recommended NPK fertilizers doses are 69 kg N/ha, 21 kg P/ha, 35.5kg K/ha. The experiment was laid out in two factors Randomized Complete Block Design (RCBD) with four replications. There were 24 unit plots, each plot measuring 2 m × 2 m. The data were analyzed using MSTAT-C program. The mean differences among the treatments were compared by Duncan's Multiple Range Test (DMRT). The following agronomical parameter of the varieties such as total tillers hill^{-1}, effective tillers hill^{-1}, non-effective tillers hill^{-1}, filled grains panicle^{-1}, unfilled grains panicle^{-1}, panicle length, 1000-grain weight, grain yield were studied. The tallest plant was found in *Chinigura*. BRRI dhan38 achieved maximum number of total tillers hill^{-1}, effective tillers hill^{-1}, panicle length, number of filled grain panicle^{-1}. Among the two varieties the higher grain yield (3.37 t ha^{-1}) was found in BRRI dhan38. Different NPK fertilizers doses significantly affected all growth characters. The maximum number of total tillers hill^{-1}, effective tiller hill^{-1}, panicle length and number of filled grains panicle^{-1} were found at 125% recommended NPK fertilizer dose. The highest grain yield (3.44 t ha^{-1}) was also recorded at 125% recommended NPK fertilizer dose. Among the combined effects of varieties and NPK fertilizer doses, the highest grain yield (3.67 t ha^{-1}) was observed from the combination of BRRI dhan 38 with higher fertilizer dose. Among the two varieties, *Chinigura* contained the maximum total N (1.22% and 0.50%) in grain and straw, respectively. On the other hand,BRRI dhan38 contained the maximum amount of phosphorus (0.22% and 0.14%) and potassium (0.93% and 1.68%) in grain and straw, respectively. In both varieties it is increased significantly with the increasing fertilizer dose.

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LIST OF ABBREVIATIONS AND ACRONYMS

AEZ	=	Agro- Ecological Zone
BARC	=	Bangladesh Agricultural Research Council
BBS	=	Bangladesh Bureau of Statistics
BINA	=	Bangladesh Institute of Nuclear Agriculture
BRRI	=	Bangladesh Rice Research Institute
cm	=	Centi-meter
cv.	=	Cultivar
DAT	=	Days after transplanting
^0C	=	Degree Centigrade
DF	=	Degree of freedom
EC	=	Emulsifiable Concentrate
et al.	=	and others
etc.	=	Etcetera
FAO	=	Food and Agricultural Organization
ns	=	Non significant
%	=	Percent
CV %	=	Percentage of Coefficient of Variance
P	=	Phosphorus
K	=	Potassium
ppm	=	Parts per million
PU	=	Prilled urea
SAU	=	Sher-e- Bangla Agricultural University
S	=	Sulphur
SCU	=	Sulphur coated urea
t ha^{-1}	=	Tons per hectare
UNDP	=	United Nations Development Program
USG	=	Urea supergranules
Zn	=	Zinc

Chapter 1
Introduction

CHAPTER 1

INTRODUCTION

Rice is the staple food for nearly half of the world's population. However, more than 90% of this rice is consumed in Asia, where it is a staple food for a majority of the population including 560 million hungry people (Mohanty, 2013). It is estimated that by the year 2025, the world's farmers should produce about 60% more rice than at present to meet the food demands of the expected world population at that time (Fageria, 2007). The people in Bangladesh depend on rice and have tremendous influence on agrarian economy of Bangladesh. The population of Bangladesh became almost double over last three decade from 72 million in 1972 to 140 million in 2005 with an average increase by over 2 million per year and to feed the increased population in 2020, about 32800 thousand metric tons of rice will be needed to produce in the country (MoA, 2007). 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 were 11.53 million hectares and 33.91 million tons, respectively (AIS, 2013). The majority of rice area was covered by aman (autumn) rice and the area was 5.58 million hectares with the total production of 12.80 million metric tons and the average yield was 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 rice constitute a small but special group of rice which is considered best in quality. These rice have long been popular in the orient but now becoming more popular in Middle East, Europe and the United States (Singh *et al.*, 2000a). This contains natural ingredient 2- acetyl-1-pyrroline which is responsible for their fragrant taste and aroma (Gnanavel and Anbhazhagan, 2010). Aromatic rice as reported by Singh *et al.* (2000), had 15 times more 2- acetyl -1- pyrroline content than non - aromatic rice (0.14 and 0.009 ppm, respectively). In addition to 2- acetyl - 1- pyrroline, there are about 100 other volatile compounds, including 13 hydrocarbons, 14 acids, 13 alcohols, 16 aldehydes, 14 ketones, 8 esters, 5 phenols and some other compounds, which are associated with the aroma development in rice (Singh *et al.*, 2000b). 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 obtain 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 in Bangladesh (BBS, 2005).

Fertilizer is very important input for intensive rice production and the profitability of rice production systems depends on yield and input quantities. So the appropriate fertilizer input that is not only for getting high grain yield but also for attaining maximum profitability (Khuang *et al*, 2008). Nitrogen and phosphorus fertilizer is a major essential plant nutrient and key input for in increasing crop yield (Dastan *et al*, 2012; Alinajati-Sisie and Mirshekari, 2011; Alam *et al*, 2009). Nitrogen deficiency generally results in stunted growth and chlorotic leaves caused by poor assimilate formation that leads to premature flowering and shortening of the growth cycle. The presence of N in excess promotes development of the above ground organs with abundant dark green (high chlorophyll) tissues of soft consistency and relatively poor root growth. This increases the risk of lodging and reduces the plants resistance to brash climatic condition and foliar diseases (Mohammadin Roshan *et al*, 2011). Nitrogen contributes to carbohydrate accumulation in culms and leaf sheaths during the pre-heading stage and in the grain during the ripening stage of rice (Swain *et al*, 2010).

Phosphorus deficit is a most important restrictive factor in plant growth and recognition of mechanisms that increase plant phosphorus use efficiency is important (Alinajati-Sisie and Mirshekari, 2011). Phosphorus is a major component in ATP, the molecule that provides "energy" to that plant for such processes as photosynthesis, protein synthesis, nutrient translocation, nutrient uptake and respiration. Phosphorus is also a component of other compounds necessary for protein synthesis and transfer of genetic material DNA, RNA

(Wilson *et al.*, 1998). Phosphorus application to rice increased P accumulation but did not consistently increase rice yields because flooding decreased soil P sorption and increased P diffusion.

Potassium in rice producing soils is one of the limiting factors for increasing rice yield. Doberman and Cassman (1996) reported that for irrigated rice in Asia, the K fertilizer demand will be about 9 to 15 million tons in 2025, which represents an increase of 65% to 70% over the 1990s requirements. Demand for aromatic rice in recent years has increased to a great extent for both internal consumption and export. Therefore, the present experiment was conducted to achieve the following objectives:

1. To find out the effect of variety on the growth and yield of aromatic rice,
2. To study the effect of different levels of NPK on growth and yield of BRRI dhan38 and Chinigura.
3. To determine the optimum rate of NPK for the aromatic rice cultivation.

Chapter 2

Review of literature

CHAPTER 2

REVIEW OF LITERATURE

Variety is an important factor as it influences the plant population per unit area, availability of sunlight, nutrient competition, photosynthesis, respiration etc. Which ultimately influence the growth and development of the crops. The available relevant reviews of related to varieties and NPK fertilizer in the recent past have been presented and discussed under the following headings:

2.1 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.

2.1.1 Effect on growth characters

2.1.1.1 Plant height

Ashrafuzzaman *et al.* (2009) evaluated the growth performance of six rice varieties, *viz.* BRRI dhan34, BRRI dhan38, Kalizira, Chiniatop, Kataribhog and Basmati in an experiment under rainfed conditions. The rice varieties differed significantly ($P<0.05$) with respect to plant height and internodes length.

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.

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.

BINA (1993) evaluated the performance of four rice varieties- IRATOM 24, BR14, BINA dhan 13 and BINA dhan 19. 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.

2.1.1.2 Tillering pattern

Islam *et al.* (2009) conducted an experiment with four level of N fertilizer and three rice cultivars BINA dhan 5, Tainan3 and BINA dhan 6. They found that plant height, number of tillers hill^{-1}, number of leaves hill^{-1}, leaf area hill^{-1} (cm^2), DM (dry matter) of root, stem and leaves hill^{-1}, and TDM (total dry matter) varied significantly. BINA dhan 5 and BINA dhan 6 showed similar result.

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.

Duy *et al.* (2004) found that the growth of tillers of 12 rice cultivars and lines in the practice of nitrogen-free basal dressing with sparse planting density (BNo) both the primary and secondary tillers m^{-2} were smaller than the conventional cultivation (CONT) in 1999, 2000 and 2001. A large number of tillers in conventional cultivation, especially the secondary tillers, were unproductive and most of those in BNo were productive.

Inthapanva *et al.* (2000) reported that there is significant difference both in genotype and genotype-by-fertilizer interaction in total tiller number of rice varieties.

Devaraju *et al.* (1998) in a study with two rice hybrids such as Karnatak Rice Hybrid 1 (KRH1) and Karnataka rice Hybrid2 (KRH2) along with HYV IR20 as the check variety found that KRH2 out yielded IR20, the tiller number was higher than that of KRH2.

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.

2.1.2 Effect on yield contributing characters

Ndaeyo *et al.* (2008) conducted an experiment in Nigeria with five rice varieties WAB340- 8-8-2HI, WAB881-10-37-18-8-2-HI, WAB99-1-1, WAB224-8-HB, WAB189-B-B-B-8-HB and found that WAB881-10-37-18-8-2-HI gave higher tiller number.

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.

Wang *et al.* (2006) studied the effects of plant density and row spacing (equal row spacing and one seedling $hill^{-1}$, equal row spacing and 3 seedlings $hill^{-1}$, wide-narrow row spacing and one seedling $hill^{-1}$, and wide-narrow row spacing and 3 seedlings $hill^{-1}$) on the yield and yield components of hybrids and conventional cultivars of rice. Compared with conventional cultivars, the hybrids had larger panicles, heavier seeds, resulting in an average yield increase of 7.27%.

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.

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.

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.

2.1.3 Effect on grain 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 dhan 39 (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}).

Islam *et al.* (2010) conducted an experiment with three rice variety BRRI dhan46, BR22 and Nizersail from 2006-2007 in *aman* season and found that BRRI dhan46 was significantly higher than other test varieties irrespective of planting dates due to heavier individual grain weight and higher grains/panicle and panicle length among the test varieties.

Alam *et al.* (2009) examined the relative performance of inbred and hybrid rice varieties at different levels of Phosphorus (P). Three varieties of inbred and hybrid rice (BRRI dhan29, Aloron and Hira 2) and five levels of P (0, 24, 48, 72 and 96 kg P_2O_5 ha^{-1}) were used as treatment. They reported that the number of tillers $hill^{-1}$, filled grains $panicle^{-1}$, unfilled grains $panicle^{-1}$, spikelet sterility, 1000-grain weight, grain yield, straw yield, biological yield and harvest index varied significantly due to the variety.

IFAD (2008) reported that the BRRI dhan46 yielded an additional 20 percent of paddy 4.5 tons per hectare compared with 3.6 tons per hectare for Pajam and there is another advantage of BRRI dhan46 is that compared to other high yielding *aman* varieties, it matures earlier – in about 124 days compared to 140 days for a traditional variety.

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.

Swain *et al.* (2006) reported that the control cultivar IR64, with high translocation efficiency and 1000-grain weight and lowest spikelet sterility recorded a grain yield of 5.6 t ha^{-1} that was at par with hybrid PA6201.

Duy *et al.* (2004) reported that the yield of 12 rice cultivars and lines in the practice of nitrogen-free basal dressing with sparse planting density (BNo) were lower than the conventional cultivation (CONT) in 1999, 2000 and 2001. The difference between BNo and CONT in grain yield varied with the cultivar and the year.

Molla (2001) reported that Pro-Agro6201 rice variety (hybrid) had a significant higher yield than IET 4786 (HYV) due to more mature panicles m^{-2}, higher number of filled grains $panicle^{-1}$ and greater seed weight.

Patel (2000) studied that the varietal performance of Kranti and IR36. He observed that Kranti produced significantly higher grain and straw yield than IR36. The mean yield increased with Kranti over IR36 was 7.1 and 10.0% for grain and straw, respectively.

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.

2.2 Effect of NPK

Luu and Nguyen (2006) was conducted inoculant of Trichoderma fungi was used to treat into rice straw at different times for decomposition to study "Effect of decomposed rice straw at different times on rice yields". The decomposed rice straw at 1, 2, 3, 4 weeks gave C/N ratio from 24.12 - 31.71 in dry season and from 16.64 - 31.12 in wet season, these C/ N ratio was lower as compared to rice straw, which was not treated by inoculant of Trichoderma fungi (C/ N: 42.43 and 45.70 in dry and wet seasons, respectively); The decomposed rice straw at different times gave pH value of soil solution from 4.60 - 6.74 in dry season and from 6.38 - 6.83 in wet season and these pH value was not toxic to rice plant growth. The decomposed rice straw at different times in combination with 50% NPK fertilizer increased yield over control from 26.98% - 37.04% in dry season and from 33.45% - 48.08% in wet season and these above treatments were also found to be higher in microbial population; ETS activities and total protein in soil as compared to alone application of NPK fertilizers.

Islam *et al.* (2011) was conducted at the Bangladesh Rice Research Institute, R/S Sagordi farm, Barisal to evaluate the effectiveness of NPK briquette on rice in tidal flooded soil condition during Boro season, 2010. NPK briquettes of size 2.4 g and 3.4 g were compared with urea super granules (USG) and prilled urea (PU), each supplemented with PKS. The results showed that NPK briquettes, USG and PU produced statistically similar grain yield. N-treated plots (briquettes, USG and PU) gave significantly higher grain yield than N control. The highest grain yield (7.47 t ha^{-1}) was observed in NPK briquette (2.4 g × 2) followed by PU. There was no significant difference between N control and absolute control plots in respect of yield indicating that N was the only yield limiting factor under that condition. The NPK briquettes showed higher agronomic efficiency than PU and USG. The small size briquettes (2.4 g) could save 33 kg N ha^{-1} compared to recommend PU. There was no residual effect of NPK briquettes on soil chemical properties. The NPK briquettes were found beneficial to the farmers in tidal ecosystem.

Yosef-Tabar (2012) investigate the effect of nitrogen and phosphorus fertilizer on growth and yield in rice cultivar Tarom Hashemi, an experimental design in north of Iran in 2011 cropping season. Nitrogen fertilizer at 50, 100 and 150 kg/ha was main plot and phosphorus fertilizer at 4 level 0 (control), 30, 60 and 90 kg/ha as sub plot. Using randomized complete block design (RCBD) with 3 replication. The results showed that tiller number, fertile tiller, total grain, 1000-grain weight and yield increased significantly with nitrogen and phosphorus fertilizer. Interesting in comparison to 50 and 100 kg/ha level application of higher N-fertilizer 150 kg/ha showed a positive respond to application of high nitrogen for Taroom Hashemi cultivar. Effect of different application of P-fertilizer was significantly on this parameter, increase application of phosphorus increase parameter above. Study of interaction effect of N and P- fertilizer was significant in fertile tiller and 1000-grain weight.

Verma and Pandey (2013) conducted rice-wheat sequence of 2007-08 and 2008-09 to assess the effect of rice residue management on growth, yield and protein content in grain and straw of wheat. The various rice residue and nutrient management systems significantly affect the plant height and number of tillers per meter and were maximum with 30% additional NPK + recommended NPK over sowing of wheat without incorporation of rice residue and recommended NPK and rice residue incorporation + recommended NPK at wheat sowing during both the years. Among the yield attributes and yield viz. number of effective tillers, length of ear head, number of spikelets per spike, grain and strawn yield were also recorded maximum with the same treatment. Nitrogen uptake by grain and straw influenced significantly by rice residue and nutrient management practices during both the years. Highest nitrogen uptake by grain and straw was recorded under the treatment when rice residue incorporated with 30% additional N+P+K + recommended NPK against sowing of wheat without incorporation of rice residue+ recommended NPK and rice residue incorporation + recommended NPK.

Nitrogen fertilizer is a major essential plant nutrient and key input for in increasing crop yield, this experiment was carried out in randomized complete block desing with 3 replication in 2006 growing seasons. Main polt was nitrogen rates including (100, 200 and 300 kgN/ha) applied as urea and sub plot was split application at three level T_1 (1/2basel-1/2mid tillering), T_2 (1/3basel-1/3mid tillaring-1/3panicle initiation) and T_3 (1/4basel-1/4 mid tillering-1/4panicle initiation-1/4 flowering). The results showed that panicle number, panicle length, panicle dry matter, number of primary branches, total grain and grain yield, increased significantly with nitrogen fertilizer. Application 300 kg/ha N fertilizer observed high rate of this parameter. Effect of different split application N-fertilizer were significantly on this parameter, this parameter increased significantly with increase split application but the maximum number of panicle umber and total grain weight observed in 3 split application. The interaction effect of treatment's revealed that the panicle length at harvesting stage and total grain increased significantly with an application of 300 kg/ha N-fertilizer at four stage. According resulted of this study panicle structure such as number of panicles (heads) spikelet density, panicle length, panicle curvature and the number of grains per panicle is determined by the nitrogen application (Yosef-Tabar, 2013).

Nath *et al.* (2013) conducted for irrigated, transplanted and high yielding rice (*Oryza sativa* L.) during Boro season 2012. Four treatments (NPK, PK, NK, and NP) were applied in a randomized complete block design to assess the effects of indigenous nutrient elements on rice yield and yield components. The trials were conducted so as to develop a site specific nutrient management approach for the farmers of Gangtic Tidal Floodplain ecosystem. The highest grain-yield of 5.64 t ha^{-1} was observed in NPK treatment, which gave 9.0, 34.4 and 50.7% higher yields than those of NP, NK and PK, respectively. The response to indigenous K was remarkable and it gave the second highest yield (5.13 t ha^{-1}). The yield response to indigenous N was very poor and the lowest yield was found in N omission treatment (2.78 t ha^{-1}). The response to indigenous P was also poor (3.7

t ha^{-1}). This result shows that nitrogen and phosphorus are the most vibrant factors to increase yield since omission of N and P had significant impact on yield during Boro season. Use of N, P and K at 128.7, 8.08 and 12.78 kg, respectively could be recommended for growing BRRI dhan47 in Boro season. It could save P and K nutrient by 55.11 and 75.89 % compared to that of NPK treatment, respectively.

Debnath *et al.* (2014) was carried out at the field laboratory of Department of Agronomy, Patuakhali Science & Technology University, Dumki, during the period from July 2011 to December 2011 to assess the comparative advantages of using Urea Super Granule (USG) and NPK briquette over normal urea, Triple super phosphate and Muriate of Potash and also predict the better performing T. aman rice. The effect of different levels of fertilizer was studied on growth, yield and yield attributing character of T. aman. Six fertilizer Treatments Control (No urea), Total urea (150 kg ha^{-1}) during land preparation at available tide free time, Urea (75 kg ha^{-1}) at 2 split, Urea (50 kg ha^{-1}) at 3 split, Urea Super Granule (54 kg N ha^{-1}) at 10 days after transplanting and NPK briquette (42 Kg N ha^{-1} 9 Kg P ha^{-1} 12 Kg K ha^{-1}) at 10 days after transplanting of T. aman rice). Besides, TSP, MOP, zinc sulphate and Gypsum were applied @ 100, 70, 50 and12 kg ha^{-1} respectively as basal dose. The experiment was laid out in a Split plot design with 3 replications. The analysis revealed that different fertilizer management practices with a few exceptions significantly influenced the growth, yield and yield attributes of the T. aman rice. Plant height, number of effective tillers $hill^{-1}$, number of non-effective tillers $hill^{-1}$, panicle length (cm), number of grains panicle^{-1}, number of sterile spikelet's panicle^{-1}, nitrogen use efficiency (%), straw yield(t ha^{-1}) and grain yield (t ha^{-1}) were found highest when NPK briquette was applied and all the characters showed lowest value when control. Highest number of effective tillers hill^{-1} (13.00) and grain yield (6.60 t ha^{-1}) was obtained from NPK briquette and where lowest number of effective tillers hill^{-1} (5.66) and grain yield (4.48 t ha^{-1}). The NPK briquettes showed higher agronomic efficiency than Prilled urea (PU) and Urea super granule (USG). The small size briquettes (2.4 g) could save 33 kg N ha^{-1} compared to recommend PU. There was no residual effect of NPK briquettes on soil chemical properties. The NPK briquettes were found beneficial to the farmers in tidal ecosystem.

Bi *et al.* (2014) were conducted to investigate the effect of chemical fertilization on rice yield, yield trends, soil properties, agronomic efficiency of applied nutrients and nutrient balance for the double rice cropping systems in subtropical China. The treatments were different combinations of N, P and K fertilizers (N, NP, NK and NPK), double dose of recommended NPK (2NPK) and no fertilizer control (control). Compared with no fertilizer control, all fertilization treatments had no significant effects on soil pH and SOC contents ($P > 0.05$), but generally increased nutrients content when corresponding elements were applied. The impact of fertilizers on grain yields was 2NPK > NPK > NP > NK > N, and application of P fertilizer not only increased the rice yield, but improved yield stability. The trend of agronomic use efficiency of applied P was significantly positive ($P < 0.05$) only for the first rice crop, suggesting that P fertilizer played a less important role in the second rice season than in the first rice season. The study indicated that the current local fertilizer recommendations should be optimized for the consideration of differences in indigenous nutrient supplies in different rice seasons.

2.3 Combined effect of variety of rice and NPK

Manzoor *et al.* (2006) conducted during the kharif seasons of three successive years from 2000 to 2002 at Rice Research Institute, Kala Shah Kaku, Lahore, Pakistan to find out the most appropriate level of nitrogen to get maximum paddy yield of rice variety, Super Basmati. Effect of nine different nitrogen levels i.e. 0, 50, 75, 100, 125, 150, 175, 200 and 225 kg/ha on paddy yield and yield components were studied in this experiment. Plant height, number of productive tillers per hill, panicle length, number of grains per panicle, 1000 grain weight and paddy yield showed increasing trend from 0 kg N/ha up to 175 kg N/ha. The yield parameters including paddy yield, number of grains per panicle and 1000 grain weight started declining at 200 kg N/ha level and above. Maximum paddy yield (4.24 t/ha) was obtained from 175 kg/ha nitrogen application treatment which also produced highest values of number of grains per panicle (130.2) along with a maximum 1000 grain weight (22.92 gm). The plant height (139.8 cm) along with number of productive tillers per hill (23.42) and panicle length (29.75 cm) was maximum at 225 kg N/ha level.

Ndaeyo *et al.* (2008) were conducted in 2005 and 2006 to assess the effects of different NPK (15:15:15) fertilizer rates on the growth and yield of upland rice varieties. The experiment was conducted in high rain forest ecology of Uyo, Akwa Ibom State, Nigeria. The treatments consisted of factorial combination of five rice varieties (WAB340- 8-8-2HI, WAB881-10-37-18-8-2-HI, WAB99-1-1, WAB224-8-HB, WAB189-B-B-B-8-HB) and four rates of NPK (15:15:15) fertilizer (0, 200, 400 and 600 kg/ha) laid out in a randomized complete block design and replicated three times. The results showed that 600 kg/ha NPK (15:15:15) fertilizer rate significantly ($P < 0.05$) increased plant height, number of leaves and tillers per plant in both years. The 400 kg/ha rate increased the number of panicles per plant, length of central panicle per plant and the overall grain yields over other rates by 4-32% and 2-21% in 2005 and 2006, respectively. Among the varieties, WAB224-8-HB produced the highest grain yield (4.73 and 4.40 t/ha) followed by WAB189-B-B-B-8-HB (4.37 and 4.20 t/ha) for both years. The interaction effects between rice variety and fertilizer rates were generally significant. The mean grain yield for both years showed that WAB224-8-HB variety performed better than other varieties by 6-24% while the grain yield in the 400kg/ha plot superceded other rates by 3-26% and hence have potentials to support upland rice production in Uyo agroecology.

Sikdar *et al.* (2008) was carried out at Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh to evaluate the effect of nitrogen (N) level on the quality of aromatic rice and fertility status of the post harvest soil. The experiment comprised of three varieties viz., Kalizira, Badshabhog and Tulshimala and three levels of nitrogen viz., 40, 60 and 80 kg ha^{-1}. Kalizira was found significantly superior to Tulshimala and Badshabhog with respect to quality of grain and soil fertility of the post harvest soil. Among three N levels, 80 kg ha^{-1} performs the best to quality of aromatic rice and fertility status of the post harvest soil. The effect of interaction of varieties and N levels were not significant on the quality of aromatic rice and fertility status of the post harvest soil.

Hoque *et al.* (2010) conducted to assess the influence of N and P on nutrient contents and their uptake by aromatic rice (cv. BRRI dhan34) in the Central Farm of Bangladesh Agricultural University, Mymensingh during the period from July to December, 2009. The experiment comprised of four levels of N and four levels of P viz. 0, 55, 110 and 165 kg N ha^{-1} (N_o, N_1, N_2 and N_3) and 0, 25, 50 and 75 kg P ha^{-1} (Po, P_1, P_2 and P_3), respectively and laid out in a randomized complete block design (RCBD) with four replications. Significant variations were found both in nutrient contents and their uptake by grain and straw due to the single effect of N and P except K content. The highest N, P, S and K contents and their uptake recorded from N_2P_2 treatment and the lowest values were found from control. The highest values in most of the parameters were obtained from the treatment combination of N_2P_2. The overall results thus suggest that aromatic rice particularly cultivar BRRI dhan34 can be grown in non-calcareous soil fertilized with 110 kg N in combination with 50 kg P ha^{-1} to maximize its large scale production and better nutrition in Bangladesh.

Chapter 3
Materials and methods

CHAPTER 3

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, 2014.

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 I.

3.4 Planting materials and features

Rice cv. BRRI dhan38 and *Chinigura* were used as planting materials for the present study. These varieties are recommended for aman season. The features of these two varieties are presented below:

BRRI dhan38: It is modern transplanted *aman* rice released in 1998. The grains are of long size and slender. The color, size and scent of BRRI dhan38 rice is like that of *Basmoti* rice. 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 125 cm. It has the average yield potential of about 3.50 t ha^{-1}.

Chinigura: Chinigura is 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.

3.5 Treatments

The experiment consisted of two factors as mentioned below:

a) Factor A: Variety

V_1 = BRRI dhan38

V_2 = Chinigura

b) Factor B: NPK fertilizers doses

T_0= 0% recommended fertilizer dose of NPK, [Recommended NPK fertilizers: 69 kg N/ha, 21 kg P/ha, 35 5.kg K/ha) (BRRI, 2000)]

T_1=75% recommended fertilizer dose of NPK,

T_2=100% recommended fertilizer dose of NPK,

T_3=125% recommended fertilizer dose of NPK

3.6 Experimental design and layout

The experiment was laid out in two factors Randomized Complete Block Design (RCBD) with four replications. The experimental unit was divided into four blocks each of which represents a replication. Each block was divided into 8 plots in which treatments were applied at random. The distance maintained between two plots was 1m and between blocks was 1.5 m. The plot size was 2 m × 2 m.

3.7 Growing of crops

3.7.1 Raising of seedlings

Seed collection

The seeds of the tested varieties i.e. BRRI dhan 38 and Chinigura were collected from Bangladesh Rice Research Institute, (BRRI) Joydebpur, Gazipur.

Seed sprouting

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

Preparation of nursery bed and seed sowing

Common procedure was followed in raising seedling in the seedbed. The seedbed was prepared by puddling with repeated ploughing followed by laddering. Weeds were removed and irrigation was gently provided to the bed as and when necessary. No fertilizer was used in the nursery bed. The sprouted seeds were sown on seedbed on 1 August, 2014.

Preparation of main field

The plot for the experiment was opened in the first week of August 2014, with a power tiller and was exposed to the sun for a week. After one week the land was harrowed, ploughed and cross ploughed several times followed by laddering to obtain a good tilth. Weeds and stubbles were removed and finally obtained a desirable tilth for transplanting.

3.7.2 Fertilization

The amounts of N, P and K, fertilizers required per plot were calculated as per the treatments.

3.7.3 Uprooting of seedlings

The nursery bed was made wet by the application of water one day before uprooting of seedlings. The seedlings were uprooted on 30 August, 2014 without causing much mechanical injury to the roots and they were immediately transferred to the main field.

3.7.4 Transplanting of seedlings in the field

Transplanting was done with 30 days old seedlings on 30 August, 2014. Seedlings were transplanted in lines following line to line distance of 25 cm and hill to hill distance of 15 cm.

3.7.5 Intercultural operation

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

3.7.6 Irrigation and drainage

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

3.7.7 Gap filling

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

3.7.8 Weeding

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

3.7.9 Plant protection

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

3.7.10 Harvesting, threshing and cleaning

The rice was harvested depending upon the maturity of the crop and 4 m^2 area of each plot was harvested manually on 1 December 2014. The harvested crop of each plot was bundled separately, properly tagged and brought to the threshing floor. Enough care was taken for harvesting, threshing and also cleaning of rice seed. The grains were weighted in plot wise and finally the weight was adjusted to a moisture content of 14%. The straw was also sun dried, and weighed the yields of grain and straw $plot^{-1}$ was converted to ha^{-1}.

3. 8 Data recording

The data were recorded on the following characters:

3.8.1 Plant height (cm)

The plant height was recorded in centimeter (cm) at 25, 45, 65 DAT and at harvesting. Data were recorded as the average of 5 hills selected randomly from the inner rows of each plot. The height was measured from the ground level to the tip of the leaf before heading and tip of the flag leaf after heading.

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

Number of tillers $hill^{-1}$ was recorded at 25, 45, 65 DAT and at harvesting. Data were recorded as the average of 5 hills selected randomly from the inner rows of each plot.

3.8.3 Effective tillers hill^{-1}

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

3.8.4 Non-effective tillers hill^{-1}

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

3.8.5 Number of filled grain

Average number of filled grain panicle^{-1} was calculated by counting the number of filled grain of 5 panicles hill^{-1}.

3.8.6 Number of unfilled grain

Number of unfilled grain panicle^{-1} was also counted.

3.8.7 Panicle length (cm)

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

3.8.8 Weight of 1000-grains (g)

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

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

The dry weight of grains from each plot (4 m^2 area) was taken from the plots and finally converted them to t ha^{-1}. The grains weight was adjusted with 14% moisture basis.

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

The dry weight of straw of central 4 m^2 areas from each plot was recorded and finally converted to t ha^{-1}.

3.9 Chemical analysis of plant samples

3.9.1 Collection and preparation of plant samples

Grain and straw samples were collected after threshing for N, P and K analyses. The plant samples were dried in an oven at 70 ^{0}C for 72 hours and then ground by a grinding machine (wiley-mill) to pass through a 20-mesh sieve. The samples were stored in plastic vial for analyses of N, P and K. The grain and straw samples were analyzed for determination of N, P and K concentrations. The methods were as follows:

3.9.2 Digestion of plant samples for N determination

For the determination of nitrogen an amount of 0.5 g oven dry, ground sample were taken in a micro kjeldahl flask. 1.1 g catalyst mixture (K_2SO_4: $CuSO_4$ $5H_2O$: Se in the ratio of 100: 10: 1), and 7 mL conc. H_2SO_4 were added. The flasks were heated at 160^0 C and added 2 mL 30% H_2O_2 then heating was continued at 360^0 C until the digests become clear and colorless. After cooling, the content was taken into a 100 mL volumetric flask and the volume was made up to the mark with de-ionized water. A reagent blank was prepared in a similar manner. Nitrogen in the digest was estimated by distilling the digest with 10 N NaOH followed by titration of the distillate trapped in H_3BO_3 indicator solution with 0.01N H_2SO_4.

3.9.3 Digestion of plant samples with diacid mixture for the determination of P and K

A sub sample weighing 0.5 g was transferred into a dry, clean 100 ml digestion vessel. Ten ml of di-acid (HNO_3: $HClO_4$ in the ratio 2:1) mixture was added to the flask. After leaving for a while, the flasks were heated at a temperature slowly raised to 200^0C. Heating were stopped when the dense white fumes of $HClO_4$ occurred. The content of the flask were boiled until they were became clean and colorless. After cooling, the content was taken into a 50 ml volumetric flask and the volume was made up to the mark with de-ionized water. P and K were determined from this digest by using different standard methods.

3.9.4 Determination of P and K from plant samples

3.9.4.1 Phosphorus

Plant samples (grain and straw) were digested by diacid (Nitric acid and Perchloric acid) mixture and P content in the digest was measured by blue color development. Phosphorus in the digest was determined by using 5 mL for grain and straw sample from 100 mL digest by developing blue color with reduction of phosphomolybdate complex and the color intensity were measured colorimetrically at 660 nm wavelength and readings were calibrated with the standard P curve.

3.9.4.2 Potassium

One mL of digest sample for the grain and straw were taken and diluted 20 mL volume to make desired concentration so that the flame photometer reading of samples were measured within the range of standard solutions. The concentrations were measured by using standard curves.

3.10 Statistical analysis

The data obtained for different parameters were statistically analyzed to find out the significant difference of different treatments on yield and yield contributing characters of rice. The significance of the difference among the treatment means was estimated by the Duncan's Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

Chapter 4

Results and discussion

CHAPTER 4

RESULTS AND DISCUSSION

This chapter comprises the presentation and discussion of the results from the experiment. The experiment was conducted to determine the effect of NPK on the growth and yield of aromatic rice cultivars. Some of the data have been presented and expressed in table (s) and others in figures for ease of discussion, comparison and understanding. A summary of all the parameters have been shown in possible interpretation wherever necessary have given under the following headings.

4.1. Plant height

4.1.1. Effect of variety

The plant height of rice was influenced by different varieties at 25, 45, and 65 days after transplanting (DAT) and at harvest (Figure 1). Results for V_2 (*Chinigura*) showed the highest plant height at 25, 45 and 65 days after transplanting (DAT) and at harvest (62.45, 102.86, 122.84 and 163.94 cm, respectively). The smallest plant was observed in V_1 (BRRI dhan 38) at 25, 45, and 65 days after transplanting (DAT) and at harvest that were 59.37, 92.32 , 109.68 and 132.68 cm, respectively. In the early stage of growth, the increase of plant height was very slow. The rapid increase of plant height was observed from 25 to 85 DAT and then increase of plant height was ceased at harvest. Probably the genetic makeup of varieties was responsible for the variation in plant height. This confirms the reports of Ashrafuzzaman *et al.* (2009), Bisne *et al.* (2006), BINA (1993), BRRI (1991) and Shamsuddin *et al.* (1988).

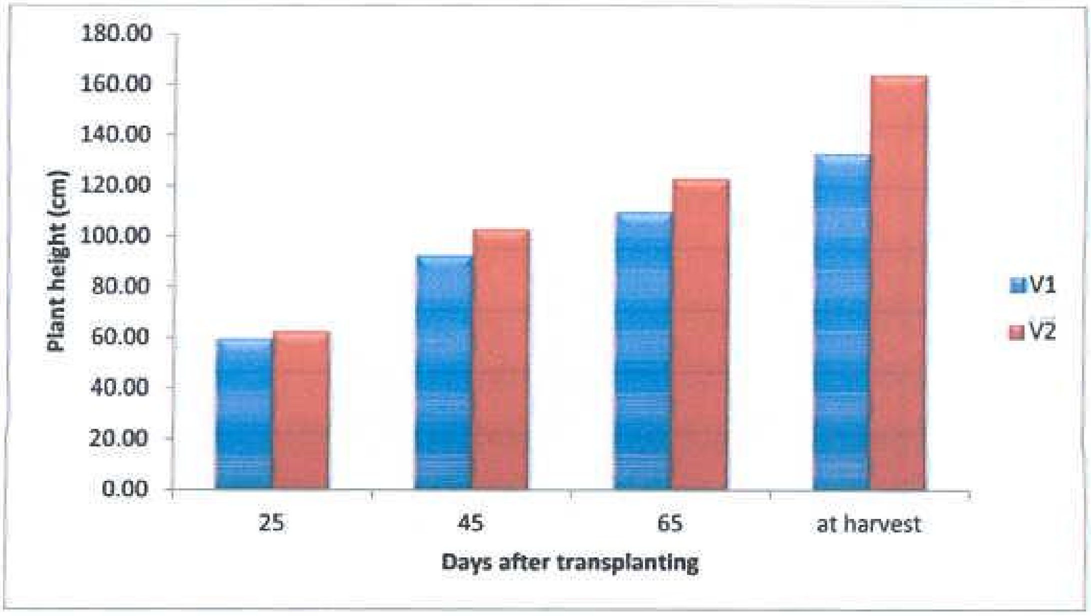

Figure 1. Effect of variety on plant height of rice at different days after transplanting.

4.1.2. Effect of fertilizer

Figure 2 revealed that the plant height was increased gradually with the increased fertilizers at all studied durations. The maximum fertilizer dose (T_3) gave significantly the highest plant heights of 63.73 cm, 106.4 cm, 119.5 cm and 150.7 cm at 25, 45, 65 DAT and at harvest, respectively. The minimum fertilizer dose (T_0) showed the lowest plant heights of 56.64 cm, 87.49 cm, 110.00 cm and 143.7 cm at 25, 45, 65 DAT and at harvest, respectively. Higher fertilizer doses showed the higher plant height at different days. It might be due to continuous availability of nutrient that enhanced the growth of the crop than the lower dose of fertilizer. Hasanuzzaman *et al.* (2010) reported that plant height was significantly influenced by different fertilizer dose. These results were in agreement with Amin *et al.* (2004) and Saha *et al.* (2004) who reported that increased fertilizer dose of NPK increases plant height of rice.

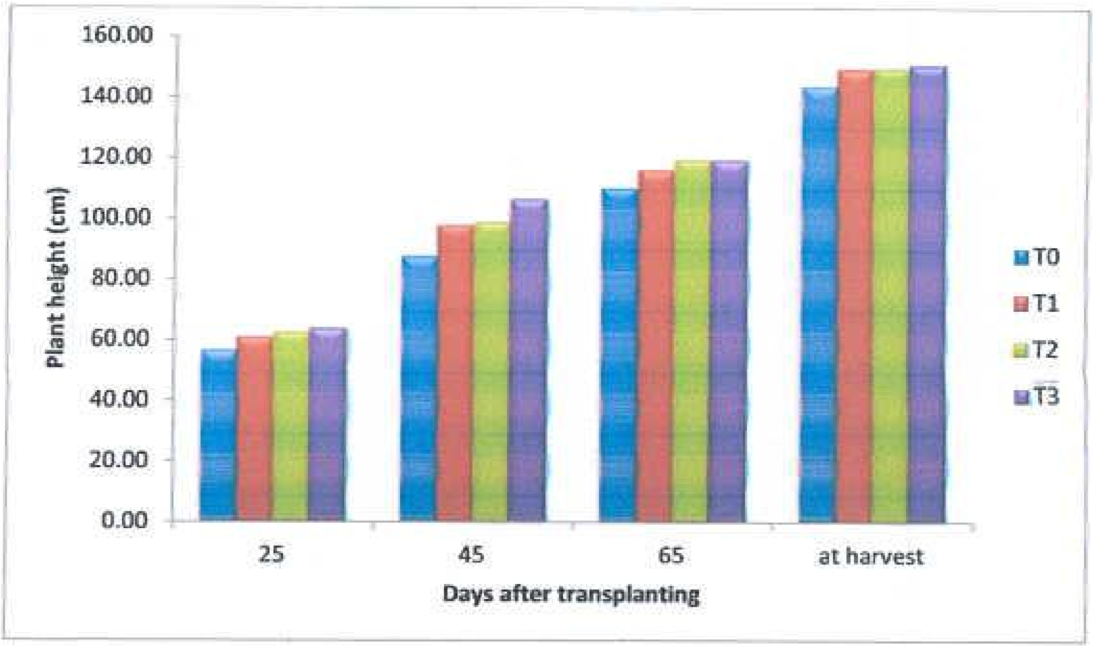

Figure 2. Effect of fertilizer dose on plant height of rice at different days after transplanting.

4.1.3. Interaction effect of variety and fertilizer dose

Interaction effect of variety and fertilizer dose had significant influence on plant height at different growth stages of rice (Table 1). Results indicated that the longest plant (64.12, 117.9, 126.3 and 166.5cm at 25, 45, 65 DAT and at harvest, respectively) were found in V_2T_3, which are significantly different from all other treatments. On the other hand, V_1T_0 showed the lowest plant height (53.34, 82.41, 101.1 and 127.2 cm at 25, 45, 65 DAT and at harvest, respectively). The increase in plant height attributed probably to the cell elongation and cell multiplication as optimized with variety and optimum fertilizer. Singh *et al.* (2003) reported that plant height of rice was significantly influenced by NPK fertilizer dose.

Table 1. Interaction effect of variety and fertilizer dose on plant height at different days after transplanting of rice

Treatment	Plant height (cm)							
	25 DAT		45 DAT		60 DAT		At harvest	
V_1T_0	53.34	b	82.41	c	101.10	c	127.20	B
V_1T_1	57.67	b	95.00	b	112.10	b	137.40	B
V_1T_2	62.10	ab	95.61	b	112.40	b	133.80	B
V_1T_3	63.81	a	101.70	b	125.80	a	165.10	A
V_2T_0	59.94	ab	92.57	b	113.10	b	132.30	B
V_2T_1	62.65	ab	96.28	b	118.90	ab	160.10	A
V_2T_2	63.65	a	99.25	b	120.30	ab	164.00	A
V_2T_3	64.12	a	117.90	a	126.30	a	166.50	A
Level of Significance	*		*		*		*	
LSD(0.05)	5.71		8.70		8.27		13.18	
CV(%)	6.37		6.06		5.35		6.04	

* 5 % level of Significance

4.2. Total tillers hill^{-1}

4.2.1. Effect of variety

The number of total tillers hill^{-1} was influenced by variety at all crop growth durations (Figure 3). BRRI dhan 38 (V_1) showed maximum tillers hill^{-1} as 13.25, 18.6, 14.44, and 13.38 at 25, 45, 65 DAT and at harvest, respectively. Chinigura (V_2) was found minimum number of total tillers hill^{-1} (11.81, 17.81, 13.38, & 12.19 at 25, 45, 65 DAT and at harvest, respectively). Irrespective of varieties, the tillers decreased at the later stage was due to greater competition for light and nutrients as observed by Ishizuka and Tanaka (1963). 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 Islam *et al.* (2009), Duy *et al.* (2004), Hossain and Alam (1991).

4.2.2. Effect of fertilizer

Maximum fertilizer dose (T_3) influenced plant to produce greater number of tiller hill^{-1} at all growth duration (Figure 4), the values were 13.63, 19.13, 15.25, and 13 at 25, 45, 65 DAT and at harvest and significantly differed. Lower fertilizer dose (F_0) gave minimum tillers as 11.00, 16.88, 13.25 and 12.5 at 25, 45, 65 DAT and at harvest. Ndaeyo *et al.* (2008) stated that increase the rate of NPK increase the total tiller number hill^{-1}. Ahmad and Hussain (1974) reported that increase in NPK fertilizer rates significantly increased tiller number plant^{-1}.

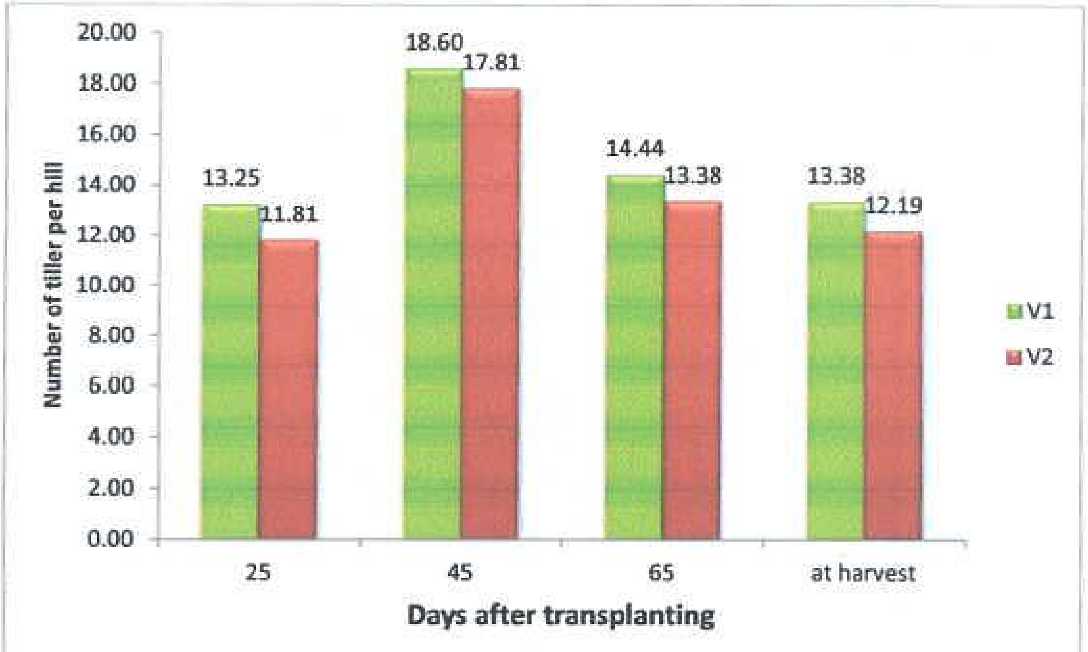

Figure 3. Effect of variety on total tiller number hill^{-1} at different days after transplanting of rice.

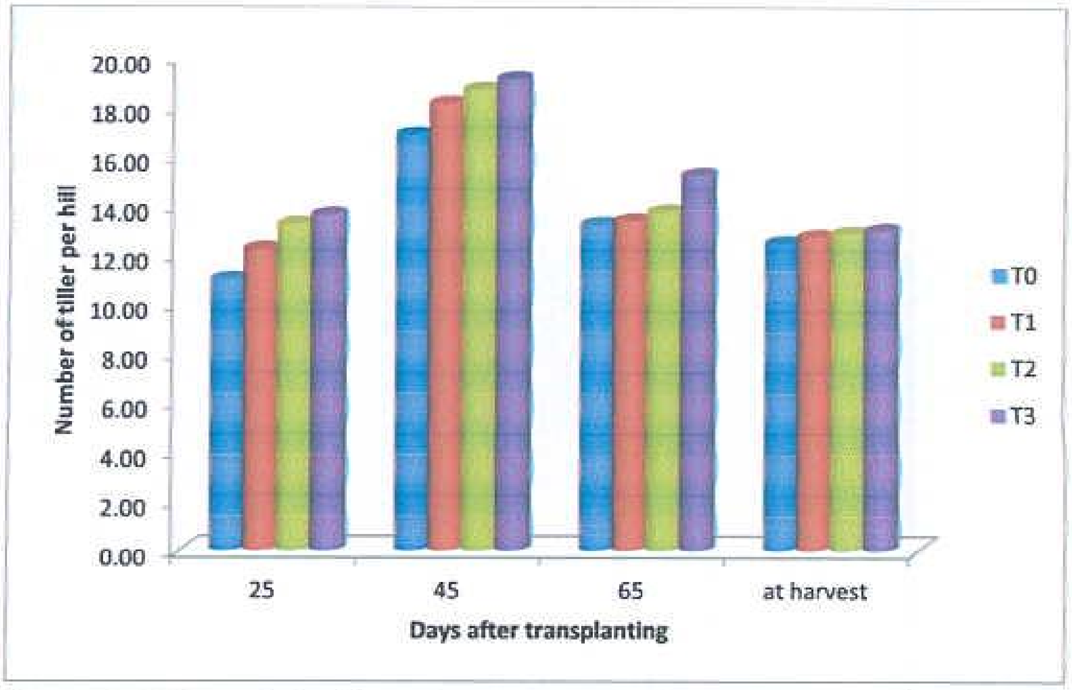

Figure 4. Effect of fertilizer dose on total tiller number hill^{-1} at different days after transplanting of rice.

4.2.3. Interaction effect of variety and fertilizer dose

Interaction effect of variety and fertilizer had significant influence on number of tillers hill^{-1} at different growth stages of rice (table 2). Results indicated that the highest number of tillers hill^{-1} (15, 20.00, 17.00, and 14.75 at 25, 45, 65 DAT and at harvest, respectively) were with V_1T_3, which were closely followed by V_1T_2 at all growth stages. On the other hand, V_2T_0 showed the lowest number of tillers hill^{-1} (9.75, 16.75, 12.25 and 11.25 at 25, 45, 65 DAT and at harvest, respectively) which were significantly different from all other treatments. Inthapanva *et al.* (2000) reported that there was both genotype and genotype-by-fertilizer interaction in total tiller number of rice.

Table 2. Interaction effect of fertilizer dose and variety on total tiller number hill^{-1} at different days after transplanting of rice

Treat	Number of tiller per hill			
	25 DAT	45 DAT	60 DAT	At harvest
V_1T_0	12.25 b	16.75 b	13.50 bc	11.75 b
V_1T_1	12.25 b	18.25 ab	13.75 bc	12.75 ab
V_1T_2	15.00 a	19.50 a	14.00 bc	13.00 ab
V_1T_3	15.00 a	20.00 a	17.00 a	14.75 a
V_2T_0	9.75 c	16.75 b	12.25 c	11.25 b
V_2T_1	12.25 b	17.00 b	12.75 bc	12.25 ab
V_2T_2	12.25 b	17.90 ab	12.75 bc	12.75 ab
V_2T_3	13.00 b	19.50 a	15.25 ab	13.75 ab
Level of Significance	*	*	*	*
$LSD_{(0.05)}$	1.55	2.20	2.53	2.45
CV (%)	11.60	12.37	8.02	9.05

* 5 % level of Significance

4.3. Effective tillers hill^{-1}

4.3.1. Effect of variety

It was evident from table 3 that variety had influence on numbers of effective tiller hill^{-1}. BRRI dhan38 produced higher number of effective tillers hill^{-1} (11.44) than chinigura (10.40). This confirms the report of Sawant *et al.* (1986), who reported that variable effect of variety on the number of effective tillers hill^{-1} of rice.

4.3.2. Effect of fertilizer

Irrespective of fertilizer dose the production of effective tillers hill^{-1} gradually increased with increased fertilizer dose. Different NPK fertilizer levels were not significantly influenced the number of effective tillers hill^{-1} (Table 3). The maximum number of effective tillers hill^{-1} (11.22) was obtained from the 125% recommended fertilizer dose. The lowest fertilizer dose produced minimum number of effective tillers hill^{-1} (10.50). This confirms the report of Ndaeyo *et al.* (2008) and Venkateswarlu and Singh (1980) who reported that the number of effective tillers per plant across the rice cultivars increased with increased rate of NPK.

Table 3. Effect of variety, NPK fertilizers and their interaction on effective tillers and non-effective tillers hill^{-1}, panicle length, filled grain and unfilled grain of rice

Treatment	Effective Tiller		Non-effective Tiller		Panicle length(cm)		Filled Grain		Unfilled Grain	
Effect of Variety										
V_1	11.44		2.67		26.42		176.56	a	38.02	
V_2	10.40		3.39		26.06		114.91	b	48.12	
Level of Significance	NS		NS		NS		*		NS	
LSD(0.05)	2.26		0.72		2.36		32.13		20.19	
CV (%)	14.05		6.17		6.11		5.99		9.87	
Effect of Fertilizer										
T_0	10.50		3.51	a	24.60	b	136.30	c	49.12	a
T_1	10.77		3.30	a	25.49	ab	139.30	bc	46.06	ab
T_2	11.18		3.16	ab	26.49	ab	144.90	b	39.35	b
T_3	11.22		2.15	b	28.39	a	162.40	a	37.74	b
Level of Significance	NS		*		*		*		*	
LSD(0.05)	2.178		1.102		3.608		6.463		11.16	
CV(%)	14.05		6.17		6.11		5.99		9.87	
Interaction effect of variety and fertilizer dose										
V_1T_0	10.10	b	3.71	a	25.18	bc	107.70	f	50.30	ab
V_1T_1	10.81	ab	3.31	ab	25.80	bc	167.20	c	37.78	b
V_1T_2	11.02	ab	2.79	bc	25.97	bc	170.90	c	32.47	b
V_1T_3	12.25	a	2.04	c	29.06	a	191.80	a	31.51	b
V_2T_0	9.98	b	4.08	a	23.41	c	105.40	f	66.72	a
V_2T_1	10.73	ab	3.54	ab	25.79	bc	113.50	e	43.00	b
V_2T_2	10.77	ab	2.53	c	27.01	ab	133.10	d	41.83	b
V_2T_3	11.66	ab	2.25	c	27.72	ab	176.40	b	40.92	b
Level of Significance	*		*		*		*		*	
LSD(0.05)	1.71		0.72		2.36		4.22		20.19	
CV(%)	14.05		6.17		6.11		5.99		9.87	

* 5 % level of Significance, NS- Not significant

4.3.3. Interaction effect of variety and fertilizer dose

The effect of interaction between variety and fertilizer was found to be significant in respect of number of productive tillers $hill^{-1}$ (Table 3). Combination of BRRI dhan38 with 125% recommended fertilizer dose (V_1T_3) produced the highest (12.25) number of productive tillers $hill^{-1}$ which is statistically similar with V_1T_1, V_1T_2, V_2T_1 and V_2T_2. Chinigura with lower fertilizer dose (V_2T_0) gave minimum number of effective tillers $hill^{-1}$ (9.98) which was statistically similar with V_1T_0.

4.4. Non-effective tillers $hill^{-1}$

4.4.1. Effect of variety

It was evident from table 3 that variety had influence on numbers of non-effective tillers $hill^{-1}$. Chinigura produced higher number of non-effective tillers (3.39). BRRI dhan38 produced lower number of non- effective tillers (2.67).

4.4.2. Effect of fertilizer

Irrespective of fertilizer dose the production of non-effective tillers $hill^{-1}$ gradually decreased with increased fertilizer dose. Different NPK fertilizer levels were significantly influenced the number of non-effective tillers $hill^{-1}$ (Table 3). The maximum number of non-effective tillers $hill^{-1}$ (3.31) was obtained from the control treatment. The highest fertilizer dose produced minimum number of non effective tillers $hill^{-1}$ (2.15).

4.4.3. Interaction effect of variety and fertilizer dose

The effect of interaction between variety and fertilizer was found to be significant in respect of number of non-productive tillers hill^{-1} (Table 3). Combination of Chinigura with 0% recommended fertilizer dose (V_2T_0) produced the highest number of non- productive tillers hill^{-1} (4.08) which was statistically similar with V_1T_0. BRRI dhan38 with highest fertilizer dose (V_1T_3) gave minimum number of non- effective tillers hill^{-1} (2.04) which was statistically similar with V_2T_3 and V_2T_2.

4.5. Panicle length

4.5.1. Effect of variety

The panicle length was influenced by different varieties of rice. It was observed that BRRI dhan38 produced longer panicle (26.42 cm) than Chinigura (26.06 cm). This confirms the report of Alam *et al.* (2009), Ahmed *et al.* (1997) and Idris and Matin (1990) who reported that panicle length of rice was differed due to variety.

4.5.2. Effect of fertilizer

The panicle length varied significantly due to different NPK fertilizer dose (Table 3). The longest panicle (28.39 cm) was produced due to the application of higher 125% recommended dose of NPK fertilizer (T_3). The shortest panicle length (24.60 cm) was found with lower 0% recommended dose of NPK fertilizer (T_0). A similar finding was reported by Saha *et al.* (2004). Islam *et al.*

(2009) and Asif *et al* (2000) whom reported that panicle length of rice was influenced significantly due to application of different rates of NPK nutrients.

4.5.3. Interaction effect of fertilizer dose and variety

Panicle length was statistically influenced by the interaction of variety and different NPK fertilizer dose (Table 3). The longest panicle length (29.06 cm) was found in BRRI dhan38 in combinations with 125% recommended NPK fertilizer dose (V_1T_3) which is statistically similar with V_2T_3 and V_2T_2. The shortest panicle length was found in *Chinigura* (23.41 cm) in combination with lower fertilizer dose (V_2T_0).

4.6. Filled grains panicle^{-1}

4.6.1. Effect of variety

Table 3 showed that cultivars significantly influenced on filled grains panicle^{-1}. It was revealed that BRRI dhan38 gave higher number of filled grains panicle^{-1} (176.56) than Chinigura (114.91). Alam *et al.* (2009) and BRRI (1994) found that number of filled grains panicle^{-1} significantly differed due to variety.

4.6.2. Effect of fertilizer

From the table 3 it was observed that there was a statistical variation in number of filled grains panicle^{-1} due to different levels of NPK fertilizer application. Results showed that the highest number of filled grains panicle^{-1} (162.4) was obtained with 125% recommended NPK fertilizer dose (T_3). Lower recommended NPK fertilizer dose (T_0) produced minimum filled grains, 136.3. Islam *et al.* (2009) and Saha *et al.* (2004) reported that number of filled grains per panicle of rice was influenced significantly due to application of different rates of NPK nutrients.

4.6.3. Interaction effect of variety and fertilizer dose

Interaction effect of variety and different level of NPK fertilizer was found significant for filled grains panicle^{-1} (Table 3). From the results it was observed that the highest filled grains panicle^{-1} (191.8) was found from the combination of BRRI dhan with 125% recommended dose of NPK fertilizer (V_1T_3). The lowest filled grains panicle^{-1} (105.4) was recorded from Chinigura with control (V_2T_0) which is statistically similar with (V_1T_0).

4.7. Unfilled grains panicle^{-1}

4.7.1. Effect of variety

Results showed that variety had effect on the number of unfilled grains panicle^{-1} (Table 3). BRRI dhan38 produced minimum number of unfilled grains panicle^{-1} (38.016) than Chinigura (48.12). This variation might be due to genetic characteristics. Alam *et al.* (2009), BINA (1993) and Chowdury *et al.* (1993) reported differences in number of unfilled grains panicle^{-1} due to varietal differences.

4.7.2. Effect of fertilizer

Irrespective of fertilizer dose, the increased amount of fertilizer probably influenced grain filling. Different levels of NPK fertilizer showed significant variation on the number of unfilled grains panicle^{-1} (Table 3). The lowest number of unfilled grains panicle^{-1} (37.74) was obtained from the higher level of fertilizer dose (T_3) which was statistically similar with recommended NPK fertilizer dose (T_2) (39.35). The highest number of unfilled grains (49.12) was obtained from the lower fertilizer dose (T_o). This confirmed the report of Saha *et al.* (2004) and Islam *et al.* (2009) who reported that number of unfilled grain panicle^{-1} was influenced significantly due to the application of different rates of NPK nutrients.

4.7.3. Interaction effect of variety and fertilizer dose

Interaction of variety and different fertilizer was significantly response on unfilled grains panicle^{-1} (Table 3). It was observed that the maximum unfilled grains panicle^{-1} (66.72) was collected from Chinigura with lower fertilizer dose (V_2T_0). Minimum unfilled grains panicle^{-1} (31.51) was collected from BRRI dhan38 with 125% recommended NPK fertilizer dose (V_1T_3) which is statistically similar with V_1T_2, V_1T_1, V_2T_3, V_2T_2 and V_2T_1 treatments.

4.8. 1000-grain weight

4.8.1. Effect of variety

Varietal effect on 1000-grain weight varied significantly (Table 4). The highest weight of 1000-grains (17.78g) was obtained from BRRI dhan38. Chinigura had produced lower 1000-grains weight (11.06 g). The variation of 1000-grains weight among varieties might be due to genetic constituents. Similar results were found by Alam *et al.* (2009) and Bhowmick and Nayak (2000). This result was an agreement with the findings of Rafey *et al.* (1989) and Shamsuddin *et al.* (1988) who stated that weight of 1000-grain differed due to the varietal differences.

4.8.1. Effect of fertilizer

There was no significant variation in 1000-seed weight due to different NPK fertilizer level (Table 4). The highest weight of 1000-grains (15.00g) was obtained from 125% fertilizer dose (T_3). The lowest weight of 1000-grains (14.38 g) was obtained from control (T_0), respectively.

4.8.3. Interaction effect of fertilizer dose and variety

Interaction of variety and different fertilizer level showed significant variation on 1000-grain weight (Table 4). It ranged between 10.75 g to 17.85 g. The highest weight of 1000-grains (17.85 g) was obtained from BRRI dhan38 in combination with 125% recommended fertilizer dose (V_1T_3) which was statistically similar with V_1T_2, V_1T_1, and V_2T_3. The lowest weight of 1000-grains (10.75 g) was obtained from *chinigura* in combination with 0% recommended fertilizer dose (V_2T_0).

Table 4. Effect of variety, NPK fertilizers and their interaction on grain, straw and 1000-grain weight of rice

Treatment	1000 seed weight (g)	Grain yield (t/ha)	Straw yield (t/ha)
Variety			
V_1	17.78 a	3.37	6.84
V_2	11.06 b	3.01	6.53
Level of Significance	*	NS	NS
LSD(0.05)	2.20	0.61	0.78
CV(%)	10.41	13.00	7.90
Fertilizer			
T_0	14.38	3.02 b	6.36 c
T_1	14.50	3.12 b	6.61 b
T_2	14.55	3.18 b	6.76 b
T_3	15	3.44 a	6.99 a
Level of Significance	NS	*	*
LSD(0.05)	0.6936	0.225	0.2135
CV(%)	10.41	13.00	7.90
Interaction effect of variety and fertilizer dose			
V_1T_0	11.25 b	3.03 c	6.46 c
V_1T_1	17.75 a	3.18 b	6.72 b
V_1T_2	17.75 a	3.29 b	6.84 b
V_1T_3	17.85 a	3.67 a	7.53 a
V_2T_0	10.75 c	2.85 d	6.26 d
V_2T_1	11.25 b	2.96 cd	6.38 cd
V_2T_2	17.75 a	3.21 b	6.46 c
V_2T_3	11.00 bc	3.33 b	6.81 b
Level of Significance	*	*	*
LSD(0.05)	0.45	0.15	0.14
CV(%)	10.41	13.00	7.90

* 5 % level of Significance

NS- Not significant

4.9. Grain yield

4.9.1. Effect of variety

Grain yield is a function of various yield components such as number of productive tillers, filled grains panicle^{-1} and 1000-grain weight (Hassan et al., 2010) . In present experiment variety had effect on grain yield (Table 4). It was evident that BRRI dhan38 produced higher grain yield (3.37 t ha^{-1}) which was contributed from higher number of effective tillers hill^{-1}, higher number of grains panicle^{-1} and higher number of filled grains panicle^{-1}. Chinigura produced lower grain yield (3.01 t ha^{-1}). Similar results on grain yield of rice were found by Ashrafuzzaman *et al.* (2009), Duy *et al.* (2004) and Molla (2001). Grain yield differences due to varieties were reported by Suprithatno and Sutaryo (1992), and IRRI (1978) who recorded variable grain yields among tested varieties. The probable reason for variation on yield was due to the heredity of the variety.

4.9.2. Effect of fertilizer

Different fertilizer dose had significant effect on grain yield (Table 4). Higher NPK fertilizer dose (T_3) produced significantly the highest grain yield (3.44 t ha^{-1}). Reduction rate of fertilizer gradually decreased the grain yield i.e. T_2 (3.18 t ha^{-1}), T_1 (3.12 t ha^{-1}) and T_0 (3.02 t ha^{-1}). With the application of 125% recommended NPK fertilizer dose in the present experiment produced the highest number of effective tillers hill^{-1}, filled grains panicle^{-1} which ultimately gave higher grain yield. Badruddin *et al.* (2000) found that the yield of T. aman (summer) rice (BR11) varieties increased with the application of recommended dose of N, P, K, S fertilizer. Similar results were found by Islam *et al.* (2009) and Mollah *et al.* (2008).

4.9.3. Interaction effect of variety and fertilizer dose

Grain yield was significantly influenced by the interaction of variety and fertilizer dose (Table 4). The highest grain yield (3.67 t ha^{-1}) was observed from the combination of BRRI dhan38 with 125% recommended NPK fertilizer dose (V_1T_3). The lowest grain yield (2.85 t ha^{-1}) was found from the combination of Chinigura with control (V_2T_0).

4.10. Straw yield

4.10.1. Effect of variety

The yield of straw was varied due to varieties (Table 4). It was evident from the experimental results that BRRI dhan38 produced the higher straw yield (6.84 t ha^{-1}) compared to Chinigura (6.53 t ha^{-1}). The result was in agreement with the findings of Panda and Leeuwrik (1971) who reported that the straw yield could be relate to plant height. Ashrafuzzaman *et al.* (2009) found that straw yield differed due to variety.

4.10.2. Effect of fertilizer

From the Table 4 it was found that straw yield was significantly affected due to the different fertilizer dose. The mean straw yield due to application of NPK fertilizer revealed that the straw yield (6.99 t ha^{-1}) was the highest with T_3. Yadav and Tripathi (2006), Amin *et al.* (2004) and Sudha and Chandini (2002) found increased straw yield with increased fertilizer doses.

4.4.3. Interaction effect of fertilizer dose and variety

It was evident from the Table 4 that interaction of variety and fertilizer dose had significant effect on straw yield. The highest straw yield (7.53 t ha^{-1}) was found from the combination of BRRI dhan38 with 125% recommended NPK fertilizer dose (V_1T_3). The lowest straw yield (6.26 t ha^{-1}) was observed from the combination of Chinigura with lower fertilizer dose (V_2T_0).

4.11. Nitrogen content in grain

4.11.1 Effect of variety

The effects of varieties on the N content of grain are presented in Table 5. Total nitrogen in grain was influenced by varieties of rice. Between two varieties, V_2 (Chinigura) contained higher nitrogen content (1.22%) than V_1 (BRRI dhan38) (1.18%).

4.11.2 Effect of fertilizer dose

Total nitrogen in grain showed statistically significant NPK differences due to the application of different NPK fertilizer doses in rice. The highest total nitrogen in grain (1.28%) was recorded from T_3 as 125% recommended NPK which was statistically identical to (1.26%) with T_2 (100% recommended NPK). On the other hand, the lowest total nitrogen in grain (1.06%) was obtained from control treatment. Uppal and Shidul (1995) reported that N and protein content increased with the increasing level of N up to 120 kg N ha^{-1}.

4.11.3. Combined effect of variety and fertilizer dose

The combined effect of variety and different doses of NPK fertilizers on the N content in grain of rice field was significant (Table 5). The highest total nitrogen in grain (1.31%) was recorded from V_2T_3 (Chinigura with 125% recommended NPK fertilizer dose) which is statistically similar to V_2T_2. On the other hand, the lowest total nitrogen in grain (1.05%) was obtained from V_1T_o (BRRI dhan38 with control treatment) which is statistically similar with V_2T_0.

4.12. Nitrogen content in Straw

4.12.1 Effect of variety

The effects of varieties on the N content of straw are presented in Table 5. Total nitrogen in straw was influenced by varieties of rice. Between two varieties, V_2 (Chinigura) contained higher nitrogen content (0.50%) than V_1 (BRRI dhan38) (0.46 %).

4.12.2 Effect of fertilizer dose

Total nitrogen in straw showed statistically significant differences due to the application of different NPK fertilizer doses in rice. The highest total nitrogen in straw (0.55%) was recorded from T_3 as 125% recommended NPK which is statistically identical with T_2 (100% recommended NPK) (0.53%). On the other hand, the lowest total nitrogen in straw (0.39 %) was obtained from control treatment. Uppal and Shidul (1995) reported that N and protein content increased with the increasing level of N up to 120 kg N ha^{-1}.

Table 5. Effect of variety, NPK fertilizers and their interaction on N, P and K content in grain and straw of rice

Treatment	Grain N%	Straw N%	Grain K%	Straw K%	Grain P%	Straw P%
Variety						
V_1	1.18	0.46	0.93 a	1.68 a	0.22	0.14
V_2	1.22	0.50	0.87 b	1.35 b	0.20	0.12
Level of Significance	NS	NS	*	*	NS	NS
LSD(0.05)	0.06	0.22	0.05	0.08	0.07	0.05
CV(%)	5.41	10.89	4.19	6.53	5.53	4.04
Fertilizer						
T_0	1.06 b	0.39 b	0.45 c	0.93 c	0.18 b	0.10 b
T_1	1.19 ab	0.45 ab	0.71 b	1.58 b	0.20 b	0.11 ab
T_2	1.26 a	0.53 a	1.21 a	1.75 a	0.23 a	0.14 ab
T_3	1.28 a	0.55 a	1.24 a	1.81 a	0.23 a	0.16 a
Level of Significance	*	*	*	*	*	*
LSD(0.05)	0.1423	0.1006	0.0712	0.0712	0.0225	0.045
CV(%)	5.41	10.89	4.19	6.53	5.53	4.04
Interaction effect of variety and fertilizer dose						
V_1T_0	1.05 d	0.38 d	0.44 e	1.42 d	0.22 b	0.11 bc
V_1T_1	1.18 c	0.44 cd	0.47 e	1.60 c	0.23 b	0.11 bc
V_1T_2	1.21 abc	0.49 bc	0.53 d	1.81 b	0.23 b	0.15 b
V_1T_3	1.27 abc	0.54 ab	2.06 a	1.90 a	0.25 a	0.21 a
V_2T_0	1.07 d	0.40 d	0.42 e	0.44 e	0.14 d	0.10 c
V_2T_1	1.19 bc	0.47 bc	0.44 e	1.57 c	0.20 c	0.10 c
V_2T_2	1.29 ab	0.56 a	0.89 c	1.61 c	0.20 c	0.12 bc
V_2T_3	1.31 a	0.57 a	1.98 b	1.80 b	0.22 b	0.13 bc
Level of Significance	*	*	*	*	*	*
LSD(0.05)	0.09	0.07	0.05	0.05	0.01	0.04
CV(%)	5.41	10.89	4.19	6.53	5.53	4.04

* 5 % level of Significance

NS- Not significant

4.12.3 Combined effect of variety and fertilizer dose

The combined effect of variety and different doses of fertilizer on the N content in straw of rice field was significant (Table 5). The highest total nitrogen in straw (0.57%) was recorded from V_2T_3 (Chinigura with 125% recommended NPK fertilizer dose) which is statistically similar with V_2T_2 (0.56%). On the other hand, the lowest total nitrogen in grain (0.38%) was obtained from V_1T_o (BRRI dhan38 with control treatment), which is statistically similar with V_2T_0.

4.13. Phosphorus content in grain

4.13.1 Effect of variety

The effects of variety on the P content of grain are presented in Table 5. Between two varieties, V_1 (BRRI dhan38) contained higher phosphorus content (0.22%) than V_2 (Chinigura) (0.20%).

4.13.2 Effect of fertilizer

Phosphorus in grain showed significant differences due to the application of different NPK fertilizer doses in rice. The P in grain increased due to increased application of fertilizer dose. The highest phosphorus in grain (0.23%) was recorded from T_3 and T_2 treatment and the lowest phosphorus in gain (0.18%) was obtained from T_0 (control treatment) which was closely followed (0.20%) by T_1 (Table 5). The P content in rice at different growth stages increased progressively with an increase of P levels which was reported by Islam *et al.* (2008).

4.13.3 Combined effect of variety and fertilizer

The combined effect of varieties and different doses of fertilizer on the phosphorus in grain of rice was significant (Table 5). The highest phosphorus in grain (0.25%) was recorded from V_1T_3 treatment and the lowest phosphorus in grain (0.14%) was obtained from V_2T_0 treatment.

4.14. Phosphorus content in Straw

4.14.1Effect of variety

The effects of variety on the P content of straw of rice presented in Table 5. Between two varieties, V_1 (BRRI dhan38) contained higher phosphorus content (0.14%) than V_2 (Chinigura) (0.12%).

4.14.12 Effect of fertilizer

Phosphorus in straw was showed significant differences due to the application of different NPK fertilizer doses in rice. The P content in straw increased due to increased application of fertilizer dose. The highest phosphorus in straw (0.16%) was recorded from T_3 and the lowest phosphorus in straw (0.10%) was obtained from T_0 (control treatment) (Table 5). The P content in rice at different growth stages increased progressively with an increase of P levels which was reported by Islam *et al.* (2008).

4.14.3 Combined effect of variety and fertilizer

The combined effect of varieties and different doses of fertilizer on the phosphorus in straw of rice field were significant (Table 5). The highest phosphorus in straw (0.21%) was recorded from V_1T_3 treatment and the lowest phosphorus in straw (0.10%) was obtained from V_2T_0 treatment.

4.15. Potassium content in grain

4.15.1 Effect of variety

The effects of variety on the K content of grain are presented in Table 5, where V_1 (BRRI dhan38) contained higher potassium content (0.93%) than V_2 (Chinigura) (0.87%).

4.15.2 Effect of fertilizer

Potassium in grain showed significant differences due to the application of different NPK fertilizer doses in rice. The K content in grain increased due to increased application of fertilizer dose. The highest Potassium in grain (1.24%) was recorded from T_3 which is statistically similar with T_2 treatment and the lowest Potassium content in gain (0.45%) was obtained from T_0 (control treatment) (Table 5). Similar results were also obtained by krishnappa *et al.* (2006) and in rice.

4.15.3 Combined effect of variety and fertilizer

The combined effect of varieties and different doses of fertilizer on the Potassium content in grain of rice differed significantly (Table 5). The highest Potassium content in grain (2.06%) was recorded from V_1T_3 treatment and the lowest Potassium content in grain (0.42%) was obtained from V_2T_0 treatment which is statistically similar with V_1T_0, V_2T_1 and V_1T_1 treatment.

4.16. Potassium content in Straw

4.16.1 Effect of variety

The effects of variety on the K content in straw of rice differed significantly (Table 5). Between two varieties, V_1 (BRRI dhan38) contained higher Potassium content (1.68%) than V_2 (Chinigura) (1.35%).

4.16.2 Effect of fertilizer

Potassium in straw was showed significant differences due to the application of different NPK fertilizer dose in rice. The K content in straw increased due to increased application of fertilizer dose. The highest Potassium content in straw (1.81%) was recorded from T_3 which is statistically similar to T_2 treatment and the lowest Potassium content in straw (0.93%) was obtained from T_0 (control treatment) (Table 5). Similar results were also obtained by krishnappa *et al.* (2006) and in rice.

4.16.3 Combined effect of variety and fertilizer

The combined effects of varieties and different doses of fertilizer on the Potassium content in straw of rice were significant (Table 5). The highest Potassium content in straw (1.90%) was recorded from V_1T_3 treatment and the lowest Potassium content in straw (0.44%) was obtained from V_2T_0 treatment.

Chapter 5

Summary and conclusion

CHAPTER 5

SUMMARY AND CONCLUSION

A field experiment was conducted at the farm of Sher-e-Bangla Agricultural University (SAU), during July to December, 2014 to study the effect of NPK fertilizers on the growth, yield and nutrients content of aromatic rice cultivars. Two Varieties: BRRI dhan38 (V_1) and Chinigura (V_2) and Four NPK fertilizers doses: 0% recommended fertilizer dose of NPK (T_0), 75% recommended fertilizer dose of NPK (T_1), 100% recommended fertilizer dose of NPK (T_2) and 125% recommended fertilizer dose of NPK (T_3) are included in the experiment. Recommended NPK fertilizers doses are 69 kg N/ha, 21 kg P/ha, 35 5.kg K/ha. The experiment was laid out in two factors Randomized Complete Block Design (RCBD) with four replications.

The following agronomical parameter of the varieties such as total tillers hill^{-1}, effective tiller hill^{-1}, non effective tiller hill^{-1}, filled grains panicle^{-1}, unfilled grains panicle^{-1}, panicle length, 1000-grain weight, grain and straw yield were studied. The variety Chinigura produced the highest plant height at 25, 45, and 65 days after transplanting (DAT) and at harvest (62.45, 102.86, 122.84 and 163.94 cm, respectively). The variety BRRI dhan 38 (V_1) showed maximum tillers hill^{-1} as 13.25, 18.6, 14.44, and 13.38 at 25, 45, 65 DAT and at harvest, respectively. The variety BRRI dhan38 gave maximum number of effective tiller hill^{-1} (11.44). The variety BRRI dhan38 produced lower number of non effective tiller (2.67) but longer panicle (26.42 cm) was produced by BRRI dhan38. The higher number of filled grains panicle^{-1} (176.56) was found from BRRI dhan38 and found the minimum number of unfilled grains panicle^{-1} (38.016). The highest weight of 1000-grains (17.78g) was obtained from BRRI dhan 38. This variety produced the highest grain yield (3.37 t ha^{-1}). This variety produced the higher straw yield (6.84 t ha^{-1}). The highest total nitrogen in grain (1.22%) and straw (0.50%) were recorded from Chninigura. The highest total phosphorus content in grain (0.22%) and straw (0.14%) was recorded from BRRI dhan38. The highest total Potassium content in grain (0.93%) and straw (1.68%) was recorded from BRRI dhan38.

Different NPK fertilizer dose significantly affected all growth characters. Among the yield contributing parameters effective tillers hill^{-1} and filled grains panicle^{-1} affected significantly. Grain yield, straw yield, significantly increased with the increase of NPK fertilizer dose. The maximum fertilizer dose (T_3) gave significantly the highest plant heights of 63.73 cm, 106.4 cm, 119.5 cm and 150.7 cm at 25, 45, 65 DAT and at harvest, respectively. The maximum number of tiller hill^{-1} (13.63, 19.13, 15.25, and 13 at 25, 45, 65 DAT and at harvest, respectively) was recorded from T_3. The maximum number of effective tillers hill^{-1} (11.22) was obtained from the 125% recommended fertilizer dose. Highest fertilizer dose (T_3) produced minimum number of non effective tillers hill^{-1} (2.15). The longest panicle (28.39 cm) was produced due to the application of higher 125% recommended dose of NPK fertilizer (T_3). The highest number of filled grains panicle^{-1} (162.4) was obtained with 125% recommended NPK fertilizer dose (T_3). The lowest number of unfilled grains panicle^{-1} (37.74) was obtained from the higher level of fertilizer dose (T_3). The highest weight of 1000-grains (15.00g) was obtained from 125% fertilizer dose (T_3). The highest NPK fertilizer dose (T_3) produced significantly the highest grain yield (3.44 t ha^{-1}). The straw yield (6.99 t ha^{-1}) was the highest with T_3. The highest total nitrogen content in grain (1.28%) and straw (0.55%) were recorded from T_3 as 125% recommended NPK. The highest total phosphorus content in grain (0.23%) and straw (0.16%) was recorded from T_3. The highest Potassium content in grain (1.24%) and straw (0.93%) was recorded from T_3 (125% recommended NPK).

Interaction effect of variety and fertilizer dose also significantly affected growth as well as yield and yield contributing characters. The longest plant (64.12, 117.9, 126.3 and 166.5cm at 25, 45, 65 DAT and at harvest, respectively) were found in V_2T_3. Highest number of tillers per hill (15, 20.00, 17.00, and 14.75 at 25, 45, 65, DAT and at harvest, respectively) was observed V_1T_3, Combination of BRRI dhan 38 with 125 % recommended fertilizer dose (V_1T_3) produced the highest number of productive tillers $hill^{-1}$ (12.25). BRRI dhan38 with 125% recommended fertilizer dose of NPK (V_1T_3) gave minimum number of non-effective tiller $hill^{-1}$ (2.04). The longest panicle length (29.06 cm) was found in BRRI dhan38 combinations with 125% recommended NPK fertilizer dose (V_1T_3). The highest number of filled grains $panicle^{-1}$ (191.8) was found from the combination of BRRI dhan with 125% recommended dose of NPK fertilizer (V_1T_3). The Minimum number of unfilled grains (31.51) was found from BRRI dhan38 with 125% recommended NPK fertilizer dose (V_1T_3). The highest weight of 1000-grains (17.85 g) was obtained from BRRI dhan38 combination with 125 % recommended fertilizer dose (V_1T_3). The highest grain yield (3.67 t ha^{-1}) was observed from the combination of BRRI dhan38 with 125% recommended NPK fertilizer dose (V_1T_3). The highest straw yield (7.53 t ha^{-1}) was found from the combination of BRRI dhan38 with 125% recommended NPK fertilizer dose (V_1T_3). The highest total nitrogen content in grain (1.31%) and straw (0.57%) were recorded from V_2T_3 (Chinigura with 125% recommended NPK fertilizer dose). The highest total phosphorus content in grain (0.25%) and straw (0.21%) were recorded from V_1T_3 treatment. The highest Potassium content in grain (2.06%) and straw (1.90%) were recorded from V_1T_3 treatment.

From the above discussion it can be concluded that BRRI dhan38 had effect on yield and yield contributing characters. Application of 125% recommended NPK fertilizer dose is most favorable for improving yield and yield contributing characters of BRRI dhan38 in *amon* season.

From the results of the present study, the following recommendations and suggestions may be made:

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

2. Another combination of NPK and others organic manures with different varieties of rice may be further studied.

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Appendices

APPENDICES

Appendix I. Monthly average RH, air temperature, total rainfall and sunshine hours of Dhaka during June to December, 2014

Month	Average RH (%)	Average Temperature (°C)		Total Rainfall (mm)	Average daily Sunshine hours
		Max.	Min.		
June	81	32.1	26.1	340.4	4.7
July	84	31.4	26.2	373.1	3.3
August	80	31.6	26.3	316.5	4.9
September	80	31.6	25.9	300.4	3.0
October	78	31.6	23.8	172.3	5.2
November	77	29.6	19.2	34.4	5.7
December	69	26.4	14.1	12.8	5.5

Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka-1207.

Appendix II. Physicochemical properties of the initial soil of the experimental site

Characteristics	Value
Partical size analysis.	
% Sand	26
% Silt	45
% Clay	29
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: Soil Resources Development Institute (SRDI), Dhaka-1207