# YIELD AND QUALITY OF AROMATIC RICE VARIETIES AS INFLUENCED BY COMBINATION OF CHEMICAL FERTILIZER AND GREEN MANURE

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# *CERTIFICATE*

*This is to certify that the thesis entitled "* ***YIELD AND QUALITY OF AROMATIC RICE VARIETIES AS INFLUENCED BY COMBINATION OF CHEMICAL FERTILIZER AND GREEN MANURE*** *" 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 results of a piece of bona fide research work carried out by* ***MD. JAFRUL ISLAM SUMON,*** *Registration. No.* ***09-03646*** *under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma.*

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



Dated:

Dhaka, Bangladesh

**(Prof. Dr. Tuhin Suvra Roy)**

**Supervisor**

DEDICATED TO

MY

BELOVED PARENTS

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# YIELD AND QUALITY OF AROMATIC RICE VARIETIES AS INFLUENCED BY COMBINATION OF CHEMICAL FERTILIZER AND GREEN MANURE


## ABSTRACT

A field experiment was conducted to evaluate the response of green manure and chemical fertilizer on growth, yield and quality of aromatic rice varieties in aman season at the research farm of Sher–e–Bangla Agricultural University, Dhaka, Bangladesh during the period from July to December, 2014. The experiment consisted of two factors; viz. factor A: Three rice varieties namely $V_1$= Kataribhog, $V_2$ = Raniselute and $V_3$ = BRRI dhan34 and factor B: fertilizer doses *viz.*, $T_1$: Recommended doses of NPKSZn, $T_2$ = 80% recommended doses of NPKSZn + green manure 3.5 t $ha^{-1}$, $T_3$ = 60% recommended doses of NPKSZn + green manure 7 t $ha^{-1}$, $T_4$ = 40% recommended doses of NPKSZn + Green Manure 10.5 t $ha^{-1}$, $T_5$ = 20% recommended doses of NPKSZn + Green Manure 14 t $ha^{-1}$ and $T_6$ = Green Manure 17.5 t $ha^{-1}$ were used for the present study. The experiment was laid out in a split-plot design with three replications. In case of variety green manure and chemical fertilizer significantly affected all characters except dry matter content $hill^{-1}$ at 15 DAT. Similarly, all traits were also affected significantly due to the effect of fertilizer management, the treatment $T_2$ (80% recommended doses of NPKSZn + green manure 3.5 t $ha^{-1}$) showed outstanding performance for getting the better growth and higher yield compared to those of other treatments. Most of the studied traits were also influenced significantly due to the effect of interaction of variety and fertilizer management where the growth and yield showed significant variation. The variety BRRI dhan34 treated with 80% recommended doses of NPKSZn + green manure 3.5 t $ha^{-1}$ ($V_3T_2$) as well as the highest number of tillers $hill^{-1}$ (13.93, 19.78, 21.33, 21.00, 20.44 and 19.44 at 15, 30, 45, 60, 75 DAT and at harvest, respectively), maximum effective tillers $hill^{-1}$ (15.50), the highest number of grains $panicle^{-1}$ (252.10), maximum filled grains $panicle^{-1}$ (212.8) and highest yield of grain (2.67 t $ha^{-1}$) were recorded. The highest (8.85%) and lowest (8.52%) protein content in rice grain was observed in Kataribhog ($V_1$) and BRRI dhan34 ($V_3$), respectively. The highest protein content in rice grain (9.42%) was observed in $V_3T_6$ and the lowest protein content in rice grain (7.76%) was found in $V_3T_4$. The highest (77.63%) and lowest (77.12%) carbohydrate content in rice grain was observed in BRRI dhan34 ($V_3$) and Raniselute ($V_2$), respectively. The highest carbohydrate content in rice grain (79.24%) was observed in $V_1T_1$ and the lowest (75.00%) was found in $V_1T_4$. Considering the above fact, 80% recommended dose of NPKSZn + green manure 3.5 t $ha^{-1}$could be considered the best fertilizer management practice for optimizing the production of aromatic rice during aman season.

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## LIST OF ACRONYMS

| | | |
|---|---|---|
| AEZ | = | Agro-Ecological Zone |
| BADC | = | Bangladesh Agricultural Development Corporation |
| BARI | = | Bangladesh Agricultural Research Institute |
| cm | = | Centimeter |
| CV% | = | Percentage of coefficient of variance |
| cv. | = | Cultivar |
| DAS | = | Days after sowing |
| *et al.* | = | And others |
| G | = | Gypsum |
| G | = | Gram (g) |
| $ha^{-1}$ | = | Per hectare |
| HI | = | Harvest Index |
| Hr | = | Hour |
| kg | = | Kilogram |
| LAI | = | Leaf area index |
| LSD | = | Least Significant Difference |
| Max | = | Maximum |
| Min | = | Minimum |
| mm | = | Millimeter |
| MP | = | Muriate of Potash |
| N | = | Nitrogen |
| No. | = | Number |
| NPK | = | Nitrogen, Phosphorus and Potassium |
| NS | = | Non significant |
| ppm | = | Parts per million |
| q | = | Quintal |
| SAU | = | Sher-e-Bangla Agricultural University |
| SRDI | = | Soil Resources and Development Institute |
| T | = | Ton |
| TSP | = | Triple Super Phosphate |
| viz. | = | Videlicet (namely) |
| Wt. | = | Weight |
| % | = | Percent |
| µg | = | Micro gram |
| $^{0}C$ | = | Degree Celsius |

# CHAPTER 1

# INTRODUCTION

Rice (*Oryza sativa* L.) belongs to the *Poaceae* family and it is the vital food for 2.4 billion people in Asia, nearly 90% of the world's rice is produced and consumed in this region and more than four hundred millions of people in Africa and Latin America (IRRI, 2011). In worldwide, 474.86 million metric tons of rice was produced from 159.64 million hectares of land with an average yield of 4.43 t $ha^{-1}$ during the year of 2014-15 (USDA, 2015). The people in Bangladesh depend on rice as staple food and have tremendous influence on agrarian economy of Bangladesh. Rice alone constitute of 97% of the food grain production in Bangladesh (BBS, 2013). Among different groups of rice, transplant aman (T. Aman) rice cover about 49.11% of total rice area and it contributes to 38.11% of the total rice production in the country (BBS, 2013). In Bangladesh, rice dominates over all other crops and covers 75% of the total cropped area (Rekabdar, 2004) of which around 27% is occupied by fine rice varieties (BBS, 2003).

Aromatic rice is long and medium grained, with a characteristic pleasant and fragrant aroma, which makes aromatic rice highly favoured in South East Asian and international markets. Aromatic rice is known for its characteristic fragrance when cooked. This constitutes a small but special group of rice, which is considered best in quality. Aromatic varieties fetch higher price in rice market than the non-aromatic ones. 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). More than four thousand landraces of rice are adopted in different parts of Bangladesh. Only some of these are unique for quality traits including fineness, aroma, taste and protein contents (Kaul *et al.*, 1982). Aromatic rice varieties have occupied about 12.5% of the total transplanted aman rice cultivation (BBS, 2005).

Due to the extensive and improper use of chemical fertilizers in the soil, our soil is degrading to an alarming level, causing an imbalance in the ecosystem and environmental pollution as well. More recently, attention is being focused on the global environmental problems; utilization of green manure as the most effective measure for the purpose. Green manure is the safer sources of plant nutrient without any detrimental effect to crops and soil. Green manure is excellent sources of organic matter as well as primary plant nutrients (Pieters, 2004). However, after the industrial revolution wide spread introduction of inorganic fertilizers led to a decline in the use of organic material in the cropping systems. The impact of increased fertilizer use on crop production has been large and important (Hossain and Singh, 2000). It has been estimated that fertilizer use growth contributed to about 25% of the total increase in rice production in Asia between 1965 and 1980 (Barker *et al.*, 1985). However, in recent years there has been serious concern about long term adverse effect of continuous and indiscriminate use of inorganic fertilizers on deterioration of soil structure, soil health and environmental pollution (Ghosh and Bhat, 1998; Shukla *et al.*, 1998; Singh, 2000). The yield of rice has reached a plateau due to declining factor productivity under increasing intensification. Therefore, farmers are compelled to apply increasing rates of fertilizers to maintain current yield levels (Pagiola, 1995). The reasons for low yield of rice are manifold; some are varietals, others are technological and rests are climatic. Undoubtedly, with the introduction of high yielding varieties the yield of rice has been increased, but the trend of increase is not linear. The yield can be increased by using improved cultural practices like use of quality seed, high yielding varieties, adopting plant protection measures, judicious application of fertilizers, etc. Integrated nutrient management for rice can increase the productivity of rice. Use of organic manures alone, as a substitute to chemical inorganic fertilizer is not profitable and will not be enough to maintain the present levels of crop productivity of high yielding varieties (Garrity and Flinn, 1988). Therefore, integrated nutrient management in which both organic manures and inorganic fertilizers are used simultaneously is probably the most effective method to maintain healthy sustainable soil system can improve soil structure, improve nutrient exchange and maintain soil health has again raised interest in organic farming (Becker *et al.*, 1995; Ayoub, 1999).

In Bangladesh, most of the cultivated soils have less than 1.5% organic matter while a good agricultural soil should contain at least 2% organic matter. Evidences from different AEZ of the country have shown a decrease in the content of organic matter by the range of 15 to 30% over the last 20 years (Miah, 1994). Moreover, this important component of soil is declining with time due to intensive cropping and use of higher dose of chemical fertilizers with little or no addition of organic manure while increasing crop productivity (Janssen, 1993).

The sources of nutrients for crops are nutrient reserve of soil, organic and inorganic fertilizers. None of the source is complete and therefore, no one is sufficient to sustain soil fertility and productivity. Soil organic matter plays an important role in preserving the fertility and productivity of soil. Organic matter content in Bangladesh soil is declining due to high cropping intensity and which also causes quick decomposition of organic matter. It was observed that the highest grain yield was obtained with the incorporation of green manure in the rice field (Sarkar and Pramanik, 2004). Integration of green manure and chemical fertilizers may facilitate the utilization of nutrients for crop growth and productivity and help replenish the organic matter status in soil. Thus application of green manure and chemical fertilizers may play an important role in rice cultivation when used alone or in combination with chemical fertilizers. In view of limited information on the problems mentioned above, this present study was therefore, undertaken with the following objectives:

i. To compare the growth performance of three aromatic aman rice varieties using green manure and chemical fertilizers,
ii. To evaluate the yield performance of the different aromatic rice varieties using different combination of green manure and chemical fertilizers and
iii. To find out the influence of green manure and chemical fertilizers on the quality of three varieties of aromatic aman rice.

# 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. In agronomic point of view fertilizer management for modern rice cultivation has become an important issue. Considering the above points, available literature was reviewed under different rice variety and fertilizer management of rice.

## 2.1 Effect of varieties

Wirnas *et al*. (2015) reported that the genotypes evaluated Mekongga, and IPB 3S have higher yield potential and significantly different from IR 64, Situ Patenggang, and Kalimutu. All of the varieties evaluated had lower total grain number due to high temperature stress, but only significantly different for Inpari 13, IPB 4S, IPB 5R, and IPB 7R. The Inpari 13, IPB 3S, IPB 4S, IPB 5R, and IPB 7R varieties had lower grain weight and 1000 grain weight due to high temperature stress. Varieties IR 64 and Situ Patenggang were able to sustain the grain weight under high temperature stress, but have a lower grain weight than other varieties.

Wiangsamut *et al*. (2015) found that the plant height of RD14 rice genotype was significantly taller than San–pah–tawng1 rice genotype. Grain yield of RD14 rice genotype was significantly higher than San–pah–tawng1 rice genotype; mainly due to RD14 rice genotype having had higher filled grain number panicle$^{-1}$ and harvest index.

Haque *et al*. (2015) evaluated the two popular indica hybrids (BRRI hybrid dhan 2 and Heera 2) and one elite inbred (BRRI dhan45) rice varieties. Both hybrid varieties out yielded the inbred. However, the hybrids and inbred varieties exhibited statistically identical yield in late planting. Filled grain (%) declined significantly at delayed planting in the hybrids compared to elite inbred due to increased temperature impaired–inefficient transport of assimilates. Results suggest that greater remobilization of shoot reserves to the grain rendered higher yield of hybrid rice varieties.

Roy *et al*. (2014) evaluated 12 indigenous Boro rice varieties where the plant height and tillers hill$^{-1}$ at different DAT varied significantly among the varieties up to harvest. At harvest, the tallest plant (123.80 cm) was recorded in Bapoy and the shortest (81.13 cm) in GS. The maximum tillers hill$^{-1}$ (46.00) was observed in Sylhety Boro and the minimum (19.80) in Bere Ratna. All of the parameters of yield and yield contributing characters differed significantly at 1% level except grain yield, biological yield and harvest index. The maximum effective tillers hill$^{-1}$ (43.87) was recorded in the variety Sylhety *Boro* while Bere ratna produced the lowest effective tillers hill$^{-1}$ (17.73). The highest (110.57) and the lowest (42.13) filled grains panicle$^{-1}$ was observed in the variety Koijore and Sylhety Boro, respectively. Thousand grain weight was the highest (26.35 g) in Kali Boro and the lowest (17.83 g) in GS one. Grain did not differ significantly among the varieties but numerically the highest grain yield (5.01 t ha$^{-1}$) was found in the variety Koijore and the lowest in GS one (3.17 t ha$^{-1}$).

Hossain *et al*. (2014b) conducted an experiment at the research farm of SAU on the yield and yield attributes of exotic hybrid rice varieties. Significantly longer panicle was recorded from Heera 2 (24.70 cm) which was statistically identical with Aloron (24.52 cm). Both hybrid rice varieties Heera 2 (119.8) and Aloron (111.8) produced the highest spikelets panicle$^{-1}$ than that of BRRI dhan48 (105.5).In BRRI dhan48, the highest filled spikelets panicle$^{-1}$ (79.53) was recorded. This was may be due to lower sensitiveness of BRRI dhan48 to high temperature and low sunshine hour at grain filling stage compared to test hybrid varieties. The highest spikelet filling percent was recorded from BRRI dhan48 (74.43%) due to favorable environmental condition at grain filling stage. Aloron produced heavier grain size than that of Heera 2 and BRRI dhan48. BRRI dhan48 gave significantly higher grain yield 3.51 tha$^{-1}$over the tested hybrid varieties Heera 2 (3.03 t ha$^{-1}$) and Aloron (2.77 tha$^{-1}$). Biological yield did not varied significantly among studied hybrid and inbred rice varieties. The highest HI was obtained from BRRI dhan 48 while it was lowest in Aloron.

Hossain *et al*. (2014a) evaluated the five rice cultivars (one hybrid: WR 96, three modern: BR16, BR26 and BRRI Dhan27 and one local: Pari). Most of the yield contributing characters examined and showed wide variations among the cultivars whereas modern cultivar BR 16 produced the highest panicle length, number of grain panicle$^{-1}$and grain yield ha$^{-1}$. At the same time as local cultivar Pari generated the lowest number of tiller plant$^{-1}$, panicle length, grain number panicle$^{-1}$ and grain yield ha$^{-1}$. Moreover, hybrid cultivar WR 96 produced the highest percentage of spotted grain panicle$^{-1}$.

Sokoto and Muhammad (2014) conducted a pot experiment to determine the effect of water stress and variety on productivity of rice. The results indicated significant ($P < 0.05$) differences among genotypes. Faro 44 differed significantly from others in plant height, number of leaves plant$^{-1}$, harvest index and grain yield. FARO 44 differed significantly from NERICA 2 and FARO 15 at all the parameters under study.

Shiyam *et al*. (2014) conducted an experiment to evaluate the performance of four Chinese hybrid rice varieties where it was showed comparative superiority of FARO 15 to the hybrids in all growth and yield components assessed. FARO 15 was taller (140 cm) with more productive tillers (11.0), higher spikelets plant$^{-1}$ (166.0), higher filled grains panicle$^{-1}$ (156.17), higher filled grains (92.17%), highest 100 grain weight of 2.63 g and the higher paddy yield (5.021 t ha$^{-1}$) than others. Despite the comparative poor performance of the hybrids, Xudao151came close to FARO 15 with grain yield of 2.987 t ha$^{-1}$.

Akter (2014) investigated the growth, yield and nutrient content of 15 Boro rice cultivars. BR 15, BRRI dhan29 and BRRI dhan28 were the three rice cultivars having high potentials for grain and straw production during Boro season. The highest yield was recorded 5.26 t ha$^{-1}$ which is still very low compared to other rice growing countries of the world. Chola *Boro* and Sada bore are two local land races having potentials for producing higher number of effective tillers and higher 1000 grain weight. Sada Boro and Chola Boro, two local cultivars were found very high in grain nitrogen content compared to other test cultivars.

Sarker *et al*. (2013) found that the BRRI dhan28 was shorter in plant height, having more tillering capacity, higher leaf number which in turn showed superior growth character and yielded more than those of the local cultivars. The HYV BRRI dhan 28 produced higher grains panicle$^{-1}$ and bolder grains resulted in higher grain yield over the local cultivars. The BRRI dhan 28 produced higher grain yield (7.41t ha$^{-1}$) and

Bashful, Poshurshail and Gosi yielded ha$^{-1}$, respectively. Among the local rice cultivars, Gosi showed the higher yielding ability than Bashful and Poshursail.

Islam *et al*. (2013) found that the highest plant height (116.00 cm) was found in the variety Morichsail and the lowest in the variety Khaskani. Filled grains panicle$^{-1}$ was found highest (100) with the variety Khaskani and the lowest was recorded in the variety Raniselute. Raniselute produced the highest 1000 grain weight (32.09 g) and the lowest (13.32 g) was recorded from the variety Kalijira.The variety Morichsail produced the highest grain yield (2.53 t ha$^{-1}$) followed by Kachra (2.41 t ha$^{-1}$), Raniselute (2.13 t ha$^{-1}$) and Badshabhog (2.09 t ha$^{-1}$) and the lowest grain yield (1.80 t ha$^{-1}$) was obtained from Kalijira.

Hossain *et al*. (2013) reported that the evaluated five rice cultivars showed wide variations regarding most of the yield contributing characters. Modern cultivar BR16 produced the highest panicle length, number of grain panicle$^{-1}$ and grain yield ha$^{-1}$. At the same time as local cultivar Pari generated the lowest number of tiller plant$^{-1}$, panicle length, grain number panicle$^{-1}$and grain yield ha$^{-1}$.

Garba *et al*. (2013) studied on the effects of variety, seeding rate and row spacing on growth and yield of rice. Variety Ex–China produced significantly ($P<0.05$) higher numbers of tillers plant$^{-1}$ and spikes hill$^{-1}$. However, NERICA-1 produced significantly ($P<0.05$) higher numbers of spikelets spike$^{-1}$, seeds spike$^{-1}$, weight of seed spike$^{-1}$, weight of seed hill$^{-1}$, 1000 grain weight and yield in kg ha$^{-1}$ than Ex-China.

Mahamud *et al*. (2013) showed that rice cultivars differed significantly in all growth characters, such as plant height, tillers number and dry matter weight of different plant parts, panicle length, filled grain, unfilled grain, filled grain percentage, 1000 grain weight, grain yield and straw yield.

Yao *et al*. (2012) found in significant difference in grain yield between the cv. AWD and CF. On average, YLY6 produced 21.5% higher yield than HY3 under AWD conditions. Like grain yield, YLY6 showed consistently higher water productivity and physiological nitrogen use efficiency than HY3. Both total dry weight and harvest index contributed to higher grain yield of YLY6.

Sritharanand Vijayalakshmi (2012) evaluated the physiological traits and yield potential of six rice cultivars *viz.*, PMK 3, ASD 16, MDU 3, MDU 5, CO47 and RM 96019. The plant height, total dry matter production and the growth attributes like leaf area were found to be higher in the rice cultivar PMK 3 that showed significant correlation with yield. Yield and yield components like number of productive tillers, fertility co-efficient, panicle harvest index, grain weight and harvest index were found to be higher in PMK 3.

Panwar *et al*. (2012) studied to evaluate the performance of rice varieties. Growth parameters viz plant height (cm), No. of tillers $m^{-2}$, leaf area index and dry matter accumulation (g) was highest in JGL-3844 over rest of varieties. The effective tillers $m^{-2}$ (331.6), panicle length (25.63), grains $panicle^{-1}$ (68.23), sterility percent (12.1), grain yield (60.90 q $ha^{-1}$) and straw yield (92.58 q $ha^{-1}$) yield were also highest in variety JGL-3844.

Oko *et al*. (2012) assessed the agronomic characteristics of 15 selected indigenous and newly introduced hybrid rice varieties in Ebonyi State, Nigeria. Significant variation ($P<0.05$) was detected among the 20 rice varieties for all the traits evaluated. The results showed that plant height ranged between 144.01 cm in “Mass (I)” and 76.00 cm in “Chinyeugo”. Cv. “E4197” had the highest value of 38±0.02 cm for panicle length and “Chinyereugo” had the highest value of 6.3g ± 0.03 for panicle weight. Leaf area showed the highest value of 63.8 $cm^2$± 0.01 in “Mass (I)”. Cv. “Co–operative” had highnumber of seeds $panicle^{-1}$(139 ± 0.19). “Chinyereugo” had the highest value of 25.9g±1.4 for 1000 grains weight. The grain of “E4314” was the longest (8.00 mm ± 0.89) of the varieties studied.

Mannan *et al*. (2012) reported that the Badshabhog and Kalijira showed taller plants and Chinigura was shorter while Chinigura produced the greatest tillers at early, mid and at later growth stages and the lower tillers was observed in Badshabhog. Chinigura produced the highest amount of DM and while least amount of DM was observed in Kataribhog. The Chinigura produced significantly the highest panicles but it was statistically identical with Kalijira, while, Kataribhog exhibited lower number of panicles but number of grains $panicle^{-1}$ was found more in Badshabhog. The heaviest grain was found in Kataribhog while the light grain was observed in Badshabhog. The grain yield of Chinigura and Kalijira was almost identical. Lower grain yield was found in Kataribhog which may be attributed to the lower number of panicles and grains panicle$^{-1}$.

Alam *et al*. (2012) found that the cultivar BRRI dhan33 gave significantly the tallest plant (113.17 cm), while the shortest plant was found in BRRI dhan32 cultivar (105.07 cm). Among the cultivars, BR11 produced the maximum total tillers hill$^{-1}$ (12.33), maximum fertile spikelets panicle$^{-1}$(103.83) while lowest fertile spikelets panicle$^{-1}$ (102.10) and minimum total tillers hill$^{-1}$(10.17) were found in BRRI dhan32. BR11 also produced the highest 1000 grain weight (23.79g) and highest grain yield (5.92 tha$^{-1}$) while BRRI dhan33 produced the lowest 1000 grain weight (21.69 g)and grain yield. The cultivar BR11 produced the highest grain yield; it might be due to the highest number of total tillers hill$^{-1}$, number of effective tillers hill$^{-1}$and 1000 grain weight and lowest number of sterile spikelets panicle$^{-1}$.

Khushik *et al*. (2011) studied to assess the performance of rice hybrid and other varieties planted in rice growing areas of Sindh and Balochistan. The results revealed that average yield of hybrid rice were 195 mds ha$^{-1}$, followed by IRRI-6 (151 mds ha$^{-1}$), B-2000 (91 mds ha$^{-1}$) and Rosi (94 mds ha$^{-1}$). This indicates that the yield of hybrid rice was higher by 29% than the major variety IRRI-6.

Islam (2011) conducted a field experiment at BINA, Mymensingh on five aromatic rice genotypes viz., BRRI dhan34, Ukunimadhu, RM-100/16, KD5 18–150 and Kalozira by at BINA, Mymensingh. Among the varieties, KD5 18-150 showed higher grain yield, total dry matter plant$^{-1}$ and harvest index under temperature stress.

Baset Mia and Shamsuddin (2011) reported that the aromatic rice cultivars showed tallest plant stature, profuse tillers hill$^{-1}$, grain yield, lowest straw yield and harvest index compare modern rice. The highest grain yield of modern rice cultivars was due to the higher harvest index. Poor yield in aromatic rice cultivars was due to lower translocation of assimilates.

Akinwale *et al*. (2011) evaluated 14 rice varieties (10 commercial hybrids, 2 inbred and 2 low land NERICAs) at the Africa Rice Center to compare the grain yield performance. The number of panicles m$^{-2}$, number of grains panicle$^{-1}$ were significantly higher in the hybrids than in the inbred and inter-specific varieties. The hybrids had the highest grain yield compared to the inbred and the inter-specific low land NERICA varieties. The results indicated that hybrids exhibited significant yield increase of 13.44% over the best low land NERICAs and 15.17% over the best inbred variety WITA 4.

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 10 WP @ 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 at Bangladesh Rice Research Institute, regional station, Rajshahi in 2008 and 2009 to evaluate the performance of yield and yield contributing characters of three popular BRRI *aman* varieties having different growth duration (BRRI dhan39, BRRI dhan49 and BR11) 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 $ha^{-1}$).

Islam *et al*. (2010) found that the rice cultivar 1R76712H produced the highest grain yield (7.70 t $ha^{–1}$) followed by 1R75217H and Magat (7.60 t $ha^{–1}$) in WS; in DS, 1R79118H produced the highest grain yield (9.17 t $ha^{–1}$) followed by 1R73855H (8.90 t $ha^{–1}$) and SL-8H (8.80 t $ha^{–1}$) due to high harvest index. Hybrid produced higher spikelets panicle$^{-1}$ and 1000 grain weight than inbred rice. Spikelet filling percent was higher in inbred than hybrid rice.

Islam *et al*. (2009b) reported that the genotype BINA dhan5 and BINA dhan6 showed similar performance in respect of most of the parameters but BINA dhan6 produced the highest grain yield (40.26 g hill$^{-1}$) compared to BINA dhan5 (35.54 g hill$^{-1}$) and Tainan 3 (33.90 g hill$^{-1}$).

Islam *et al*. (2009a) reported that BRRI dhan3l had about 10–15% higher plant height, very similar tillers plant$^{-1}$, 15–25% higher LA at all DAT compared to Sonarbangla-1 in 2001. Sonarbangla-1 had about 40% higher DM production at 25 DAT but had very similar DM production at 50 and 75 DA. BRRI dhan-3l had higher panicles plant$^{-1}$ than Sonarbangla-1, but Sonarbangla-1 had higher grains panicle$^{-1}$, 1000 grain weight and grain yield than BRRI dhan31. In 2002, BRRI dhan31 had the highest plant height at 25 DAT, but at 75 DAT, BRRI hybrid dhan-l had the highest plant height. Sonarbangla-1 had the largest LA at 25 and 50 DAT while BRRI dhan 31 had the largest LA.

Sohel *et al*. (2009) found that BRRI dhan41 produced higher grain yield (4.70 t ha$^{-1}$) which was the contribution of higher number of grains panicle and heavier grain weight. Lower yield (4.51 t ha$^{-1}$) was recorded in BRRI dhan40.

Razzaque *et al*. (2009) studied on salt tolerant genotypes PVSB9, PVSB19, PNR381, PNR519, Iratom 24 and salt sensitive genotype NS15 along with one standard check salt tolerant rice cultivar Pokkali. The different morphological characters studied include plant height, total number of tillers, Root Dry Weight (RDW), Shoot Dry Weight (SDW) and Total Dry Matter (TDM) content of the selected rice genotypes in view to evaluate their response at different salinity levels. The genotypes Pokkali, PVSB9, PVSB19 showed significantly higher values and the lowest value of all these characters were recorded in NS15.

Jeng *et al*. (2009) found that the cultivar Tainung 67 had greater yield (7.2 mg ha$^{-1}$) than SA419 (6.2 mg ha$^{-1}$). The greater yield of SA419 than Tainung 67 in autumn was due to its higher net assimilation rate and better dry matter partitioning during grain filling. Significant panicle branch effects on the distribution pattern of grain weight were also found between Tainung 67 and SA419 with greater variation for the former than the latter.

Ashrafuzzaman *et al*. (2009) reported that the Kalizira was the tallest (107.90 cm) while it was shortest (93.40 cm) in Chiniatop and was identical to Kataribhog (95.30 cm) due to genetic makeup of the cultivar, but the environmental factors also influence it. There was also significant difference on 1000 grain weight among the cultivars whereas the highest 1000 grain weight was recorded in BR38 (20.13 g) and the lowest was recorded in BR34 (12.17 g). BR34 produced the maximum grain yield and Basmati produced the lowest. The highest harvest index was recorded from BR34 (34.94%) and the lowest harvest index was obtained from Basmati (31.51%).

Alam *et al*. (2009) reported that the tallest plant was observed with BRRI dhan29 due to its genetic characters while numerically the highest DM of plant was found in Hira 2 and lowest in BRRI dhan29 at all the growth stages except 25 DAT.

Masum *et al*. (2008) reported that that Nizershail produced the taller plant height than BRRI dhan44 at different DAT. Total tillers hill$^{-1}$ was significantly influenced by variety at all stages. At 30 and 60 DAT, Nizershail had significant by higher amount of DM (35.46% higher at 30 DAT and 18.01% higher at 60 DAT) than BRRI dhan44 but at harvest BRRI dhan44 had significantly higher amount of DM (39.85 g hill$^{-1}$) that was 18.42% higher than Nizershail. BRRI dhan44 produced higher (4.85 t ha$^{-1}$) grain yield than Nizershail (2.46 t ha$^{-1}$). Nizershail produced higher (7. 22 t ha$^{-1}$) straw yield compared to BRRI dhan44 (6.34 t ha$^{-1}$).

Hossain *et al*. (2008) reported that all the yield contributing characters differed significantly due to cultivar. The tallest plant was observed in Chinigura (162.8 cm) which statistically similar to Kataribhog. Kalizira produced the maximum number of grains panicle$^{-1}$ (135.90). Among the cultivars, BRRI dhan38 gave the maximum grain yield (4.00 t ha$^{-1}$).

Five varieties were evaluated by Ndaeyo *et al*. (2008). Among the 5 varieties, the variety WAB224–8–HB produced the highest grain yield (4.73 and 4.40 t ha$^{-1}$) followed by WAB189–B–B–B–8–HB (4.37 and 4.20 t ha$^{-1}$) for both years.

Akram *et al*. (2007) studied on fifteen rice hybrids where two hybrids viz., MK Hybrid 111 and 27P72 produced more productive tillers than KS 282. Allmost all the hybrids produced more number of grains panicle$^{-1}$ and higher 1000 grain weight. Yield advantage of the hybrids over the commercially grown rice variety ranges between 4.59-21.33 % except RH-257 and GNY-40. These two hybrids were low yielder by 4.20 % and 14.95 %, respectively, than the check variety.

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 grain was highest in BRRI dhan38.

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.

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

A pot experiment was conducted by Islam *et al*. (2007) at the BINA, Mymensingh, to find out the growth and yield attributes of mutant rice under varied saline levels. Three rice genotypes viz. Q-31, Y-1281 and MR-219 were used as tests materials. Among the genotypes, MR-219 showed best performance in respect of yield and yield contributing characters such as plant height, number of tiller hill$^{-1}$, effective tillers hill$^{-1}$, panicle length, filled grains panicle$^{-1}$, 1000 grain weight (g), grain yield hill$^{-1}$(g). The genotypes Q-31 and Y-1281 showed its susceptibility to salinity stress. Thus MR–219 was found best salt tolerant genotype than others.

Khan *et al*. (2006) reported that the variety Rachna showed the highest yield of 4009.590 kg ha$^{-1}$ followed by Basmati-385, Shaheen and Super with the production of 3678.983, 2939.257 and 2175.303 kg ha$^{-1}$, respectively. However, the plant height (cm) of Rachna was at 2$^{nd}$ position (125.400 cm) after Basmati-385 at 129.767

cm.The maximum tillers plant$^{-1}$ (18) was obtained by variety Rachna, which significantly differ from variety Super that produced 10 tillers plant$^{-1}$. The maximum spikes plant$^{-1}$18 were shown by variety Rachna and the number of tillers plant$^{-1}$ produced by Rice variety Basmati–385 i.e., 17. The highest yield of Rachna variety was due to the best performance in terms of tillers plant$^{-1}$, spikes plant$^{-1}$ and weight of 1000 grain.

Amin *et al*. (2006) studied on traditional and modern rice cultivars at BSMRAU, Salna, Gazipur. Cultivar KK–4, a high yielding variety out yielded (4772 kg ha$^{-1}$) the indigenous varieties Jharapajam (4150 kg ha$^{-1}$), Lalmota (3628 kg ha$^{-1}$) and Bansful Chikon (3575 kg ha$^{-1}$).

George *et al*. (2005) evaluated the 12 aromatic rice varieties/cultivars where pooled analysis of the yield data indicates that ‘Pusa Basmati-1’ had the highest grain yield of 2777 kg ha$^{-1}$. But it was statistically at par with that of ‘Jeerakasala’ (2743 kg ha$^{-1}$) and IET–12606 (2610 kg ha$^{-1}$), implying the suitability of these three varieties for cultivation in Wayanad district.

Guilani *et al.* (2003) studied on crop yield and yield components of rice cultivars (Anboori, Champa and LD183) in Khusestan, Iran, during 1997. Grains panicle$^{-1}$ was not significantly different among cultivars. The highest grains panicle$^{-1}$ was obtained with Anboori. Grain fertility percentages were different among cultivars. Among the cultivars, LD183 had the highest 1000 grain weight.

BRRI (2000) 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 4.00 t ha$^{-1}$. About 30% higher yield was obtained from the advanced lines over the checks.

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.

BRRI (1998) 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.

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.

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.

Alam *et al.* (1996) conducted an experiment to evaluate the performance of different rice varieties. Among the 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.

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.

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.

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 higher than that of traditional cultivars.

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. Effect of fertilizer managements**

Azarpour *et al.* (2014) studied on yield and physiological traits of three rice cultivars (Khazar, Ali Kazemi and Hashemi) due to the effect of N fertilizer (0, 30, 60, and 90 Kg N $ha^{-1}$). Results of growth analysis indicated that, nitrogen increasing rates of fertilizer caused the increment of growth indexes and yield of rice.

Islam *et al.* (2014) found that application of Sesbania green manure incorporated at 50 DAS in combination with 75% recommended dose of nitrogen could be considered more effective for BINA dhan7 production.

Salahin *et al.* (2013) found that incorporation of *S. aculeata* and deep tillage practice gives the highest yield of agronomic crops (T. aman and maize).

Mo *et al.* (2013) reported that yield formation and growth of "super" rice (Oryza sativa L.) was affected by nitrogen application. The results showed that, N 187.5 kg $ha^{-1}$ had the highest LAI at full heading, which resulted in a significantly high increase in grain yield from 24.19–29.84% and 5.01–6.26% as compared to N 0 and 225 kg $ha^{-1}$, respectively.

Yoseftabar (2013) reported that N fertilizer is a major essential plant nutrient and key input for in increasing crop yield. 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 N $ha^{-1}$ observed high rate of this parameter.

Uddin *et al.* (2013) found that application of nitrogen at 80 kg ha$^{-1}$ produced the highest total spikelets and maximum grains panicle$^{-1}$ resulted in the highest grain yield. Based on the results it may be recommended that nitrogen should be applied at 80 kg for obtaining the higher grain yield of NERICA-1 rice.

Naidu *et al.* (2013) reported that the highest growth, yield attributes, lesser spikelet sterility and higher grain yield were obtained with the application of 100–50–50 kg ha$^{-1}$ N, $P_2O_5$, $K_2O$ and these parameters were at their minimum with the supply of 60–30–30 kg ha$^{-1}$ of N, $P_2O_5$, $K_2O$. The increase in yield with supply of 100–50– 50 kg ha$^{-1}$ N, $P_2O_5$, $K_2O$ ($N_3$), compared to supply of 60–30–30 kg ha$^{-1}$ N, $P_2O_5$, $K_2O$ ($N_1$) was 15.1 and 15.4% respectively during 2006 and 2007, respectively.

Maqsood *et al.* (2013) reported that the nitrogen application at 100 kg ha$^{-1}$ N provided a maximum paddy yield (4.39 and 4.67 t ha$^{-1}$) in both years under the climatic conditions of Faisalabad, Pakistan, higher paddy yield and yield components, as well as greater economic benefits, can be obtained at 100 kg ha$^{-1}$ nitrogen application.

Haque (2013) conducted an experiment to investigate the effect of five nitrogen levels viz. 0, 40, 80, 100 and 140 kg ha$^{-1}$ N and he found the longest plant, highest number of total, effective tillers hill$^{-1}$, grains panicle$^{-1}$, grain and straw yields were observed with 100 kg ha$^{-1}$ N followed by 140 kg ha$^{-1}$ N.

Yoseftabar *et al.* (2012) showed that yield and yield components increased significantly with nitrogen fertilizer. Interesting in comparison to 100 and 200 kg ha$^{-1}$ level application of higher N fertilizer 300 kg ha$^{-1}$ showed a positive respond to application of high nitrogen on hybrid cultivar. Effect of different split application N fertilizer was significantly on parameter of above.

Sharma *et al.* (2012) found that the highest grain yield of 70.60 q ha$^{-1}$ was attained with an application of 180 kg ha$^{-1}$ N. The lowest yield (44.12 q ha$^{-1}$) was recorded in the control plot.

Hasanuzzaman *et al.* (2012) conducted an experiment on growth and yield of rice due to evaluate the effect of N fertilizer (0, 80, 120, 160, 200 kg ha$^{-1}$ N, USG @ 75 kg ha$^{-1}$ N). Results indicated that N had a significant effect on effective tillers hill$^{-1}$, filled grains panicle$^{-1}$ and 1000 grain weight. USG gave the highest effective tillers hill$^{-1}$

(13.63) followed by 120 kg ha$^{-1}$ N (12.11). The highest filled grains panicle$^{-1}$ (154.7) was found from $N_2$ (USG) which was at par with 160 kg ha$^{-1}$ N (145.8), 120 kg ha$^{-1}$ N (145.4) and 200 kg ha$^{-1}$ N (144.1). Application of N created significantly variation in grain yield, straw yield, biological yield and harvest index. USG gave the highest yield (9.42 t ha$^{-1}$) which was followed by 160 kg ha$^{-1}$ N (8.58 t ha$^{-1}$). The increase in yield by the use of USG and 160 kg ha$^{-1}$ N was 76.74% and 60.98%, respectively over the $N_0$ (control).

Alim (2012) reported that the grain and straw yields were increased with the increase of nitrogen rate up to 120 kg ha$^{-1}$ at all the sources. The application of 60 kg N ha$^{-1}$ as urea with 60 kg N ha$^{-1}$ as mustard oil cake (MOC) produced maximum grain and straw yield which was statistically similar to the yield of 50 kg N ha$^{-1}$ as urea with 50 kg N ha$^{-1}$ as MOC. The lowest values were found in control nitrogen application.

Abou-Khalifa (2012) evaluated the 5 rice varieties under different N levels (0, 55, 111, 165 and 220 Kg ha$^{-1}$). Main results induced that maximum tillering, panicle initiation, roots length, heading dates, grains filling rates at five stages, number of tillers m$^{-2}$, 1000 grain weight, number of grains panicle$^{-1}$, panicle length (cm) and grain yield (t ha$^{-1}$) were the highest value at 220 kg ha$^{-1}$ N.

Tasnin (2012) observed that the height of rice plant, number of leaves, number of tillers and dry matter accumulation per hill was significantly higher with application of 50% recommended NPK through fertilizers + 50% N through gliricidia, which was closely followed by 50% recommended NPK through fertilizers + 50% N through FYM. Rice supplied with 50% recommended NPK through fertilizers + 50% N through gliricidia produced higher number of panicles per hill, length of panicles, number of grains and weight of grains per panicle. They also observed that Application of 50% recommended NPK through fertilizers + 50% N through gliricidia, 50% recommended NPK through fertilizers + 50% N through FYM to rice recorded 105.41 and 103.33% higher grain yield compared to that of 100% recommended NPK, respectively, while 50% recommended NPK through fertilizers + 50% N through gliricidia produced higher straw yield of rice followed by 50% FYM substitution.

Deshpande *et al.* (2011) found that combined application of *Sesbania* green manure and nitrogen fertilizer increased the plant height.

Salem *et al.* (2011) reported that the number of tillers hill$^{-1}$, days from sowing up to panicle initiation, heading dates, leaf area index, leaf area ratio, chlorophyll content, 1000 grain weight, panicles length, agronomic efficiency, utilization efficiency and grain yield (t ha$^{-1}$) were increased by increasing nitrogen levels up to 165 kg ha$^{-1}$ N.

Mohaddesi *et al.* (2011) found that the effect of nitrogen fertilizer rates had not significant effects on traits except 1000 grain weight in both seasons. Increasing N fertilizer levels up to 300 kg N ha$^{-1}$ resulted in increases in plant height, grain yield, biological yield but these increases were not significant.

Metwally *et al.* (2011) studied to evaluate the response of Egyptian hybrid rice 1 'H1' to nitrogen fertilizer. Nitrogen levels were 0, 50, 100, 150, 200, 250, 300, 350, and 400 kg N ha$^{-1}$. Nitrogen fertilization significantly increased grain yield. The maximum grain yield was obtained with the application of 200 kg N ha$^{-1}$. Yield components were also significantly affected by N treatments.

Khorshidi *et al.* (2011) reported that the effect of nitrogen fertilizer had no significant difference on 1000 seeds weight and number of grains panicle$^{-1}$. The effect of fertilizers on rice yield showed that application of 100 kg of nitrogen had the highest yield of 5733 kg ha$^{-1}$. Data also indicated that yield had the highest positive correlation with panicle and harvest index.

Karim (2011) studied on the effect of nitrogen fertilizer (0, 20, 40, 60, 80.100 120 kg ha$^{-1}$ N) in respect to high yield and better seed quality. Growth parameters like plant height (114.37 cm) and tillers hill$^{-1}$ (15.1) had higher at higher level of nitrogen. However, plants with moderate level of applied nitrogen showed better yield component of the variety where the highest panicle hill$^{-1}$ (11.8), grains panicle$^{-1}$ (140.5) and filled grains panicle$^{-1}$ (130.33) were recorded with 60 kg ha$^{-1}$ N. Better yield components of the variety obtained at 60 kg N ha$^{-1}$ attributed to the highest yield (4.43 t ha$^{-1}$) of the variety.

Jun *et al.* (2011) conducted an experiment in a rice field with different crop rotation systems and nitrogen application rates, surface water nitrogen content, nitrogen loss via runoff, soil fertility and rice yield were determined. Alfalfa-rice and rye-rice rotation systems enhanced soil nitrogen content, promoted rice nitrogen absorption and significantly improved rice yield.

Fageria *et al.* (2011) reported that yield and yield components were significantly increased in a quadratic fashion with increasing N rate. Based on regression equation, maximum grain yield was achieved with the application of 380 mg $kg^{-1}$ N by ammonium sulfate and 271 mg $kg^{-1}$ N by urea. Grain yield and yield components were reduced at higher rates of urea (>300 mg $kg^{-1}$ N) but these plant parameters' responses to ammonium sulfate at higher rates was constant. In the intermediate N rate range (125 to 275 mg $kg^{-1}$) urea was slightly better compared to ammonium sulfate for grain yield.

Awan *et al.* (2011) carried out an experiment to study the effect of different nitrogen levels (110, 133 and 156 kg $ha^{-1}$) in combination with different row spacing (15 cm, 22.5 cm and 30 cm). Treatment RS2N3, where 156 kg N $ha^{-1}$ were applied with 22.5 cm row to row and plant to plant spacing had maximum values of plant height (79.07 cm), tillers $m^{-2}$ (594), panicle length (25.40 cm), number of grains $panicle^{-1}$ (132.97), grain yield (5.46 t $ha^{-1}$), straw yield (9.66 t $ha^{-1}$) and least value of sterility percentage (5.7 %).

Mizan (2010) reported that the highest plant height (983.32 cm) was obtained form 160 kg N $ha^{-1}$ followed by 120 kg N $ha^{-1}$.

Mannan *et al.* (2010) studied to determine the optimum N level as well as to find out the genotype having high yield potential. The plant height, tiller number, number of panicles, panicle length, spikelet sterility and straw yield increased with the increase of nitrogen levels up to 75 kg $ha^{-1}$ N. Maximum plant growth at the highest level of N caused lodging of plant which increased spikelet sterility and lower grains $panicle^{-1}$ and ultimately decreased grain yield.

Kandil et al. (2010) found that the increasing nitrogen fertilizer levels up to 80 kg $ha^{-1}$ N resulted in marked increases in number of tillers $m^{-2}$, panicle length, panicle weight, filled grains $panicles^{-1}$, 1000 grain weight, grain and straw yields $ha^{-2}$ and harvest index in both seasons. The addition of 144 or 192 kg $ha^{-1}$ N recorded the tallest plants and the highest number of panicles $m^{-2}$ without significant differences.

Hoshain (2010) observed that no. of effective tiller, no. of grains panicle$^{-1}$, grain yield and straw yield were significantly increased with the increasing rates of N 120 Kg ha$^{-1}$ as urea where harvest index increased from up to N 80 Kg ha$^{-1}$ application.

Salahuddin *et al.* (2009) found gradual increase in panicle length (24.50 cm), grains panicle$^{-1}$ (110) and grain yield (4.91 t ha$^{-1}$) due to the increase in nitrogen levels up to 150 kg ha$^{-1}$ and declined thereafter. 1000 grain weight was not significantly influenced by application of different levels of nitrogen.

Hao *et al.* (2009) conducted an experiment on the effects of P fertilizer level on distribution of Fe, Mn, Cu and Zn and brown rice qualities in rice (*Oryza sativa* L.) observed that the protein content of brown rice increased, amylose content decreased, gel consistency elongated, and the nutritional quality improved if additional P fertilizer was applied.

Islam *et al.* (2009b) found significant variation on morphophysiological attributes of BINA dhan5, Tainan 3 and BINA dhan6 due to four N levels. Plant height, tillers hill$^{-1}$, LA hill$^{-1}$ (cm$^2$) were increased with the split application of N. Among the treatments, $T_4$(full doze of urea at three equal splits, 1/3at 15 DAT + 1/3at 30 DAT + 1/3at 55 DAT showed the best performance and grain yield (45.25 g hill$^{-1}$) compared to control (30.61 g hill$^{-1}$). Full dose of urea (215 kg ha$^{-1}$ urea) applied at three equal split at 15, 30 and 55 DAT was found to be the most beneficial one for the all the rice genotypes.

Hossain *et al.* (2008) reported that different nitrogen rates also significantly affected the aromatic rice cultivars. All the yield components were significantly increased up to 90 kg ha$^{-1}$ N. Nonetheless, maximum grain yield (3.62 t ha$^{-1}$) was observed from 60 kg ha$^{-1}$ N.

Manzoor *et al.* (2008) stated that increased grain yield of rice with split applying of potash in $T_5$ ( ½ potash applied at 25 DAT and remaining ½ at 45 DAT)may be due to continuous supply of K to crop during crop growth stages. The efficient potash uptake by rice plant results in better growth and development when applied at maximum tillering stage (25 DAT) and at panicle initiation stage (45 DAT).

Nori *et al.* (2008) studied to assess the grain yield and straw nutritive quality of MR 211 and MR 219 rice varieties due to five nitrogen rates (0, 120, 160, 200 and 240 kg $ha^{-1}$ N). Increases in nitrogen application was found to increase ($P<0.01$) the grain yield, total spikelets $m^{-2}$, spikelets $panicle^{-1}$ and straw crude protein from 4.56% to a maximum level of 8.45%.

Islam *et al.* (2008) conducted a field experiment found that the application of N fertilizer significantly influenced the plant height, number of tillers, effective tillers, panicle length, grains $panicle^{-1}$ and grain yield. The highest grain yield 4.27 t $ha^{-1}$ was recorded with the $N_4$ (100 kg $ha^{-1}$ N).

Hossain *et al.* (2007b) reported that the N levels also exerted significant effect on all the yield parameters, except for panicle length and 1000 grain weight. The highest grain yield was obtained from the application of 75 kg $ha^{-1}$ of the recommended dose of N and the lowest from the control treatment (0 kg $ha^{-1}$) of rice cv. BRRI dhan32.

Hossain *et al.* (2007a) reported that the greatest plant height and highest number of tillers $hill^{-1}$ were observed with the application of 69 kg $ha^{-1}$ N, which was significantly followed by 51.75, 34.5 and 17.25 kg $ha^{-1}$ N, respectively and the lowest was observed in control treatment (0 kg $ha^{-1}$ N).

Abbasi *et al.* (2007) found that the highest number of fertile tiller was obtained in the fifth and sixth treatments with double and triple split application of 120 kg $ha^{-1}$ N. They suggested that triple split application of 80 kg $ha^{-1}$ N could be best for rice production.

Manzoor *et al.* (2006) evaluated the nine different nitrogen levels i.e. 0, 50, 75, 100, 125, 150, 175, 200 and 225 kg $ha^{-1}$ for observing the field performance of rice. Plant height, productive tillers $hill^{-1}$, panicle length, grains $panicle^{-1}$, 1000 grain weight and paddy yield showed increasing trend from 0 kg $ha^{-1}$ N up to 175 kg $ha^{-1}$ N. The yield parameters including rice yield, grains $panicle^{-1}$ and 1000 grain weight started declining at 200 kg N $ha^{-1}$ level and above. Maximum rice yield (4.24 t $ha^{-1}$) was obtained from 175 kg $ha^{-1}$ nitrogen application treatment which also produced highest values of grains $panicle^{-1}$ (130.2) along with a maximum 1000 grain weight (22.92 gm). The plant height (139.8 cm) along with productive tillers $hill^{-1}$ (23.42) and panicle length (29.75 cm) was the maximum at 225 kg N $ha^{-1}$.

Dwivedi *et al.* (2006) conducted a field experiment on growth and yield of rice to evaluate the effect of N level. They found that 184.07 kg $ha^{-1}$ N (urea) was the optimum rate for highest yield.

Amin *et al.* (2006) found significant variation on growth, tillering and yield of three traditional rice varieties due to variable doses of N fertilizer compared with that of a modern variety at BSMRAU, Salna, Gazipur. Application of 60 kg $ha^{-1}$ N produced more TDM and lesser ineffective tillers. Application of 30 kg $ha^{-1}$ N appropriate for low responsive traditional varieties produced the highest yield (4451 kg $ha^{-1}$).

Mishra *et al.* (2006) are strongly supported by finding of other studies that GM legumes increased crop yields and improved soil organic fertility.

Hossain *et al.* (2005) carried out a study to assess the effects of nitrogen (30, 60, 90 and 120 kg $ha^{-1}$ N) and phosphorus (20, 40 and 60 kg $ha^{-1}$ $P_20_5$) on the growth and yield of rice/sorghum inter-crop. Application of nitrogen up to 90 kg $ha^{-1}$ enhanced the growth and yield of rice crop and application of phosphorus @ 40 kg $ha^{-1}$ $P_2O_5$ resulted in higher growth and yield of rice crop.

Rahman *et al.* (2005) reported that recommended 100% dose of N increasing the highest grain yield (4.80 t $ha^{-1}$) which was as par with 75% recommended dose of N producing 4.75 t $ha^{-1}$ grain.

Naik and Paryani (2005) reported that the plant height and grain yield were increased with application of N up to 150 kg $ha^{-1}$. The highest number of grains $panicle^{-1}$ (157.9), yield of grains (64.4 q $ha^{-1}$) and straw (94.4 q $ha^{-1}$) were produced significantly from rice hybrids PHB -71.

Muhammad *et al.* (2005) reported that the highest number of plant height (116.55 cm), number of spikelets $panicle^{-1}$ (118.85) and straw yield (11.00 t $ha^{-1}$) were obtained from 150 kg $ha^{-1}$ urea.

Mashkar and Thorat (2005) conducted a field experiment to study the effects of different nitrogen levels (0, 40, 80 and 120 kg $ha^{-1}$ N, respectively) on N, P and K uptake and grain yield of scented rice cultivars (Pula Basmati 1, Kasturi, Indrayani and Sugandha). The different levels of N had significant effect in augmenting the uptake of N, P and K nutrients and grains as well as straw yield of rice. Application of 120 kg $ha^{-1}$ N recorded significantly higher N, P and K uptake in rice compared to the rest of the N levels. Every increment of 40 kg $ha^{-1}$ N from 0 to120 kg $ha^{-1}$ N increased the nutrient content and uptakes.

Sidhu *et al.* (2004) reported that nitrogen fertilizers substantially increased the mean grain yield of Basmati up to 40 kg $ha^{-1}$ N in the fallow Basmati-wheat Sequence while 60 kg $ha^{-1}$ N reduced Basmati yield. Compared to the treatment No, the mean grain yield of Basmati was increased by 0.31, 0.40 t $ha^{-1}$ at doses of 20 and 40 kg N $ha^{-1}$. Subhendu *et al*. (2003) conducted a field experiment during kharif season at Hyderabad, India. They found that application of N 120 kg $ha^{-1}$ as urea in equal splits during transplanting, tillering, panicle initiation and 50% of flowering resulted in the highest 1000 grain weight (22.57 g).

Singh and Shivay (2003) evaluated that increasing level of N significantly increased the number of tillers $hill^{-1}$.

Mondal and Swamy (2003) observed that highest harvest index by applying N (120 kg $ha^{-1}$) as urea in equal splits during transplanting, tillering, panicle initiation and flowering.

Sarrantonio *et al.* (2003) found that green manure or cover crops have been shown to improve soil chemical and physical properties.

Lawal and Lawal (2002) found that grain yield of rice significantly increased by 80 kg $ha^{-1}$ N (urea) application.

Bayan and kandasamy (2002) observed that effective tiller $hill^{-1}$ was significantly affected by the level of N and recommended doses of N (Urea) in four splits at 10 days after sowing, active tillering, panicle initiation and at heading stages recorded significantly lower dry weight of weeds and increased crop growth viz., effective tillers $m^{-2}$.

Duhan *et al.* (2002) who found increased N uptake of rice with application of green manure along with N fertilizer.

Dekamedhi and Medhi (2000) reported that grain yield of rice was significantly increased due to application of green manure in combination with N fertilizer.

Yadvinder-Singh *et al.* (1991) observed green manures are the crops which are returned into the soil in order to improve the growth of subsequent crops. Green manures offer considerable potential as a source of plant nutrients and organic matter.

Ghai and Thomas ( 1989) showed that green manure (*Sesbania aculeate*) are fast growing leguminous plants cultivated annually and can accumulate more than 80 kg $ha^{-1}$ N when grown as green manures.

Antil *et al.* (1988) studied that the grain and straw yield of rice were significantly higher after application of green manure of dhaincha and moong compared to fallow and maize. The beneficial effect of green manure was mainly due to steady release of nitrogen during crop season.

Kolar and Grewal (1988) examined that burying sesbania, cowpea and sunnhemp resulted in significant increase in grain and straw yield of rice.

Jamdade and Ramteke (1986) monitored that incorporation of dhaincha and gliricidia increased the number of tillers, dry matter accumulation, number of panicles, thousand grain weight, number of filled grains per panicle as compared to no green manure, which in turn produced the highest grain yield of 52.12 and 52.09 q $ha^{-1}$, respectively.

Khind *et al.* (1983) spotted that, when 30, 45 and 60 days old crop with dhaincha (*Sesbania aculeata*) incorporated one day before transplanting of rice the amount of green matter, dry matter accumulation and nitrogen added increased progressively with the increase in age of dhaincha. The increase in the yield with the incorporation of 60 days old dhaincha was equivalent to those obtained with application of 120 kg $ha^{-1}$ N through urea.

Rinaud *et al.* ( 1983) reports that application of chemical N fertilizer (treatment 3**)** increased the grain yield by 169 g $m^{-2}$ (1.69 t $ha^{-1}$), whereas incorporating ***S.*** *rostrata* as green manure resulted in a grain yield increase of 372 g $m^{-2}$ (3.72 t $ha^{-1}$). $N_2$ fixed by *S. rostrata* was estimated to be at least 26.7 g $m^{-2}$ (267 kg N $ha^{-1}$), one third being transferred to the crop and two thirds to the soil.

Dreyfus *et al.* (1981) have found that *Sesbania rostrata,* a tropical legume which colonizes waterlogged soils in the Sénégal Valley, forms N-fixing nodules with *Rhizobiurn* on both the roots and the stem.

Bhardwaj *et al.* (1981) showed that green manuring of sunnhemp, dhaincha and *Ipomea carnea* @ 15 t $ha^{-1}$ in combination with 0, 30, 60, 90 kg $ha^{-1}$ N increased the number of tillers $m^{-2}$ and dry matter accumulation. They also marked that the incorporation of *Crotalaria juncea* and *Sesbania canabina* significantly increased the grain yield of rice on irrigated land. The prediction equation perceived that there was saving of 49.9 and 23.3 kg $ha^{-1}$ N by green manure with *Crotalaria juncea* and *Sesbania canabina*, respectively.

Jha *et al.* (1980) noted that application of green manure @ 5-10 t $ha^{-1}$ was very useful for improving the growth rate. They reported that application of green manure (*Ipomea cornea*) was very useful for improving the grain and straw yields of rice through increased number of ear bearing tillers $m^{-2}$.

Tiwari *et al.* (1980) opined that application of green manure was very useful for improving the grain and straw yield through increased number of ear bearing tillers.

Reddy *et al.* (1972) found that application of gliricidia green manure @ 7.5 or 15 t $ha^{-1}$ + 120 kg N, 60 kg $P_2O_5$ and 60 kg $ha^{-1}$ $K_2O$ significantly increased plant height, number of tillers, filled grains per panicle of rice over control. The response to the addition of green leaf manure was quadratic.

## 2.3. Interaction effect of variety and fertilizer management

Shaha (2014) reported that the different rates of cowdung with inorganic fertilizers showed significant effect on all growth parameters viz. plant height and tillers $hill^{-1}$. Among the cowdung levels with BRRI RD of inorganic fertilizers, highest grain yield (5.62 t $ha^{-1}$) was obtained from cowdung 7.5 t $ha^{-1}$ with inorganic fertilizers and lowest (5.07 t $ha^{-1}$) was recorded in control. Similarly, the highest grain yield (6.25 t $ha^{-1}$) was obtained from the treatment combination of (BR11 and cowdung 7.5 t $ha^{-1}$)

with inorganic fertilizers which was statistically identical with all BR11 in cowdung treated plot.

Sarkar (2014) found that the application of 75% RD of inorganic fertilizers + 50% cowdung showed superiority in terms of plant height (123.3 cm) and total tillers hill$^{-1}$ (13.87) where those were also highest in combination of BRRI dhan34 × 75% RD of inorganic fertilizers + 50% cowdung. Nutrient management of 75% RD of inorganic fertilizers + 50% cowdung (5 t ha$^{-1}$) gave the highest grain yield (3.97 t ha$^{-1}$) and the lowest grain yield (2.87 t ha$^{-1}$) was found in control. The highest grain yield (4.18 t ha$^{-1}$) was found in BRRI dhan34 coupled with 75% RD of inorganic fertilizers + 50% cowdung and the lowest grain yield (2.7 t ha$^{-1}$ ) was found in BRRI dhan37 in control.

Liza *et al*. (2014) found that the treatment $T_6$ (50% RFD + residual effect of CD 2.5 t ha$^{-1}$, PM 1.5 t ha$^{-1}$, and Com. 2.5 t ha$^{-1}$) produced the highest grain yield (6.87 t ha$^{-1}$) and straw yield (7.24 t ha$^{-1}$). The lowest grain yield (3.22 t ha$^{-1}$) and straw yield (4.55 t ha$^{-1}$) were found in $T_0$. Treatment $T_6$ receiving 50% RFD along with the residual effect of 2.5 t ha$^{-1}$ cowdung, 1.5 t ha$^{-1}$ poultry manure and 2.5 t ha$^{-1}$ compost was found to be the best combination of organic and inorganic nitrogen for obtaining the maximum yield of BRRI dhan29 and nutrient content and uptake by grain and straw.

Islam *et al*. (2014) found that the yield contributing characters like plant height, effective tillers hill$^{-1}$, panicle length and grains panicle$^{-1}$ of BRRI dhan49 were significantly influenced by the application of manures and fertilizers. The highest grain yield of 4.87 t ha$^{-1}$ was observed in the treatment $T_3$ [PM + STB–CF (HYG)] and the lowest value of 3.61 t ha$^{-1}$ was found in $T_0$. The straw yield ranged from 4.10 to 5.51 t ha$^{-1}$ in different treatments. The NPKS uptake by BRRI dhan49 was markedly influenced by manures and fertilizers. Based on overall results, the treatment $T_3$ [PM + STB–CF (HYG)] was found to be the best combination of manures and fertilizers for obtaining the maximum yield and quality of rice.

Hasan (2014) showed that the treatment $T_6$ (5 t CD + USG @ 78 kg ha$^{-1}$ N) produced the highest grain yield of 5.56 t ha$^{-1}$ and straw yield was highest (5.95 t ha$^{-1}$) in treatment $T_1$. The treatment $T_6$ also showed highest (23 kg grain kg$^{-1}$ N applied) N use efficiency. The N, P and K uptake by BRRI dhan32 rice were influenced profoundly due to the application of USG alone or in combination with cowdung. USG application generated available $NH_4$-N and $NO_3$-N slowly over the entire growth period; indicating a beneficial role of USG. The overall results indicate that application of USG in combination with cowdung could be considered more effective in rice production for reducing N losses, conserving N and increasing the efficiency of applied N.

Islam *et al*. (2013) studied to evaluate the effect of nitrogen supplied from organic sources (cowdung, poultry manure and compost) and inorganic source (urea) on the yield and nitrogen use efficiency of BRRI dhan28. The treatments were $T_0$ (Control), $T_1$ (100% N from RFD), $T_2$ (70% N from RFD, RFD + 30% N from CD), $T_3$ (70% N from RFD + 30% N from PM), $T_4$ (70% N from RFD + 30% N from CoM), $T_5$ [70% N from RFD + 30% N from (CD + PM + CoM)], $T_6$ [100% N from (CD + PM + CoM), $T_7$ [100% N from RFD + 30% N from (CD + PM + CoM)]. The highest grain yield of 5847 kg ha$^{-1}$ was observed in the treatment $T_7$ and the lowest grain yield of 2426 kg ha$^{-1}$ was found in $T_0$. The highest N uptake (138.9 kg ha$^{-1}$) was found in $T_7$ followed by $T_1$ (119.8 kg ha$^{-1}$). The highest nitrogen use efficiency was observed in $T_6$ and the lowest value was noted in $T_5$.

Rifat-E-Mahbuba (2013) found that the Application of N as PU, USG alone or in combination with cowdung significantly increased yield components, grain and straw yields of BRRI dhan28 rice. The treatment $T_3$ (78 kg N ha$^{-1}$ from USG) produced the highest grain yield of 5.85 t ha$^{-1}$ and straw yield of 5.50 t ha$^{-1}$ due to the treatment $T_6$. The treatment $T_2$ (104 kg N ha$^{-1}$ from USG) performed better than $T_1$ and $T_4$, indicating the superiority of USG over PU. The N, P and K uptake by BRRI dhan28 rice were influenced profoundly due to the application of USG alone or in combination with cowdung. The overall results indicate that application of USG in combination with cowdung could be considered more effective in rice production.

Haque (2013) evaluated the use of manures and fertilizers for maximizing the growth and yield of BRRI dhan28. The maximum grain yield of 5651 kg ha$^{-1}$ and straw yield of 6572 kg ha$^{-1}$ were recorded in $T_3$ [ (PM) + STB–CF]. The lowest grain and straw yields were found for $T_0$. The NPKS content and uptake by BRRI dhan28 were also influenced significantly due to integrated use of manures and fertilizers.

Fakhrul Islam *et al*. (2013) studied the fertilizer and manure effect on the growth, yield and nutrient concentration of BRRI dhan28 at Sher–e–Bangla Agricultural University research farm, Dhaka. The $T_5$ (50% RDCF + 4 ton PM $ha^{-1}$) showed the highest effective tillers $hill^{-1}$, plant height, panicle length, 1000 grain wt., grain yield (5.92 kg $plot^{-1}$) and straw yield (5.91 kg $plot^{-1}$ ). The higher grain and straw yields were obtained organic manure plus inorganic fertilizers than full dose of chemical fertilizer and manure.

Dey (2012) found that the highest grain (6.20 t $ha^{-1}$) and straw yields (7.75 t $ha^{-1}$) were produced by the $T_7$ (USG at transplanting + 50% PKS at transplanting + 50% PKS at maximum tillering) treatment. The P, K and S uptake by BRRI dhan29 significantly increased due to split fertilization. So, split application of P, K and S fertilizers along with USG exerted a beneficial effect on yield contributing characters, resulting in higher grain and straw yields for BRRI dhan29 as compared to their single application.

Basu *et al*. (2012) conducted a field experiment to study the quality aspect of rice (cv. BRRI dhan28) as response to chemical fertilizers and organic manure (cowdung) treatments comprised of four doses of chemical fertilizers (0, 0.5, 0.75 and full recommended dose) and four cowdung doses (0, 1.0, 1.5, two times of full recommended dose). The grain yield ranged from 1.92 to 4.58 t $ha^{-1}$. The highest grain yield was observed in treatment containing the full recommended dose of chemical fertilizers along with the double dose of cowdung ($F_1M_3$) and it was the lowest in without chemical fertilizers and recommended dose of cowdung ($F_0M_1$). Application of cowdung and chemical fertilizers had significant effect on the content of N, P, K, S, Ca, Mg, B, Zn, protein, starch and amylose in rice grain. Grain yield of rice was increased by application of half the recommended dose of chemical fertilizers along with recommended dose of cowdung.

Rashid *et al*. (2011) examine the effect of urea– nitrogen, cowdung, poultry manure and urban wastes on growth and yield of transplant Boro rice, cv. BRRI Dhan29. Among the treatments, $T_6$ ($N_{50}$ + $PM_{50}$) produced 43.39% higher number of effective tiller $hill^{-1}$ than control treatment. Application of 47.5 kg N along with 9.5 t poultry manure $ha^{-1}$ produced the maximum panicle length (27.03 cm) with an increase of 18.03 percent over control treatment. Treatment $T_6$ further produced the maximum number of filled grains panicle$^{-1}$(121), highest weight of 1000 grain (29.30 g), maximum grain yield (5.54 t ha$^{-1}$) and maximum straw yield (5.89 t ha$^{-1}$). The lowest number of filled grainspanicle$^{-1}$ (89), lowest weight of 1000 grain (21.17 g), lowest grain yield (3.06 t ha$^{-1}$) and the lowest straw yield (3.39 t ha$^{-1}$) was noted in control treatment.

Qian *et al*. (2011) conducted an experiment to see the effects of organic manure application on rice yield and soil fertility. Results revealed that organic manure application combined with chemical fertilizers treatments were 65.4%–71.5% ($P<0.05$) higher than CK, and 3.9%–7.8% ($P<0.05$) higher than NPK treatment in yield. Rice yield of 30F+ 70M treatment was the highest in all treatments.

Hossaen *et al*. (2011) studied on the yield and yield attributes of Boro Rice due different organic manure and inorganic fertilizer. At 30, 50, 70, 90 DAT and at harvest stage the tallest plant (24.18, 31.34, 44.67, 67.05 and 89.00 cm) and the greatest number of total tillers hill$^{-1}$(5.43, 11.64, 21.01 and 17.90) at same DAT was recorded from $T_5$ (70% NPKS +2.4 t PM ha$^{-1}$) and the lowest was observed from $T_0$ (control) in every aspect. The maximum number of effective tillers hill$^{-1}$(13.52), the longest panicle (24.59 cm), maximum number of total grains plant$^{-1}$(97.45), the highest weight of 1000 seed (21.80 g), the maximum grain yield (7.30 t ha$^{-1}$) and straw yield (7.64 t ha$^{-1}$) was recorded from $T_5$ treatment whereas the lowest number of effective tillers hill$^{-1}$(6.07), the shortest panicle (16.45 cm) , the minimum total grains plant$^{-1}$ (69.13) , the lowest weight of 1000 seed (16.73 g), the lowest grain yield (2.06 t ha$^{-1}$) and straw yield (4.63 t ha$^{-1}$) was observed from $T_0$. Treatment $T_5$ also showed the highest biological yield and harvest index.

Akter (2011) found that the treatment $T_4$ (75% Urea+ 25% N from poultry manure, 2.9 tha$^{-1}$) produced the highest grain yield of 6334 kg ha$^{-1}$and straw yield of 8175 kg ha$^{-1}$. The lowest grain and straw yields (3112 and 3489 kg ha$^{-1}$, respectively) were found in control when no nitrogen was not applied from either fertilizers or manures Further, the treatment $T_7$ (100% Urea+2.0 t ha$^{-1}$ poultry manure) performed better than $T_2$, $T_3$, $T_5$ and T6indicating the superiority of poultry manure over cowdung and compost. The N, P, K and S contents and uptake by BRRI dhan29 were profoundly influenced due to application of Urea in combination with cowdung, compost and poultry manure.

Yaqub *et al*. (2010) conducted an experiment on a traditional approach to deal with the declining yields of rice-wheat system. Results showed that averaged across Urea treatments, manuring significantly increased the number of tillers plant$^{-1}$ (11% increases), rice grain yield (6% increase), grain N content (4% increase) and grain N uptake (9% increase).

Kumari *et al*. (2010) reported that the Birsamati rice grown with RD of inorganic fertilizer produced 20.09% higher grain yield when compared with the best organic source combination of green manuring (GM) @ 5 t ha$^{-1}$ + FYM @ 10 t ha$^{-1}$ (3.3 t ha$^{-1}$). The yield attributing characters also followed the trend of grain yield. Similarly, the uptake of N, P and K by rice grown with fertilizers was 31.69%, 25.98%, and 23.74% higher than GM + FYM. The maximum available N (277 kg ha$^{-1}$) and minimum N loss (3 kg ha$^{-1}$) was recorded from the plots that received GM 5 t ha$^{-1}$ + BGA 10 kg ha$^{-1}$ + *Azotobacter* @ 500 g ha$^{-1}$. Similarly maximum available P (24.7 kg ha$^{-1}$) and maximum gain in soil P (0.7 kg ha$^{-1}$), was recorded with the application of Karanjcake (KC) 2.5 t ha$^{-1}$. However, maximum available K (202 kg ha$^{-1}$) and maximum gain in soil K (2.0 kg ha$^{-1}$) was recorded from the plot receiving GM 5 t ha$^{-1}$ + PS 10 t ha$^{-1}$. Among organic sources, GM + FYM fetched significantly higher B:C (2.61) when compared with rest of the organic sources under test.

Hossain *et al*. (2010) conducted an experiment to evaluate the effect of Urea, poultry manure (PM) and cowdung (CD) on the nutrient content and uptake by BRRI dhan29. The experiment was laid out in a RCBD with eight treatments in three replications. Application of poultry manure, cowdung and Urea significantly influenced the yield and yield components of BRRI dhan29 and N, P, K and S contents and uptake. The overall results indicate that application of PM @ 3 t ha$^{-1}$ in combination with N 100 kg ha$^{-1}$ can reduce the use of N fertilizer at a substantial level. The findings of the study suggest that integrated use of manure and fertilizer is more important for sustainable production of BRRI dhan29.

Hoshain (2010) conducted an experiment to investigate the effect of cowdung and nitrogen on rice cv. BRRI dhan50. He showed that highest number of effective tillers hill$^{-1}$, number of grains panicle$^{-1}$, grain yield (6.13 t ha$^{-1}$) and biological yield were obtained from the combination of 6 t ha$^{-1}$ cowdung with 120 kg N ha$^{-1}$.

Saha *et al*. (2009) conducted a field trial to validate some fertilizer application approaches for Boro Green manure (GM). Application of cowdung (CD) @ 6 t ha$^{-1}$ (at 15 % moisture) along with integrated plant nutrient system (IPNS) based chemical fertilizer with reduced doses of chemical fertilizer (60% N, 50% P, 50% K, and 50% S) substantially increased grain yield .The N uptake was in excess of the N added as fertilizer with an improved balance of P, S, and Zn was observed.

Rahman *et al*. (2009) reported that the Chola Boro and Sada Boro are two local land races having potentials for producing higher effective tillers and higher 1000 GW. Sada Boro and Chola Boro, two local cultivars were found very high in grain N content compared to other test cultivars. These two cultivars could be a nice tool for rice breeder to develop high nitrogen content rice. Chola Boro, Iratom24 and BR14 are three high straw K containing varieties having breeding potentials to make our future rice plant strong.

Nyalemegbe *et al*. (2009) reported that the cowdung (CD) and poultry manure (PM) were separately applied to the soil at 20 t ha$^{-1}$ solely and also 5, 10 and 15 t ha$^{-1}$, in combination with Urea fertilizer at 90, 60 and 30 kg ha$^{-1}$, respectively. Other treatments included a control and Urea fertilizer at 30, 60, 90 and 120 kg ha$^{-1}$. The application of 10 t ha$^{-1}$ CD and urea fertilizer (at 45 kg ha$^{-1}$ N) and 10 t ha$^{-1}$ PM and urea (at 60 kg ha$^{-1}$ N) both gave paddy yields of 4.7 t ha$^{-1}$, which did not differ significantly from the yield of 5.3 t ha$^{-1}$, obtained under the recommended inorganic nitrogen fertilizer application of 90 kg ha$^{-1}$ N.

Islam (2008) showed that the highest plant height (109.49 cm), number of effective tillers hill$^{-1}$ (9.43), number of total tillers hill$^{-1}$ (13.33), grain yield (6.13 t ha$^{-1}$) and harvest index (46.04%) were obtained from the combination of 50% recommended fertilizer with 5 t ha$^{-1}$ cowdung.

Aziz (2008) reported that effective tillers hill$^{-1}$, panicle length, 1000–grain weight and grain yield were highest in 15 t ha$^{-1}$ cowdung application.

Singh *et al*. (2006) conducted an experiment to evaluate the effects of chemical fertilizer (urea), cowdung and biofertilizer (*Azospirillum*) on the yield of rice and physicochemical properties of the soil. Application of chemical fertilizer, cowdung and *Azospirillum*, individually or in combinations, significantly increased the yield attributes (plant height, number of tillers, panicle length, grain yield and straw yield) over the control. The treatment comprising 80 kg N ha$^{-1}$ + *Azospirillum* + 2.5 t cowdung ha$^{-1}$ was superior over all other treatments in terms of rice yield.

Mobasser *et al*. (2005) reported that plant height, number of panicle m$^{-2}$ , grain yield were significantly higher in cowdung treated plots compared with the unfertilized control.

Brahmacharrii *et al*. (2005) conducted a field experiment to evaluate the productivity and quality development of rice (cv. IET-4094) under irrigated condition on Entisol type of new alluvial soil. They reported that the productivity of rice was maximum when this crop in sequence received both organic and inorganic sources of nutrients ($N_{40}P_{20}K_{30}$ + FYM at 10 t ha$^{-1}$). In the experiment the relationship of K content of rice plants with hulling percentage, milling percentage of grain was significantly positive.

Saleque *et al*. (2004) studied with six treatments viz. absolute control ($T_1$), 1/3 of RFD ($T_2$), 2/3 of RD ($T_3$), full doses of RF ($T_4$), $T_2$ + 5 t cowdung and 2.5 t ash ha$^{-1}$ ($T_5$) and $T_3$ + 5 t cowdung ha$^{-1}$ + 2.5 t ash ha$^{-1}$ ($T_6$) were compared. The results showed that application of cowdung and ash ($T_5$ and $T_6$) increased rice yield by about 1 t ha$^{-1}$ year$^{-1}$ over that obtained with chemical fertilizer alone.

Jha *et al*. (2004) observed that 50: 40:30 kg NPK ha$^{-1}$ + 3 t cowdung and urea mixture ha$^{-1}$ produced significantly higher plant height, number of effective tiller hill$^{-1}$ and grain yield. Gowda *et al*. (2004) reported that plant height of Phalguna variety was highest due to application of 10 t ha$^{-1}$ and 15 t ha$^{-1}$ cowdung than Jaya variety of rice.

Yaduvanshi (2003) reported that the application of NPK and its combination with green manuring and FYM increased the rice yield significantly. Fertilizers (120 kg N, 26 kg P, 42 kg K ha$^{-1}$) and it's combined use with green manure or 10 t ha$^{-1}$ FYM and 150% significantly higher (3119 and 3956 kg ha$^{-1}$ , respectively) to other treatments which received NPK fertilizers.

Usman *et al*. (2003) reported that rice produced maximum number of tillers hill$^{-1}$ and grain yield from application of organic fertilizer 10 t ha$^{-1}$ + manure 20 t ha$^{-1}$.

Mishra *et al*. (2003) recorded data for number of effective tillers $hill^{-1}$, panicle length, panicle weight, number of spikelets $panicle^{-1}$, number of fertile spikelets $panicle^{-1}$, sterility percentage, 1000 grain weight, grain yield and straw yield. Among the treatments, 75% recommended N blended within cowdung urine and 1000 ppm Cycocel (chormequat) gave the highest pooled grain yield (85.24 and 76.54 q $ha^{-1}$, respectively). While 75% recommended N+25%farmyard manure and 1000 ppm Cycocel (chormequat) gave the highest straw yield (117.28 and 107.95 q $ha^{-1}$, respectively).

Vanaja and Raju (2002) conducted a field experiment for one year during 1996-97, in sandy loam soil having pH of 8.4 at Student's Farm College of Agriculture, Hyderabad. Organic manures (FYM, poultry manure) and biofertilizers (BGA, *Azospirillum*) alone and in combination with inorganic fertilizer nitrogen were studied on rice crop. The relationship between total dry matter production at maturity and total uptake of nutrients (N, P and K) was highly significant.

Lawal and Lawal (2002) conducted an experiment to evaluate the growth and yield of low land rice during rainy season in Nigeria to varying cowdung rates and placement method of fertilizer and showed that 1000 grain weight was significantly increased.

Abro *et al*. (2002) carried out an experiment and showed that highest plant height and highest number of tiller $hill^{-1}$ were produced from 15 t $ha^{-1}$ cowdung + green manure with rice and lowest from the control.

Saitoh *et al*. (2001) conducted an experiment on the growth and yield of rice to evaluate the effect of organic fertilizer (cowdung and chicken manure) and pesticide. They found that yield of organic manure and pesticide treated free plots were 10% lower than that of chemical fertilizer and pesticide treated plots due to a decrease in the number of panicle.

Raju and Reddy (2000) was carried out a field experiment in both rainy and winter seasons at Maruteru, Andhra Pradesh, India to determine the effect of integrated nutrient supply system in rice (Oryza sativa)–rice system of coastal ecosystems. There were 12 treatments used in the experiment, 4 treatments of different levels of recommended fertilizers in rainy and winter seasons and 6 treatments of integration of chemical fertilizers with organic sources. They found that application of organic matter along with chemical N to rainy season rice reduced the 25% N fertilizer.

# 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, green manure and fertilizer application, uprooting of seedlings, intercultural operations, data collection and statistical analysis.

## 3.1. Location

The field experiment was conducted at the Agronomy field of Sher-e-Bangla Agricultural University, Dhaka during the period from July to December, 2014. 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-calcareous 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 two factors as mentioned below:

**Factor A: Varieties (3)**

- $V_1$ = Kataribhog
- $V_2$ = Raniselute
- $V_3$ = BRRI dhan34

**Factor B: Fertilizer management (6 levels)**

- $T_1$= Recommended doses of NPKSZn
- $T_2$= 80% recommended doses of NPKSZn + Green Manure 3.5 ton $ha^{-1}$
- $T_3$= 60% recommended doses of NPKSZn + Green Manure 7 ton $ha^{-1}$
- $T_4$= 40% recommended doses of NPKSZn + Green Manure 10.5 ton $ha^{-1}$
- $T_5$= 20% recommended doses of NPKSZn + Green Manure 14 ton $ha^{-1}$
- $T_6$= Green Manure 17.5 ton $ha^{-1}$

### 3.5. Plant materials

Rice cv. Kataribhog, Raniselute and BRRI dhan34 were used as plant materials for the present study. These varieties are recommended for Aman season. All of the variety had photo sensitivity and well known for their characteristic aroma.

### 3.6. Design and layout

The experiment was laid out in a split-plot design with three replications. The size of the individual plot was 3 m x 2 m and total numbers of plots were 54. Varieties were assigned to the main plots and fertilizer management to the sub-plots. There were 18 treatment combinations. The blocks and unit plots were separated by 1.0 m and 0.50 m spacing, respectively (Appendix IV).

### 3.7. Seed collection, sprouting and sowing

Seed were collected from syedpur upazilla, Dinajpur and dumuria upzilla, Khulna and Bangladesh Rice Research Institute (BRRI), Joydebpur, Gazipur. 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, 2014. Seed bed size was 10 m long and 1.5 m wide.

### 3.8. 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 transplanting.

### 3.9. Green manure and fertilizer application

The green manures (Dhaincha) are uprooted before flowering and chopped into small parts and then directly incorporated into the soil of the field before transplanting.

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.

### 3.10. 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, 2014. 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, 2014 by using two seedlings $hill^{-1}$.

### 3.11. Intercultural operations

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

### 3.11.1. Gap filling

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

### 3.11.2 Weeding

Three weeding were done on 10, 30 and 45 days after transplanting to keep the crops free from weeds.

### 3.11.3 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.

### 3.11.4. Plant protection measures

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

## 3.12. 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.

## 3.13. 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.

### 3.14. Collection of data

**A. Crop growth characters**

1. Plant height (cm) at 15, 30, 45, 60 days after transplanting (DAT) and at harvest

2. Number of tillers hill$^{-1}$ at 15, 30, 45, 60, 75 DAT and at harvest

3. Leaf Area hill$^{-1}$ (cm$^{2}$) at 15, 30, 45 and 60 DAT.

4. Dry matter content hill$^{-1}$ (g) at 15, 30, 45 and 60 DAT.

**B. Yield contributing characters and yield data**

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

2. Number of non-effective tillers hill$^{-1}$

3. Length of panicle (cm)

4. Grains panicle$^{-1}$ (no)

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

6. Unfilled grains panicle$^{-1}$ (no.)

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

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

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

10. Harvest index (%)

11. Weight of 1000 grains (g)

**C. Qualitative characters**

1. Moisture content of rice seed (%)

2. Ash content of rice seed (%)

3. Fat content of rice seed (%)

4. Protein content of rice seed (%)

5. Carbohydrate content of rice seed (%)

### 3.14.1 Procedure of sampling for growth study during the crop growth period

### 3.14.2. Plant height (cm)

The height of the rice plants was recorded at 15, 30, 45, 60 DAT and at harvest, 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.

### 3.14.3. Number of tillers hill$^{-1}$ (no.)

Total tiller number was taken at 15, 22, 30, 37, 45, 52, 60, 67, 75 DAT and at harvest. The average number of tillers of ten hills was considered as the total tiller no hill$^{-1}$.

### 3.14.4 Leaf area hill$^{-1}$ (cm$^2$)

Leaf area was measured by destructing method using CL-202 Leaf Area Meter (USA). All the leaves of the sampled plants were collected and measured leaf area and expressed in cm$^2$. Then the mean was calculated.

### 3.14.5 Dry matter content hill$^{-1}$ (g)

Three sample hills uprooted from each plot randomly, wash them in water and then dried them in an electric oven maintaining 90$^0$C for 72 hours. Then the hills were weighed in an electric balance and averaged them to have dry matter content hill$^{-1}$.

### 3.14.6. Effective and ineffective 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$^{-1}$.

### 3.14.7. Grains panicle$^{-1}$

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

### 3.14.8. Number of filled and unfilled 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.

### 3.14.9. Weight of 1000-grain (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.

### 3.14.10. Grain and straw yield (t ha$^{-1}$)

An area of 1 $m^2$ 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.

### 3.14.11. Biological yield (t ha$^{-1}$)

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

### 3.14.12. Harvest index (%)

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

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

### 3.14.13. Moisture content of rice seed (%)

Moisture content was calculated by using the following formula:

$$\textbf{Moisture}\ (\%) = \frac{\textbf{Sample weight} - \textbf{Constant dry weight of sample}}{\textbf{Sample weight}} \times \mathbf{100}$$

### 3.14.14. Ash content of rice seed (%)

Ash content of rice seed was determined by following AOAC method (AOAC, 1975).

### 3.14.15. Fat content of rice seed (%)

Fat content of rice seed was determined by the Soxhlet Oxidation procedure (AOAC, 1975) using 10 g of samples and petroleum ether extraction done continuously for 8 hours.

### 3.14.16. Protein content of rice seed (%)

Protein content of rice seed was determined by the Micro-Kjeldahl method using automated nitrogen determination system (AOAC, 1990).

### 3.14.17. Carbohydrate content of rice seed (%)

Carbohydrate content of rice seed was determined by following AOAC method (AOAC, 1990).

## 3.15. Statistical analysis

The collected data were compiled and analyzed statistically using the analysis of variance (ANOVA) technique with the help of a computer package program MSTAT-C and the mean differences were adjusted by Least Significance Difference (LSD) test at 5% level of significance (Gomez and Gomez, 1984).

# CHAPTER 4

# RESULT AND DISCUSSION

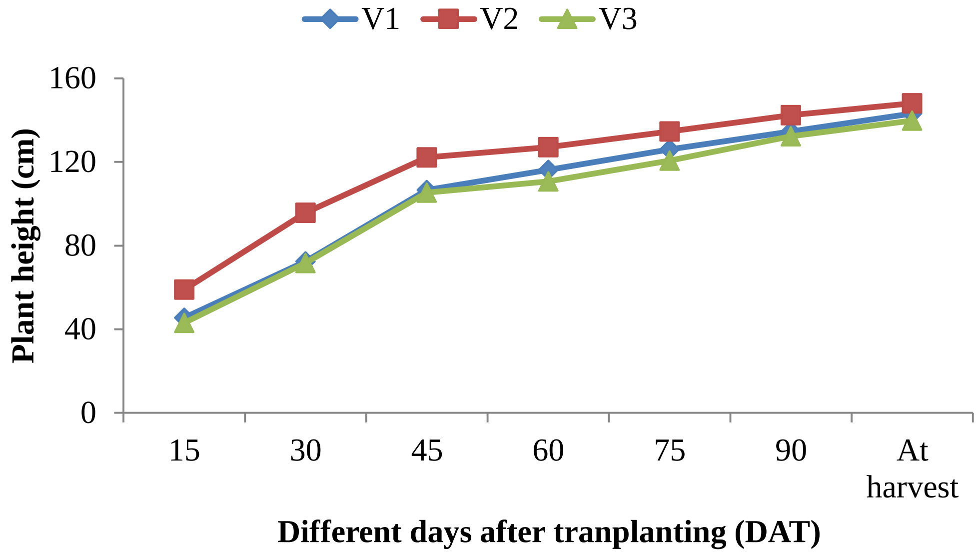
Result obtained from the study of green manure and chemical fertilizer on growth, yield and quality of aromatic rice varieties in aman season have been presented and discussed in this chapter. Treatments effect of fertilizer management and variety on all the studied parameters have been presented in various tables and figures and discussed below under the following sub-headings.

## 4.1. Growth Performance of aman rice

### 4.1.1 Plant height (cm)

#### 4.1.1.1 Effect of varietal variation

Aman rice variety exhibited significant difference on plant height at different growth stages except 90 DAT (Figure 01). Among the varieties, Raniselute ($V_2$) showed significantly the tallest plant (59.05, 95.72, 122.20, 127.00, 134.60, and 148.10 cm at 15, 30, 45, 60, 75 and harvest, respectively) which was statistically similar with $V_1$ at harvest. Significantly the shortest plant (43.02, 71.70, 105.40, 110.70, 120.70 and 139.70 cm at 15, 30, 45, 60, 75 DAT and harvest, respectively) was found in BRRI dhan34 ($V_3$) which was statistically similar with $V_1$ at 15, 30, 45, 60 DAT and harvest, respectively. The results consistent with the findings of Roy *et al*. (2014), Islam *et al*. (2013) and Bisne *et al.* (2006) who observed plant height differed significantly among the varieties.

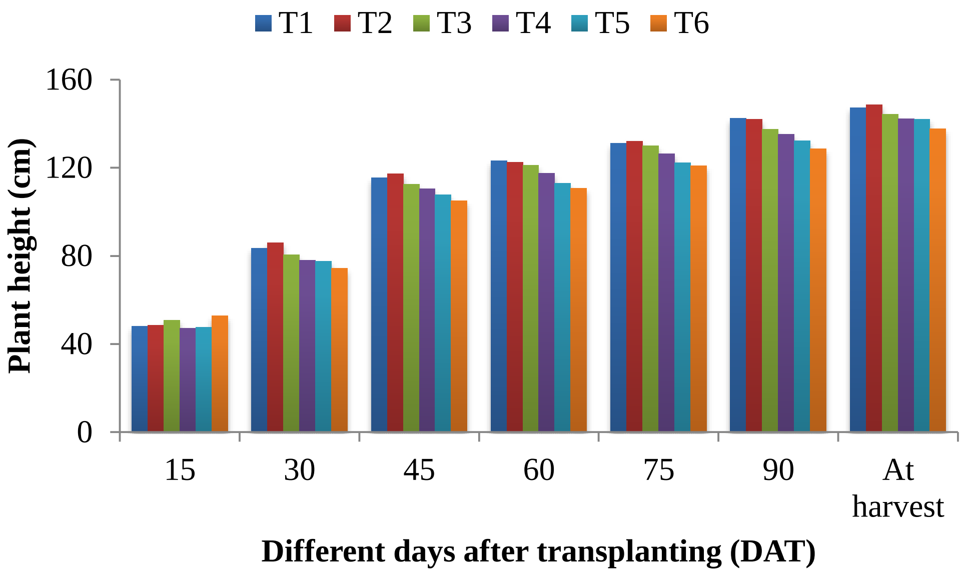



$V_1$: Kataribhog, $V_2$: Raniselute and $V_3$: BRRI dhan34

**Figure 01. Effect of varietal variation on the plant height of rice at different days after transplanting** (LSD $_{(0.05)}$ = 5.33, 3.26, 4.53, 7.74, 4.25, NS and 7.17 at 15, 30, 45, 60, 75, 90 DAT and at harvest, respectively)

#### 4.1.1.2 Effect of fertilizer management

Effect of green manure and chemical fertilizer showed a significant variation on plant height for all growth stages (Figure 02). At 15 DAT, the tallest plant (52.85 cm) was recorded from $T_6$ which was statistically similar with $T_3$, while the shortest plant (47.22 cm) was recorded from $T_4$ which was statistically similar with all fertilizer treatments except $T_6$. At 30 and 45 DAT, the tallest plant (86.04 and 117.3 cm, respectively) was recorded from $T_2$ which was statistically similar with $T_1$ and $T_3$, while the shortest plant (74.37 and 105.0 cm, respectively) was recorded from $T_6$ which was statistically similar with $T_3$, $T_4$ and $T_5$ at 30 DAT; $T_4$ and $T_5$ at 45 DAT. At 60 DAT, the tallest plant (123.2 cm) was recorded from $T_1$ which was statistically similar with $T_2$, $T_3$ and $T_4$, while the shortest plant (110.8 cm) was recorded from $T_6$ which was statistically similar with $T_4$ and $T_5$. At 75 DAT, the tallest plant (132.10 cm) was recorded from $T_2$ which was statistically similar with $T_1$ and $T_3$, while the shortest plant (120.90 cm) was recorded from $T_6$ which was statistically similar with $T_5$. At 90 DAT, the tallest plant (142.40 cm) was recorded from $T_1$ which was statistically similar with all other treatments except $T_6$, while the shortest plant (128.60 cm) was recorded from $T_6$ which was statistically similar with $T_3$, $T_4$ and $T_5$. At harvest, the tallest plant (148.7 cm) was recorded from $T_2$ which was statistically similar with all other treatment except $T_{6,}$ while the shortest plant (137.6 cm) was recorded from $T_6$ which was statistically similar with $T_3$, $T_4$ and $T_5$. The results were similar with the findings of Kohayashi *et al.* (1989) who observed increasing plant height with FYM + fertilizer N applied plots.




$T_1$ = Recommended doses of NPKSZn
$T_2$ = 80% recommended doses of NPKSZn + Green Manure 3.5 ton $ha^{-1}$
$T_3$ = 60% recommended doses of NPKSZn + Green Manure 7 ton $ha^{-1}$
$T_4$ = 40% recommended doses of NPKSZn + Green Manure 10.5 ton $ha^{-1}$
$T_5$ = 20% recommended doses of NPKSZn + Green Manure 14 ton $ha^{-1}$
$T_6$ = Green Manure 17.5 ton $ha^{-1}$

**Figure 02. Effect of fertilizer management on the plant height of rice at different days after transplanting** (LSD $_{(0.05)}$ = 3.86, 7.36, 5.65, 6.92, 3.99, 12.51 and 8.38 at 15, 30, 45, 60, 75, 90 DAT and at harvest, respectively)

#### 4.1.1.3 Interaction effect of varietal variation and fertilizer management

Interaction of variety and fertilizer management showed an increasing trend with advances of growth period in respect of plant height (Table 01). The increasing rate was much higher in the early stages of growth 15 DAT to 60 DAT. After that the increasing rate was much slower up to harvest. However, the tallest plant (68.91 cm at 15 DAT) was found in $V_2T_6$ which was statistically different from others, (107.7 and 132.7 cm at 30 and 45 DAT, respectively) in $V_2T_2$ which was statistically similar with $V_2T_1$ and $V_2T_3$, (134.6 cm at 60 DAT) in $V_2T_1$ which was statistically similar with $V_2T_2$, $V_2T_3$ and $V_2T_4$; (141.40 cm at 75 DAT) in $V_2T_2$ which was statistically similar with $V_2T_1$ and $V_2T_4$; (149.20 cm at 90 DAT) in $V_2T_2$ which was statistically similar with all other interactions except $V_1T_5$ and $V_3T_6$; (152.1 cm at harvest) in $V_2T_2$ which was statistically similar with all other interactions except $V_1T_6$ and $V_3T_6$. The shortest plant (40.71 cm at 15 DAT) was found in $V_3T_2$ which was statistically similar with $V_1T_1$, $V_1T_2$, $V_1T_4$, $V_1T_5$, $V_1T_6$, $V_3T_1$, $V_3T_3$, $V_3T_4$, $V_3T_5$ and $V_3T_6$; (67.89 cm at 30 DAT) in $V_3T_6$ which was statistically similar with all interactions between $V_1$ and $V_3$ with fertilizer treatments; (101.3 cm at 45 DAT) in $V_1T_6$ which was statistically similar with all interactions between $V_1$ and $V_3$ with fertilizer treatments except $V_1T_1$ ; (100.0 cm at 60 DAT) in $V_3T_6$ which was statistically similar with $V_1T_5$, $V_3T_4$ and $V_3T_5$; (110.70 cm at 75 DAT) in $V_3T_6$ which was statistically similar with $V_1T_5$; (120.70 cm at 90 DAT) in $V_3T_6$ which was statistically similar with all other interactions except $V_1T_{1,}$ $V_2T_{1,}$ $V_2T_2$ and $V_2T_3$ . The shortest plant (131.00 cm at harvest) was found in $V_3T_6$ which was statistically similar with all interactions except $V_1T_1$, $V_1T_2$, $V_2T_1$, $V_2T_2$, $V_2T_3$, $V_2T_4$ and $V_2T_5$.

**Table 01. Interaction effect of varietal variation and fertilizer management on plant height of rice at different days after transplanting**

| Treatment combinations | Days after transplanting (DAT) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 15 | 30 | 45 | 60 | 75 | 90 | At Harvest |
| $V_1T_1$ | 45.14 ef | 74.78 de | 111.8 c-e | 122.4 b-e | 132.4 b-d | 142.4 ab | 148.7 ab |
| $V_1T_2$ | 43.77 ef | 75.11 de | 109.6 d-f | 118.2 d-f | 128.2 c-e | 138.2 a-c | 148.4 ab |
| $V_1T_3$ | 48.78 de | 73.78 de | 106.6 d-f | 119.0 c-f | 129.0 c-e | 135.7 a-c | 143.4 a-c |
| $V_1T_4$ | 46.43 d-f | 72.21 e | 107.0 d-f | 114.2 ef | 124.1 ef | 133.9 a-c | 142.3 a-c |
| $V_1T_5$ | 43.78 ef | 70.22 e | 103.4 ef | 107.7 fg | 117.0 gh | 127.2 bc | 140.2 a-c |
| $V_1T_6$ | 45.12 ef | 68.89 e | 101.3 f | 115.7 ef | 125.1 ef | 129.8 a-c | 136.4 bc |
| $V_2T_1$ | 55.90 bc | 102.7 ab | 127.1 ab | 134.6 a | 138.1 ab | 147.3 ab | 150.6 ab |
| $V_2T_2$ | 60.78 b | 107.7 a | 132.7 a | 132.7 ab | 141.4 a | 149.2 a | 152.1 a |
| $V_2T_3$ | 59.06 b | 95.44 a-c | 126.4 ab | 130.8 a-c | 137.4 ab | 142.3 ab | 147.3 ab |
| $V_2T_4$ | 51.99 cd | 91.00 bc | 119.8 bc | 127.9 a-d | 134.6 a-c | 141.8 a-c | 146.4 ab |
| $V_2T_5$ | 57.67 bc | 91.22 bc | 115.4 cd | 119.6 c-f | 129.6 c-e | 138.0 a-c | 147.1 ab |
| $V_2T_6$ | 68.91 a | 86.34 cd | 111.6 c-e | 116.8 d-f | 126.8 d-f | 135.3 a-c | 145.2 a-c |
| $V_3T_1$ | 43.58 ef | 73.11 e | 107.2 d-f | 112.6 ef | 122.9 e-g | 137.6 a-c | 143.0 a-c |
| $V_3T_2$ | 40.71 f | 75.33 de | 109.7 d-f | 116.6 d-f | 126.6 d-f | 138.7 a-c | 145.4 a-c |
| $V_3T_3$ | 44.93 ef | 72.22 e | 104.9 ef | 113.1 ef | 123.1 e-g | 134.4 a-c | 142.0 a-c |
| $V_3T_4$ | 43.25 ef | 70.78 e | 104.4 ef | 110.2 fg | 120.2 fg | 129.9 a-c | 137.8 a-c |
| $V_3T_5$ | 41.13 f | 70.89 e | 104.2 ef | 111.8 e-g | 120.8 fg | 131.8 a-c | 139.0 a-c |
| $V_3T_6$ | 44.52 ef | 67.89 e | 102.1 ef | 100.0 g | 110.7 h | 120.7 c | 131.0 c |
| **LSD $_{(0.05)}$** | **6.68** | **12.74** | **9.79** | **11.99** | **6.91** | **21.66** | **14.51** |
| **CV (%)** | **8.15** | **9.55** | **5.27** | **6.09** | **3.26** | **9.53** | **6.06** |

In a column, means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 5% level of probability

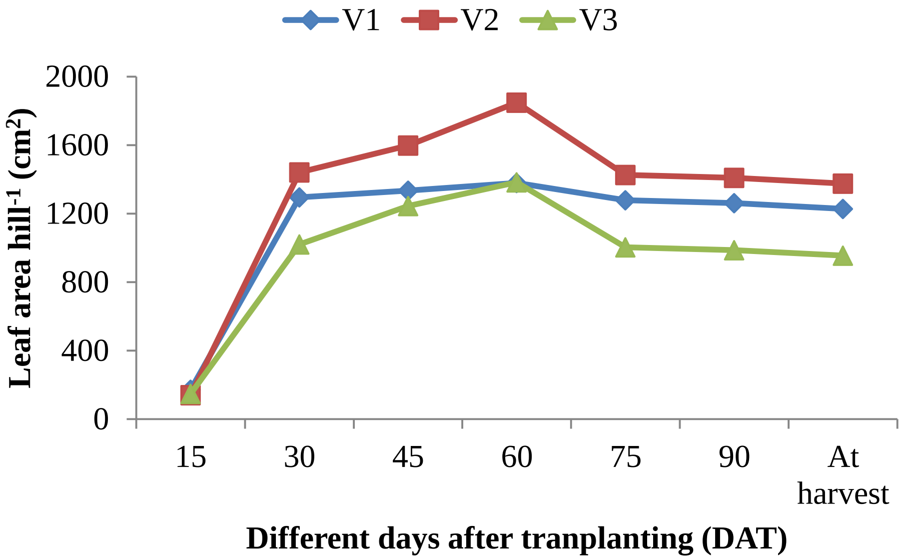
$V_1$: Kataribhog, $V_2$: Raniselute and $V_3$: BRRI dhan34

$T_1$ = Recommended doses of NPKSZn, $T_2$ = 80% recommended doses of NPKSZn + green manure 3.5 ton ha$^{-1}$, $T_3$ = 60% recommended doses of NPKSZn + green manure 7 ton ha$^{-1}$, $T_4$ = 40% recommended doses of NPKSZn + green manure 10.5 ton ha$^{-1}$, $T_5$ = 20% recommended doses of NPKSZn + green manure 14 ton ha$^{-1}$ and $T_6$ = green manure 17.5 ton ha$^{-1}$

### 4.1.2 Leaf area hill$^{-1}$ (cm$^2$)

#### 4.1.2.1 Effect of varietal variation

Significant variation was observed on leaf area hill$^{-1}$ at different growth stages of aman rice variety (Figure 03). Among the varieties, Kataribhog ($V_1$) showed significantly the maximum leaf area hill$^{-1}$ (172.0 cm$^2$ at 15 DAT) and Raniselute ($V_2$) showed (1442, 1599, 1849, 1426, 1409 and 1376 cm$^2$ at 30, 45, 60, 75, 90 DAT and harvest, respectively) which was statistically similar with $V_1$ at 30 and 75 DAT. Significantly the minimum leaf area hill$^{-1}$ (141.3 cm$^2$ at 15 DAT) was found in Raniselute ($V_2$) which was statistically similar with $V_3$; (1020 and 1245 cm$^2$ at 30 and 45 DAT, respectively) was found in BRRI dhan34 ($V_3$) which was statistically similar with $V_1$ at 45 DAT; (1379 cm$^2$ at 60 DAT) was found in Kataribhog ($V_1$) which was statistically similar with $V_3$; (1003, 987 and 954.80 cm$^2$ at 75, 90 DAT and harvest, respectively) was found in BRRI dhan34 ($V_3$). The results agreed with the findings of Sokoto and Muhammad (2014), Sarker *et al*. (2013), Islam *et al*. (2013).

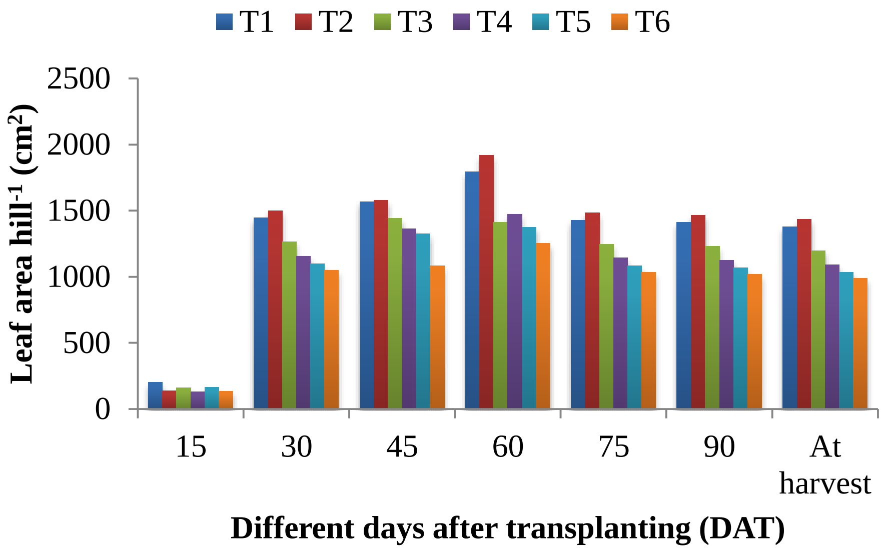



$V_1$: Kataribhog, $V_2$: Raniselute and $V_3$: BRRI dhan34

**Figure 03. Effect of varietal variation on the leaf area hill$^{-1}$ of rice at different days after transplanting** (LSD $_{(0.05)}$ = 17.05, 161.60, 125.30, 78.32, 156.00, 132.00 and 110.20 at 15, 30, 45, 60, 75, 90 DAT and at harvest, respectively)

### 4.1.2.2 Effect of fertilizer management

Effect of green manure and chemical fertilizer showed a significant variation on leaf area hill$^{-1}$ for all growth stages (Figure 04). At 15 DAT, the maximum leaf area hill$^{-1}$ (199.5 cm$^2$) was recorded from $T_1$ which was statistically different from other treatments, while the minimum leaf area hill$^{-1}$ (129.4 cm$^2$) was recorded from $T_4$ which was statistically similar with $T_2$ and $T_6$. At 30, 45, 60, 75, 90 DAT and harvest, the maximum leaf area hill$^{-1}$ (1500, 1578, 1918, 1484, 1467 and 1434 cm$^2$, respectively) was recorded from $T_2$ which was statistically similar with $T_1$, while the minimum leaf area hill$^{-1}$ (1050, 1082, 1253, 1033, 1018 and 986.50 cm$^2$, respectively) was recorded from $T_6$ which was statistically similar with $T_4$ and $T_5$ at 30 and 75 DAT; $T_3$, $T_4$ and $T_5$ at 60 DAT; $T_5$ at 90 DAT and harvest.




$T_1$ = Recommended doses of NPKSZn
$T_2$ = 80% recommended doses of NPKSZn + Green Manure 3.5 ton ha$^{-1}$
$T_3$ = 60% recommended doses of NPKSZn + Green Manure 7 ton ha$^{-1}$
$T_4$ = 40% recommended doses of NPKSZn + Green Manure 10.5 ton ha$^{-1}$
$T_5$ = 20% recommended doses of NPKSZn + Green Manure 14 ton ha$^{-1}$
$T_6$ = Green Manure 17.5 ton ha$^{-1}$

**Figure 04. Effect of fertilizer management on the leaf area hill$^{-1}$ of rice at different days after transplanting** (LSD $_{(0.05)}$ = 14.01, 138.30, 168.30, 240.90, 109.70, 97.27 and 87.72 at 15, 30, 45, 60, 75, 90 DAT and at harvest, respectively)

#### 4.1.2.3 Interaction effect of varietal variation and fertilizer management

Interaction of variety and fertilizer management showed an increasing trend with advances of growth period in respect of leaf area hill$^{-1}$ (Table 02). The maximum leaf area hill$^{-1}$ (221.9 cm$^2$ at 15 DAT) was found in $V_3T_1$ which was statistically similar with $V_1T_1$ and $V_1T_3$; (1755, 2333, 1739, 1722 and 1689 cm$^2$ at 30, 60, 75, 90 DAT and harvest, respectively) was found in $V_2T_2$ which was statistically similar with 75 DAT; $V_2T_1$ at 60 DAT; (1909 cm$^2$ at 45 DAT) was found in $V_2T_1$ which was statistically similar with $V_2T_2$ and $V_2T_3$. The minimum leaf area hill$^{-1}$ (91.34 cm$^2$ at 15 DAT) was found in $V_3T_3$ which was statistically similar with $V_1T_2$, $V_3T_4$ and $V_3T_6$; (979.1 cm$^2$ at 45 DAT) was found in $V_3T_6$ which was statistically similar with $V_1T_5$, $V_1T_6$, $V_2T_6$, $V_3T_3$ and $V_3T_5$ at 45 DAT; (879.3 cm$^2$ at 60 DAT) was found in $V_1T_3$ which was statistically similar with $V_1T_5$, $V_1T_6$, $V_3T_5$ and $V_3T_6$; (756.1, 742.8 and 716.1 cm$^2$ at 75, 90 DAT and harvest, respectively) was found in $V_3T_6$ which was statistically similar with $V_3T_5$.

**Table 02. Interaction effect of varietal variation and fertilizer management on leaf area hill$^{-1}$ of rice at different days after transplanting**

| Treatment combinations | Days after transplanting (DAT) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 15 | 30 | 45 | 60 | 75 | 90 | At Harvest |
| $V_1T_1$ | 220.8 a | 1584 | 1475 b-g | 1653 c-e | 1568 ab | 1551 b | 1518 b |
| $V_1T_2$ | 108.0 ij | 1490 | 1541 b-e | 1896 bc | 1474 bc | 1457 bc | 1424 b |
| $V_1T_3$ | 212.6 ab | 1302 | 1419 c-g | 879.3g | 1286 c-f | 1269 d-f | 1236 de |
| $V_1T_4$ | 153.6 e-g | 1157 | 1317 d-h | 1355 d-f | 1140 e-i | 1124 f-h | 1090 e-h |
| $V_1T_5$ | 179.3 cd | 1136 | 1218 f-i | 1215 fg | 1120 f-i | 1103 f-i | 1070 f-i |
| $V_1T_6$ | 157.7 d-f | 1097 | 1041 hi | 1274 e-g | 1081 g-i | 1064 g-i | 1031 g-i |
| $V_2T_1$ | 155.8 d-f | 1567 | 1909 a | 2158 ab | 1551 ab | 1534 b | 1501 b |
| $V_2T_2$ | 146.9 f-h | 1755 | 1730 ab | 2333 a | 1739 a | 1722 a | 1689 a |
| $V_2T_3$ | 172.4 c-e | 1467 | 1657 a-c | 1858 bc | 1450 b-d | 1433 b-d | 1400 bc |
| $V_2T_4$ | 124.9 hi | 1329 | 1499 b-f | 1744 b-d | 1313 c-e | 1296 c-e | 1263 cd |
| $V_2T_5$ | 118.1 i | 1256 | 1573 b-d | 1685 c-e | 1239 e-g | 1222 e-g | 1189 d-f |
| $V_2T_6$ | 129.4 g-i | 1280 | 1225 f-i | 1317 ef | 1263 d-g | 1246 ef | 1213 d-f |
| $V_3T_1$ | 221.9 a | 1181 | 1320 d-h | 1567 c-f | 1165 e-h | 1148 e-h | 1115 d-g |
| $V_3T_2$ | 159.4 d-f | 1255 | 1464 b-g | 1525 c-f | 1239 e-g | 1222 e-g | 1189 d-f |
| $V_3T_3$ | 91.34 j | 1019 | 1249 f-i | 1492 c-f | 1002 h-j | 985.8 h-j | 952.4 h-j |
| $V_3T_4$ | 109.6 ij | 985.6 | 1271 e-h | 1320 ef | 968.9 ij | 952.3 ij | 918.9 ij |
| $V_3T_5$ | 192.9 bc | 904.4 | 1185 g-i | 1226 fg | 887.7 jk | 871.0 jk | 837.7 jk |
| $V_3T_6$ | 115.3 ij | 772.8 | 979.1 i | 1167 fg | 756.1 k | 742.8 k | 716.1 k |
| **LSD $_{(0.05)}$** | **24.27** | **NS** | **291.50** | **417.20** | **190.00** | **168.50** | **151.90** |
| **CV (%)** | **9.46** | **11.47** | **12.55** | **16.28** | **9.22** | **8.29** | **7.68** |

In a column, means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 5% level of probability

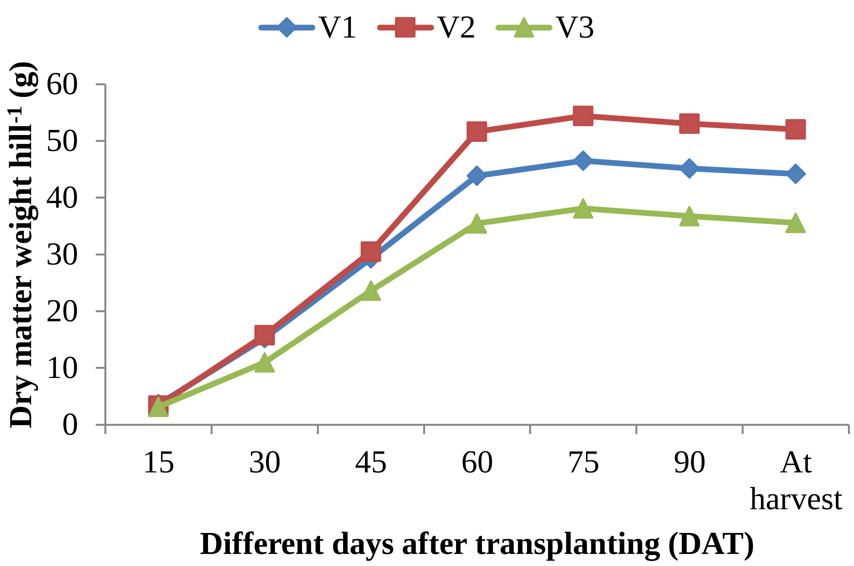
$V_1$: Kataribhog, $V_2$: Raniselute and $V_3$: BRRI dhan34

$T_1$ = Recommended doses of NPKSZn, $T_2$ = 80% recommended doses of NPKSZn + green manure 3.5 ton ha$^{-1}$, $T_3$ = 60% recommended doses of NPKSZn + green manure 7 ton ha$^{-1}$, $T_4$ = 40% recommended doses of NPKSZn + green manure 10.5 ton ha$^{-1}$, $T_5$ = 20% recommended doses of NPKSZn + green manure 14 ton ha$^{-1}$ and $T_6$ = green manure 17.5 ton ha$^{-1}$

### 4.1.3 Dry matter content hill$^{-1}$ (g)

#### 4.1.3.1 Effect of varietal variation

Significant variation was observed on dry matter content hill$^{-1}$ at different growth stages of aman rice variety except 15 DAT (Figure 05). Among the varieties, Raniselute ($V_2$) showed significantly the maximum dry matter content hill$^{-1}$ (15.78, 30.51, 51.62, 54.40, 53.03 and 52.03 g at 30, 45, 60, 75, 90 DAT and harvest, respectively) which was statistically similar with $V_1$ at 30 and 45 DAT; whereas the minimum dry matter content hill$^{-1}$ (10.95, 23.62, 35.42, 38.08, 36.75 and 35.58 g at 30, 45, 60, 75, 90 DAT and harvest, respectively) was found in BRRI dhan34 ($V_3$).

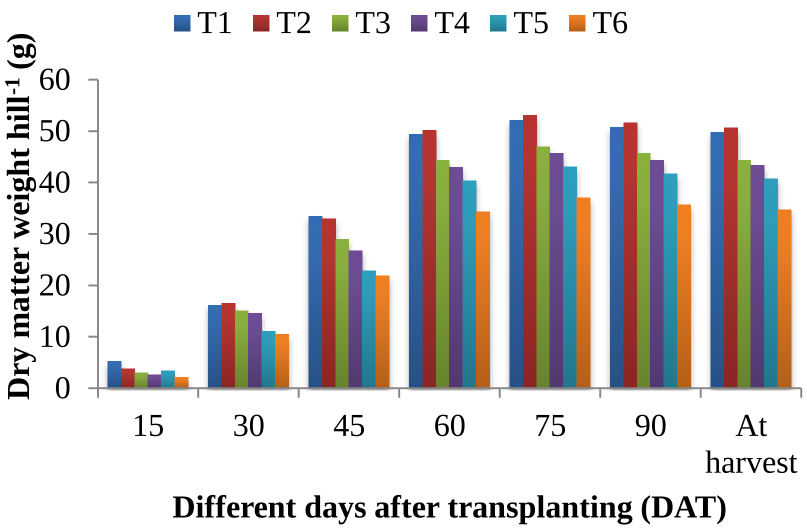



$V_1$: Kataribhog, $V_2$: Raniselute and $V_3$: BRRI dhan34

**Figure 05. Effect of varietal variation on the dry matter weight hill$^{-1}$ of rice at different days after transplanting** (LSD $_{(0.05)}$ = NS, 2.71, 3.32, 3.95, 4.48, 3.97 and 3.98 at 15, 30, 45, 60, 75, 90 DAT and at harvest, respectively)

#### 4.1.3.2 Effect of fertilizer management

Effect of green manure and chemical fertilizer showed a significant variation on dry matter weight hill$^{-1}$ for all growth stages (Figure 06). At 15 and 45 DAT, the maximum dry matter weight hill$^{-1}$ (5.21 and 33.40 g, respectively) was recorded from $T_1$ which was statistically similar with $T_2$ at 45 DAT, while the minimum (2.14 and 21.84 g, respectively) was recorded from $T_6$ which was statistically similar with $T_5$ at 45 DAT. At 30 and 60 DAT, the maximum dry matter weight hill$^{-1}$ (16.52 and 50.19 g, respectively) was recorded from $T_2$ which was statistically similar with $T_1$, while the minimum (10.49 and 34.39 g, respectively) was recorded from $T_6$ which was statistically similar with $T_5$ at 30 DAT. At 75, 90 DAT and harvest, the maximum dry matter weight hill$^{-1}$ (53.08, 51.67 and 50.67 g, respectively) was recorded from $T_2$ which was statistically similar with $T_1$, while the minimum (37.06, 35.72 and 34.72 g, respectively) was recorded from $T_6$.




$T_1$ = Recommended doses of NPKSZn
$T_2$ = 80% recommended doses of NPKSZn + Green Manure 3.5 ton ha$^{-1}$
$T_3$ = 60% recommended doses of NPKSZn + Green Manure 7 ton ha$^{-1}$
$T_4$ = 40% recommended doses of NPKSZn + Green Manure 10.5 ton ha$^{-1}$
$T_5$ = 20% recommended doses of NPKSZn + Green Manure 14 ton ha$^{-1}$
$T_6$ = Green Manure 17.5 ton ha$^{-1}$

**Figure 06. Effect of fertilizer management on the dry matter weight hill$^{-1}$ of rice at different days after transplanting** (LSD $_{(0.05)}$ = 0.36, 1.24, 2.70, 4.21, 4.01, 3.60 and 3.42 at 15, 30, 45, 60, 75, 90 DAT and at harvest, respectively)

**4.1.3.3 Interaction effect of varietal variation and fertilizer management**

Interaction of variety and fertilizer management showed an increasing trend with advances of growth period in respect of dry matter weight hill$^{-1}$ (Table 03). The maximum dry matter weight hill$^{-1}$ (5.30 g at 15 DAT) was found in $V_1T_5$ which was statistically similar with $V_1T_1$, $V_2T_1$ and $V_3T_1$; (18.68g at 30 DAT) was found in $V_2T_1$ which was statistically similar with $V_1T_1$, $V_1T_2$, $V_1T_3$, $V_2T_2$ and $V_2T_3$ at 30 DAT; whereas (56.57, 59.90, 58.33 and 57.33 g at 60, 75, 90 DAT and harvest, respectively) was found in $V_2T_2$ which was statistically similar with $V_1T_1$, $V_1T_2$, $V_2T_1$, $V_2T_3$ and $V_2T_4$. The minimum dry matter weight hill$^{-1}$ (1.63 g at 15 DAT) was found in $V_1T_6$

which was statistically similar with $V_1T_4$, $V_2T_6$, $V_3T_3$ and $V_3T_5$; (7.22 g at 30 DAT) was found in $V_3T_6$ which was statistically similar with $V_3T_5$; (22.00, 24.67, 23.33 and 22.33 g at 60, 75, 90 DAT and harvest, respectively) was found in $V_3T_6$.

**Table 03. Interaction effect of varietal variation and fertilizer management on dry matter weight hill$^{-1}$ of rice at different days after transplanting**

| Treatment combinations | Days after transplanting (DAT) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 15 | 30 | 45 | 60 | 75 | 90 | At harvest |
| **$V_1T_1$** | 5.07 a | 17.14 ab | 34.52 | 53.83 ab | 56.50 a-c | 55.17 ab | 54.17 ab |
| **$V_1T_2$** | 3.83 b | 16.83 ab | 35.93 | 52.00 ab | 54.67 a-c | 53.33 a-c | 52.33 a-c |
| **$V_1T_3$** | 3.62 bc | 16.91 ab | 31.59 | 44.00 c-e | 46.67 de | 45.33 d-f | 44.33 d-f |
| **$V_1T_4$** | 2.21 e-g | 15.77 bc | 29.17 | 42.50 c-f | 45.17 d-f | 43.83 d-g | 42.83 ef |
| **$V_1T_5$** | 5.30 a | 12.96 de | 22.94 | 36.50 f-h | 39.17 fg | 37.83 g-j | 36.83 g-i |
| **$V_1T_6$** | 1.63 g | 11.87 e | 21.63 | 34.17 h | 36.83 g | 35.50 j | 34.50 i |
| **$V_2T_1$** | 5.29 a | 18.68 a | 39.44 | 54.00 ab | 56.67 ab | 55.33 ab | 54.33 ab |
| **$V_2T_2$** | 3.62 bc | 18.63 a | 35.63 | 56.57 a | 59.90 a | 58.33 a | 57.33 a |
| **$V_2T_3$** | 3.44 bc | 17.10 ab | 29.62 | 52.00 ab | 54.67 a-c | 53.33 a-c | 52.33 a-c |
| **$V_2T_4$** | 3.02 cd | 15.47 bc | 27.92 | 51.50 ab | 54.17 a-c | 52.83 a-c | 51.83 a-c |
| **$V_2T_5$** | 2.76 de | 12.40 de | 26.13 | 48.67 bc | 51.33 b-d | 50.00 b-d | 49.00 b-d |
| **$V_2T_6$** | 1.98 g | 12.37 de | 24.32 | 47.00 b-d | 49.67 c-e | 48.33 c-e | 47.33 c-e |
| **$V_3T_1$** | 5.28 a | 12.68 de | 26.23 | 40.50 d-h | 43.17 e-g | 41.83 f-i | 40.83 f-h |
| **$V_3T_2$** | 4.03 b | 14.10 cd | 27.24 | 42.00 c-g | 44.67 d-f | 43.33 e-h | 42.33 e-g |
| **$V_3T_3$** | 2.08 fg | 11.22 e | 25.84 | 37.00 e-h | 39.67 fg | 38.33 g-j | 36.33 hi |
| **$V_3T_4$** | 2.64 d-f | 12.61 de | 23.30 | 35.00 gh | 37.67 g | 36.33 ij | 35.33 hi |
| **$V_3T_5$** | 2.07 fg | 7.893 f | 19.51 | 36.00 f-h | 38.67 fg | 37.33 h-j | 36.33 hi |
| **$V_3T_6$** | 2.80 de | 7.223 f | 19.58 | 22.00 i | 24.67 h | 23.33 k | 22.33 j |
| **LSD $_{(0.05)}$** | **0.62** | **2.15** | **NS** | **7.29** | **6.94** | **6.24** | **5.92** |
| **CV (%)** | **10.99** | **9.19** | **10.08** | **10.02** | **8.98** | **8.32** | **8.08** |

In a column, means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 5% level of probability

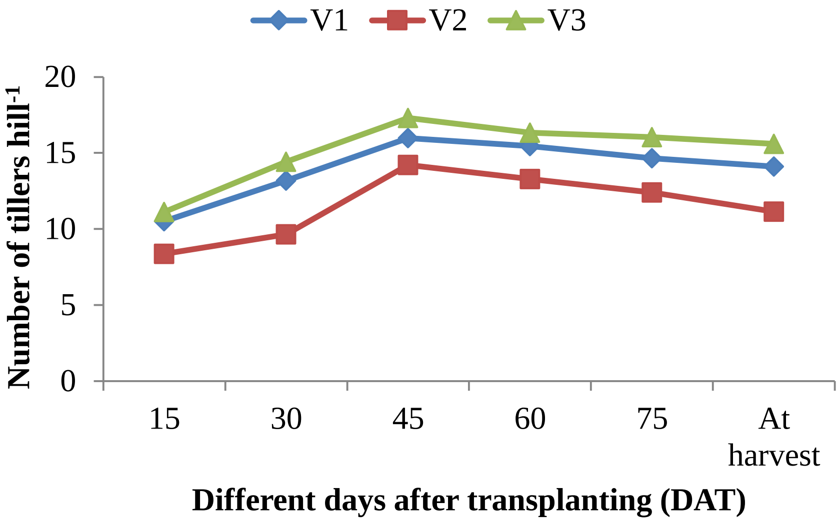
$V_1$: Kataribhog, $V_2$: Raniselute and $V_3$: BRRI dhan34

$T_1$ = Recommended doses of NPKSZn, $T_2$ = 80% recommended doses of NPKSZn + green manure 3.5 ton ha$^{-1}$, $T_3$ = 60% recommended doses of NPKSZn + green manure 7 ton ha$^{-1}$, $T_4$ = 40% recommended doses of NPKSZn + green manure 10.5 ton ha$^{-1}$, $T_5$ = 20% recommended doses of NPKSZn + green manure 14 ton ha$^{-1}$ and $T_6$ = green manure 17.5 ton ha$^{-1}$

### 4.1.4 Number of tillers hill$^{-1}$ (no.)

#### 4.1.4.1 Effect of varietal variation

Variety exerted significant effect on the number of tillers hill$^{-1}$ at 5% level of significance (Figure 07). The highest number of tillers hill$^{-1}$ (11.13, 14.43, 17.30, 16.33, 16.04 and 15.60 at 15, 30, 45, 60, 75 DAT and harvest, respectively) was produced by BRRI dhan34 ($V_3$) which is statistically similar with Kataribhog ($V_1$) at 15, 60 DAT and harvest. Among the varieties, Raniselute ($V_2$) produced lowest number of tillers hill$^{-1}$ (8.38, 9.65, 14.22, 13.28, 12.41 and 11.15 at 15, 30, 45, 60, 75 DAT and harvest, respectively). Variable effect of variety on number of total tillers hill$^{-1}$ was also reported by Roy *et al.* (2014), BINA (1998), Nuruzzaman *et al.* (2000) and Jaiswal (2001) who noticed that number of total tillers hill$^{-1}$ differed among the varieties. The variation in number of total tillers hill$^{-1}$ as assessed might be due to varietal character.

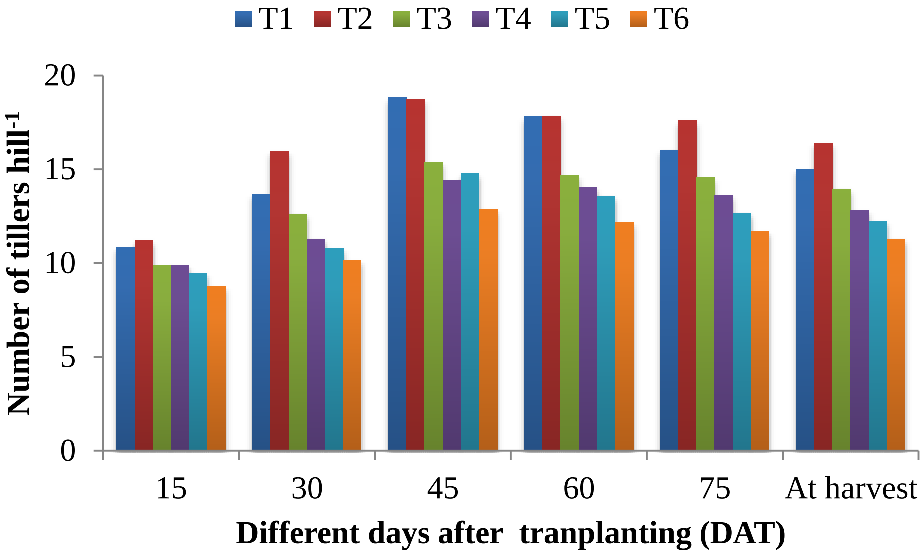



$V_1$: Kataribhog, $V_2$: Raniselute and $V_3$: BRRI dhan34

**Figure 07. Effect of varietal variation on the number of tillers hill$^{-1}$ of rice at different days after transplanting** (LSD $_{(0.05)}$ = 1.83, 1.02, 1.29, 1.26, 0.79 and 1.55 at 15, 30, 45, 60, 75 DAT and at harvest, respectively)

**4.1.4.2 Effect of fertilizer management**

Number of total tillers hill$^{-1}$ varied significantly due to different fertilizer management at 5 % level of significance (Figure 08). The highest number of tillers hill$^{-1}$ (11.20, 15.96, 17.85, 17.59 and 16.39 at 15, 30, 60, 75 DAT and harvest, respectively) was produced from $T_2$ which is statistically similar with $T_1$ at 15 and 60 DAT; (18.82 at 45 DAT) was produced from $T_1$ which is statistically similar with 45 DAT. The lowest number of tillers hill$^{-1}$ (8.78, 10.15, 12.89, 12.19, 11.70 and 11.30 at 15, 30, 45, 60, 75 DAT and harvest, respectively) was produced from $T_6$ which is statistically similar with $T_5$ at 15, 30, 60, 75 DAT and harvest; with $T_4$ at 30 DAT. The results agreed with the findings of Bayan and Kandasamy (2002), Islam *et al.* (2008) and Mannan *et al.* (2010).




$T_1$ = Recommended doses of NPKSZn
$T_2$ = 80% recommended doses of NPKSZn + Green Manure 3.5 ton ha$^{-1}$
$T_3$ = 60% recommended doses of NPKSZn + Green Manure 7 ton ha$^{-1}$
$T_4$ = 40% recommended doses of NPKSZn + Green Manure 10.5 ton ha$^{-1}$
$T_5$ = 20% recommended doses of NPKSZn + Green Manure 14 ton ha$^{-1}$
$T_6$ = Green Manure 17.5 ton ha$^{-1}$

**Figure 08. Effect of fertilizer management on the number of tillers hill$^{-1}$ of rice at different days after transplanting** (LSD $_{(0.05)}$ = 0.82, 1.42, 1.35, 1.47, 1.34 and 1.23 at 15, 30, 45, 60, 75 DAT and at harvest, respectively)

### 4.1.4.3 Interaction effect of varietal variation and fertilizer management

Tillers number hill$^{-1}$ was significantly influenced by the interaction of varietal variation and fertilizer management at all sampling days (Table 04). For all interactions, the number of tillers increased from 15 DAT to 45 DAT and after that the number of tillers hill$^{-1}$ reduced slightly. The highest number of tillers hill$^{-1}$ (13.93, 19.78, 21.33, 21.00, 20.44 and 19.44 at 15, 30, 45, 60, 75 DAT and harvest, respectively) was found in the interaction of $V_3T_2$ which was statistically similar with $V_3T_1$ at 15, 45, 60 and 75 DAT; $V_1T_1$ at 45 and 60 DAT. The lowest number of tillers hill$^{-1}$ (7.47 at 15 DAT) was found in the interaction of $V_2T_1$ which was statistically similar with $V_1T_6$, $V_2T_2$, $V_2T_4$, $V_2T_5$ and $V_2T_6$; whereas (8.78 at 30 DAT) was found in $V_2T_5$ which was statistically similar with $V_1T_6$, $V_2T_1$, $V_2T_3$, $V_2T_4$, $V_2T_6$ and $V_3T_6$; (13.33 at 45 DAT) was found in $V_1T_6$ which was statistically similar with $V_1T_3$, $V_1T_4$, $V_1T_5$, $V_2T_3$, $V_2T_4$, $V_2T_5$, $V_3T_4$, $V_3T_5$ and $V_3T_6$; (10.11, 10.56 and 9.89 at 60, 75 DAT and harvest, respectively) was found in $V_2T_6$ which was statistically similar with

$V_1T_6$, $V_2T_3$, $V_2T_4$, $V_2T_5$ and $V_3T_6$ at 75 DAT; $V_1T_6$, $V_2T_1$, $V_2T_3$, $V_2T_4$ and $V_2T_5$ at harvest.

**Table 04. Interaction effect of varietal variation and fertilizer management on number of tillers hill$^{-1}$ of rice at different days after transplanting**

| Treatment combinations | Number of tillers hill$^{-1}$ at | | | | | |
|---|---|---|---|---|---|---|
| | **15 DAT** | **30 DAT** | **45 DAT** | **60 DAT** | **75 DAT** | **At harvest** |
| **$V_1T_1$** | 12.47 b | 14.56 b-e | 19.45 a-c | 18.56 a-c | 16.33 bc | 15.94 b-d |
| **$V_1T_2$** | 11.33 bc | 16.67 b | 18.22 b-d | 17.33 b-d | 17.67 b | 17.28 b |
| **$V_1T_3$** | 10.07 c-f | 13.89 c-f | 15.44 e-g | 14.78 e-g | 14.56 c-e | 14.54 c-e |
| **$V_1T_4$** | 10.60 cd | 12.11 e-h | 14.56 fg | 14.11 e-g | 13.89 d-f | 13.11 e-g |
| **$V_1T_5$** | 10.13 c-f | 11.55 f-i | 14.89 fg | 14.22 e-g | 13.22 d-g | 12.56 e-h |
| **$V_1T_6$** | 8.53 g-i | 10.33 g-j | 13.33 g | 13.78 fg | 12.22 f-h | 11.22 g-i |
| **$V_2T_1$** | 7.47 i | 10.11 h-j | 16.67 d-f | 15.78 d-f | 13.33 d-g | 11.89 f-i |
| **$V_2T_2$** | 8.33 hi | 11.44 f-i | 16.67 d-f | 15.22 d-g | 14.67 cd | 12.44 e-h |
| **$V_2T_3$** | 9.00 e-h | 9.22 ij | 13.34 g | 12.67 g | 12.44 d-h | 11.00 g-i |
| **$V_2T_4$** | 8.73 f-i | 9.11 ij | 13.44 g | 13.22 fg | 12.33 e-h | 11.22 g-i |
| **$V_2T_5$** | 8.47 g-i | 8.78 j | 14.56 fg | 12.67 g | 11.11 gh | 10.44 hi |
| **$V_2T_6$** | 8.27 hi | 9.22 ij | 10.67 h | 10.11 h | 10.56 h | 9.890 i |
| **$V_3T_1$** | 12.60 ab | 16.33 bc | 20.33 ab | 19.11 ab | 18.44 ab | 17.16 b |
| **$V_3T_2$** | 13.93 a | 19.78 a | 21.33 a | 21.00 a | 20.44 a | 19.44 a |
| **$V_3T_3$** | 10.60 cd | 14.78 b-d | 17.33 c-e | 16.55 c-e | 16.66 bc | 16.33 bc |
| **$V_3T_4$** | 10.33 c-e | 12.67 d-g | 15.22 e-g | 14.78 d-g | 14.67 cd | 14.16 de |
| **$V_3T_5$** | 9.80 d-g | 12.11 e-h | 14.89 fg | 13.89 fg | 13.67 d-f | 13.72 ef |
| **$V_3T_6$** | 9.53 d-h | 10.89 g-j | 14.67 fg | 12.67 g | 12.33 e-h | 12.78 e-g |
| **LSD (0.05)** | **1.43** | **2.46** | **2.34** | **2.55** | **2.31** | **2.12** |
| **CV (%)** | **8.56** | **11.87** | **8.87** | **10.19** | **9.65** | **9.35** |

In a column, means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 5% level of probability

$V_1$: Kataribhog, $V_2$: Raniselute and $V_3$: BRRI dhan34

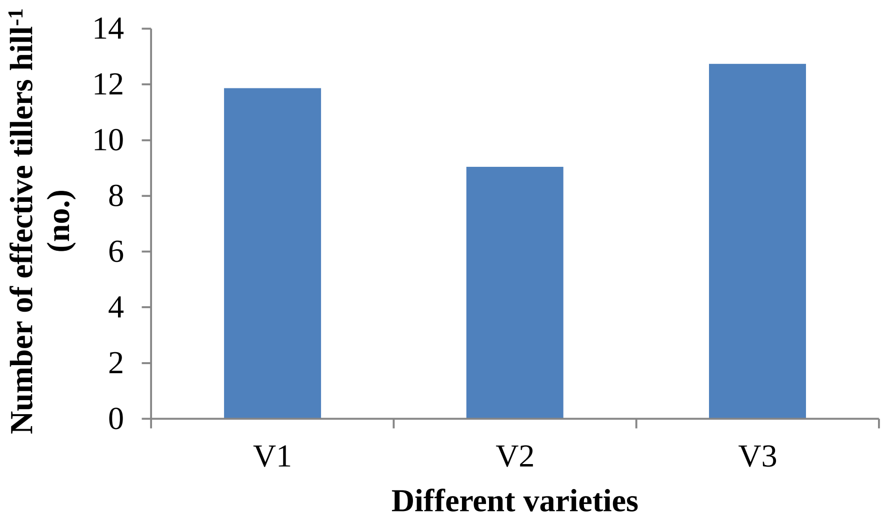
$T_1$ = Recommended doses of NPKSZn, $T_2$ = 80% recommended doses of NPKSZn + green manure 3.5 ton ha$^{-1}$, $T_3$ = 60% recommended doses of NPKSZn + green manure 7 ton ha$^{-1}$, $T_4$ = 40% recommended doses of NPKSZn + green manure 10.5 ton ha$^{-1}$, $T_5$ = 20% recommended doses of NPKSZn + green manure 14 ton ha$^{-1}$ and $T_6$ = green manure 17.5 ton ha$^{-1}$

## 4.2 Yield components of aman rice

### 4.2.1 Number of Effective tillers hill$^{-1}$ (no.)

#### 4.2.1.1 Effect of varietal variation

Significant variation was observed on number of number of effective tillers hill$^{-1}$ among the varieties in aman rice (Figure 09). The figure showed that the highest number of effective tillers hill$^{-1}$ (12.74) was found in BRRI dhan34 followed by Kataribhog (11.86). The lowest number of effective tillers hill$^{-1}$ was obtained in Raniselute (9.04). The result indicated that BRRI dhan34 produced 40.92% higher effective tillers hill$^{-1}$ than Raniselute. The probable reason of the differences in producing number of effective tillers hill$^{-1}$ may be the genetic make-up of the variety which is primarily influenced by heredity. These findings collaborate with those reported by Shiyam *et al.* (2014), Roy *et al.* (2014), BINA (1998), Om *et al.* (1998) and Bhowmick and Nayak (2000) who stated that number of effective tillers hill$^{-1}$ was varied with variety.

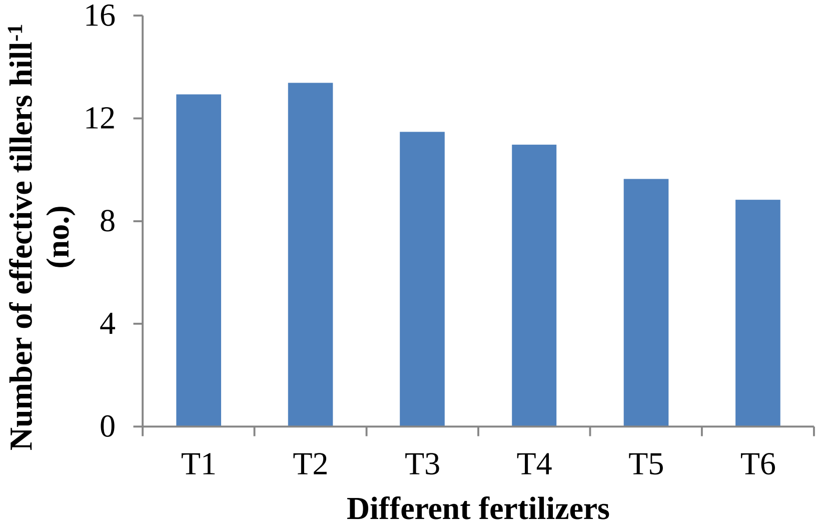



$V_1$: Kataribhog, $V_2$: Raniselute and $V_3$: BRRI dhan34

**Figure 09. Effect of varietal variation on the number of effective tillers hill$^{-1}$ of rice** (LSD $_{(0.05)}$ = 1.23)

#### 4.2.1.2 Effect of fertilizer management

Number of effective tillers hill$^{-1}$ was significantly affected due to different fertilizer management at 5 % level of significance (Figure 10). The highest number of effective tillers (13.39) hill$^{-1}$ was obtained due to application of treatment $T_2$ which was statistically similar with $T_1$. The lowest number of effective tillers (8.83) hill$^{-1}$ was obtained in $T_6$ which was statistically similar with $T_5$. The results agreed with the findings of Manzoor *et al.* (2006) and Kandil *et al.* (2010).




$T_1$ = Recommended doses of NPKSZn
$T_2$ = 80% recommended doses of NPKSZn + Green Manure 3.5 ton ha$^{-1}$
$T_3$ = 60% recommended doses of NPKSZn + Green Manure 7 ton ha$^{-1}$
$T_4$ = 40% recommended doses of NPKSZn + Green Manure 10.5 ton ha$^{-1}$
$T_5$ = 20% recommended doses of NPKSZn + Green Manure 14 ton ha$^{-1}$
$T_6$ = Green Manure 17.5 ton ha$^{-1}$

**Figure 10. Effect of fertilizer management on the number of effective tillers hill$^{-1}$ of rice** (LSD $_{(0.05)}$ = 0.92)

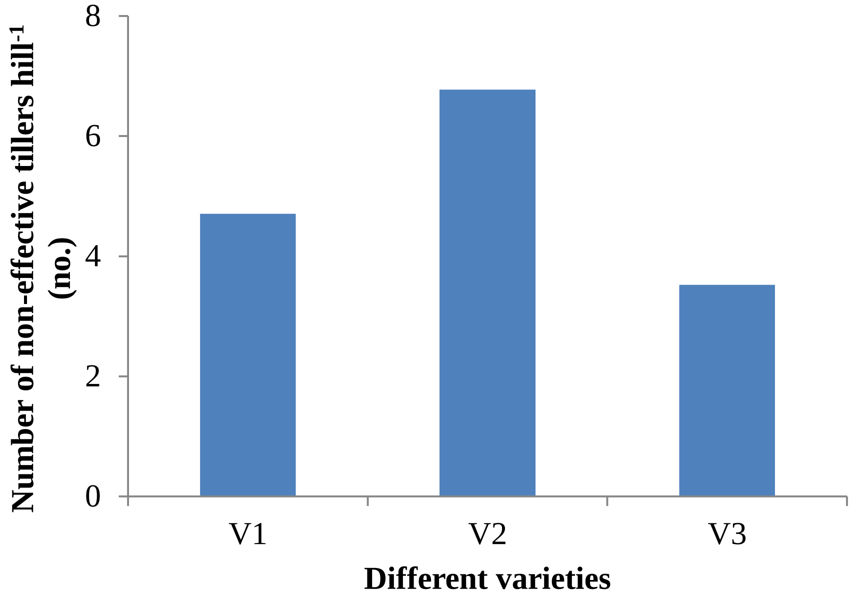
#### 4.2.1.3 Interaction effect of varietal variation and fertilizer management

Significant interaction between variety and fertilizer management was found in producing number of effective tillers hill$^{-1}$ (Table 05). The highest number of effective tillers hill$^{-1}$ (15.50) was counted in the interaction of $V_3T_2$ which was statistically similar with $V_1T_2$ and $V_3T_1$. The lowest number of effective tillers hill$^{-1}$ (6.67) was counted in $V_2T_6$ interaction treatment which was statistically similar with $V_2T_5$.

### 4.2.2 Number of non-effective tillers hill$^{-1}$ (no.)

#### 4.2.2.2 Effect of varietal variation

Number of non-effective tillers hill$^{-1}$ exerted significant difference among the varieties (Figure 11). The highest number of non-effective tillers hill$^{-1}$ (6.77) was obtained in Raniselute followed by Kataribhog (4.71). The lowest number of non-effective tillers hill$^{-1}$ was produced by BRRI dhan34 (3.52). The results agreed with the findings of Shiyam *et al.* (2014) and Roy *et al.* (2014).

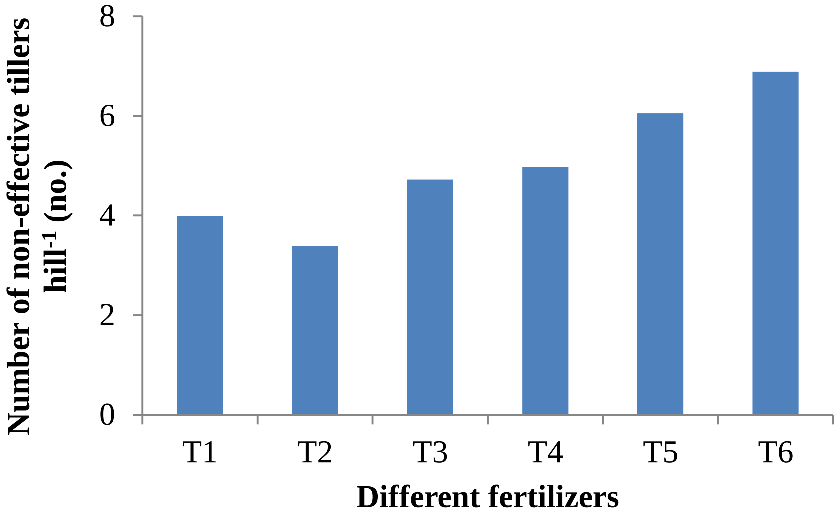



$V_1$: Kataribhog, $V_2$: Raniselute and $V_3$: BRRI dhan34

**Figure 11. Effect of varietal variation on the number of non-effective tillers hill$^{-1}$ of rice** (LSD $_{(0.05)}$ = 2.24)

### 4.2.2.2 Effect of fertilizer management

Number of non-effective tillers hill$^{-1}$ due to different fertilizer management has been shown in Figure 12. The highest number of non-effective tillers hill$^{-1}$ (6.88) was found at $T_6$ which was statistically identical with $T_5$ and the lowest number of non-effective tillers hill$^{-1}$ (3.38) was found due to the application of $T_2$ treatment which was statistically similar with $T_1$. The results agreed with the findings of Mannan *et al.* (2010) and Islam *et al.* (2008).




$T_1$ = Recommended doses of NPKSZn
$T_2$ = 80% recommended doses of NPKSZn + Green Manure 3.5 ton ha$^{-1}$
$T_3$ = 60% recommended doses of NPKSZn + Green Manure 7 ton ha$^{-1}$
$T_4$ = 40% recommended doses of NPKSZn + Green Manure 10.5 ton ha$^{-1}$
$T_5$ = 20% recommended doses of NPKSZn + Green Manure 14 ton ha$^{-1}$
$T_6$ = Green Manure 17.5 ton ha$^{-1}$

**Figure 12. Effect of fertilizer management on the number of non-effective tillers hill$^{-1}$ of rice** (LSD $_{(0.05)}$ = 0.87)

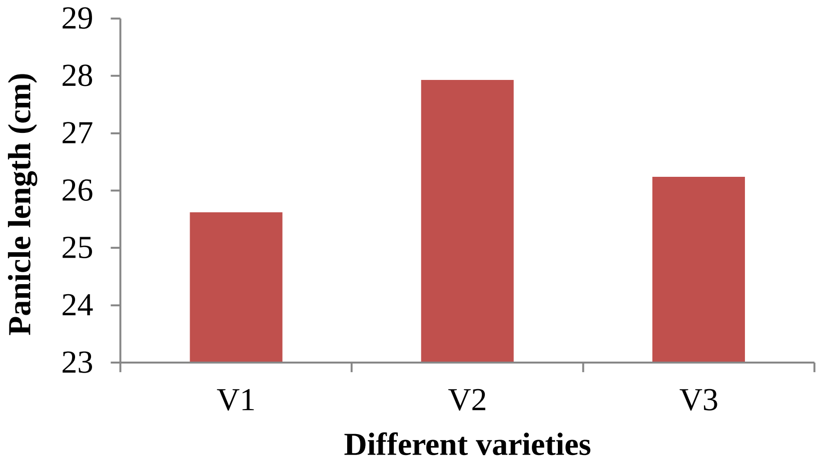
#### 4.2.2.3 Interaction effect of varietal variation and fertilizer management

Significant interaction between variety and fertilizer management was found on number of non-effective tillers hill$^{-1}$ (Table 05). The highest number of non-effective tillers hill$^{-1}$ (9.99) was recorded from the interaction of $V_2T_6$ and the lowest number of non-effective tillers hill$^{-1}$ (2.16) was recorded from the interaction of $V_3T_2$ which was statistically similar with $V_1T_1$, $V_1T_2$, $V_3T_1$ and $V_3T_4$.

### 4.2.3 Panicle length (cm)

#### 4.2.3.1 Effect of varietal variation

Significant variation was observed on panicle length among the varieties in aman rice (Figure 13). The figure showed that the maximum panicle length (27.93) was found in Raniselute which is statistically different from others. The minimum panicle length was obtained in Kataribhog (25.62). The results agreed with the findings of Hossain *et al.* (2014) and Sarker *et al.* (2013).

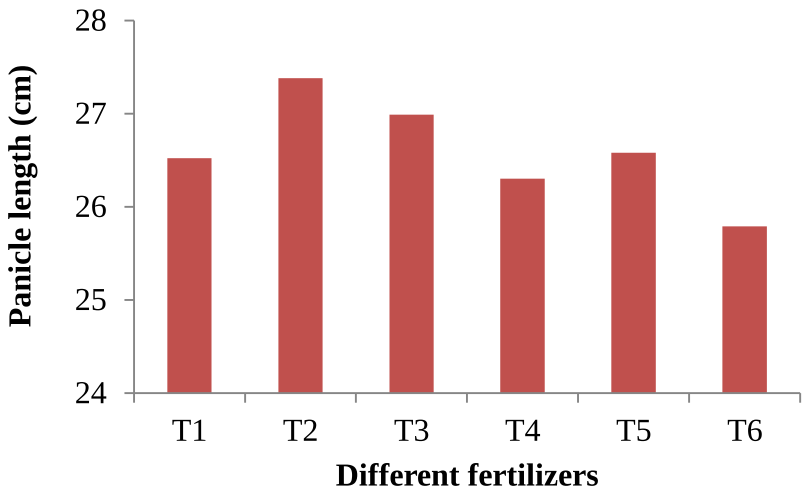



$V_1$: Kataribhog, $V_2$: Raniselute and $V_3$: BRRI dhan34

**Figure 13. Effect of varietal variation on the panicle length of rice** (LSD $_{(0.05)}$ = 0.14)

**4.2.3.2 Effect of fertilizer management**

Panicle length was significantly affected due to different fertilizer management at 5 % level of significance (Figure 14). The maximum panicle length (27.38) was obtained due to application of treatment $T_2$ which was statistically different from others. The minimum panicle length (25.79) was obtained in $T_6$. The results agreed with the findings of Mannan *et al.* (2010), Kandil *et al.* (2010) and Islam *et al.* (2008).




$T_1$ = Recommended doses of NPKSZn
$T_2$ = 80% recommended doses of NPKSZn + Green Manure 3.5 ton ha$^{-1}$
$T_3$ = 60% recommended doses of NPKSZn + Green Manure 7 ton ha$^{-1}$
$T_4$ = 40% recommended doses of NPKSZn + Green Manure 10.5 ton ha$^{-1}$
$T_5$ = 20% recommended doses of NPKSZn + Green Manure 14 ton ha$^{-1}$
$T_6$ = Green Manure 17.5 ton ha$^{-1}$

**Figure 14. Effect of fertilizer management on the panicle length of rice** (LSD $_{(0.05)}$ = 0.19)

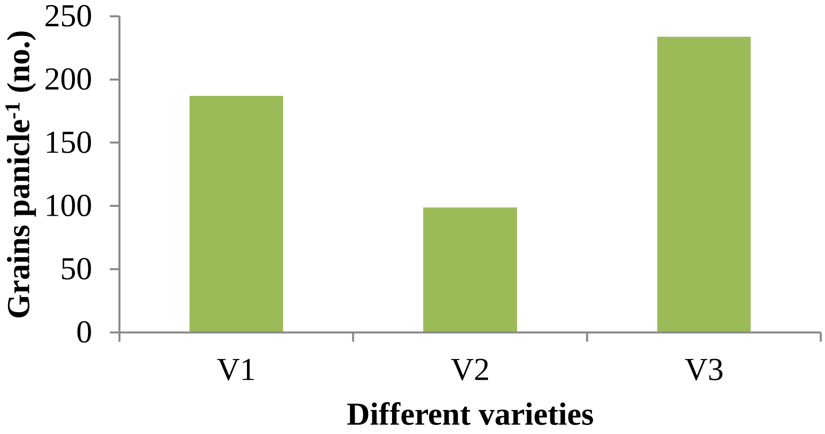
#### 4.2.3.3 Interaction effect of varietal variation and fertilizer management

Significant interaction between variety and fertilizer management was found on panicle length (Table 05). The maximum panicle length (29.29) was recorded from the interaction of $V_2T_2$ and the minimum panicle length (24.92) was recorded from the interaction of $V_1T_6$ which was statistically similar with $V_1T_4$ and $V_3T_1$.

### 4.2.4 Grains panicle$^{-1}$ (No.)

#### 4.2.4.1 Effect of varietal variation

Significant variation was observed on the number of grains panicle$^{-1}$ among the varieties in aman rice (Figure 15). The figure showed that the highest number of grains panicle$^{-1}$ (233.90) was found in BRRI dhan34 which is statistically different from others. The lowest number of grains panicle$^{-1}$ was obtained in Raniselute (98.67). Hossain *et al.* (2014) and Sarker *et al.* (2013) also find the similar results.

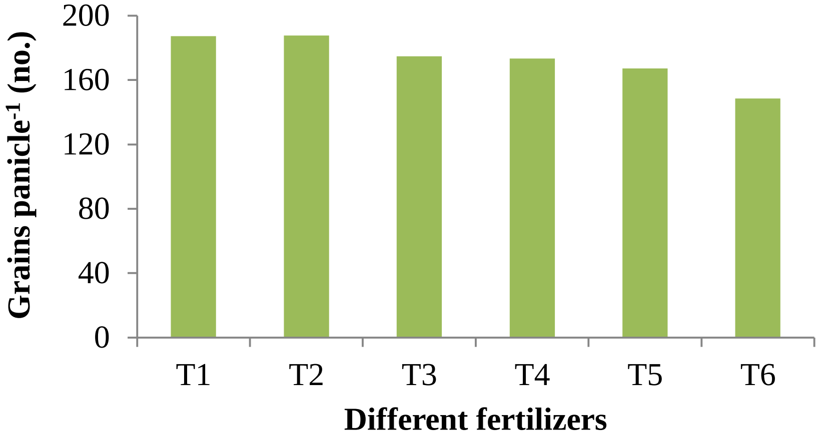



$V_1$: Kataribhog, $V_2$: Raniselute and $V_3$: BRRI dhan34

**Figure 15. Effect of varietal variation on the grains panicle$^{-1}$ of rice** (LSD $_{(0.05)}$ = 21.36)

#### 4.2.4.2 Effect of fertilizer management

Number of grains panicle$^{-1}$ was significantly affected due to different fertilizer management at 5 % level of significance (Figure 16). The highest number of grains panicle$^{-1}$ (187.80) was obtained due to application of treatment $T_2$ which was statistically similar with $T_1$, $T_3$ and $T_4$. The lowest number of grains panicle$^{-1}$ (148.60) was obtained in $T_6$.




$T_1$ = Recommended doses of NPKSZn
$T_2$ = 80% recommended doses of NPKSZn + Green Manure 3.5 ton $ha^{-1}$
$T_3$ = 60% recommended doses of NPKSZn + Green Manure 7 ton $ha^{-1}$
$T_4$ = 40% recommended doses of NPKSZn + Green Manure 10.5 ton $ha^{-1}$
$T_5$ = 20% recommended doses of NPKSZn + Green Manure 14 ton $ha^{-1}$
$T_6$ = Green Manure 17.5 ton $ha^{-1}$

**Figure 16. Effect of fertilizer management on the grains panicle$^{-1}$ of rice** (LSD $_{(0.05)}$ = 15.63)

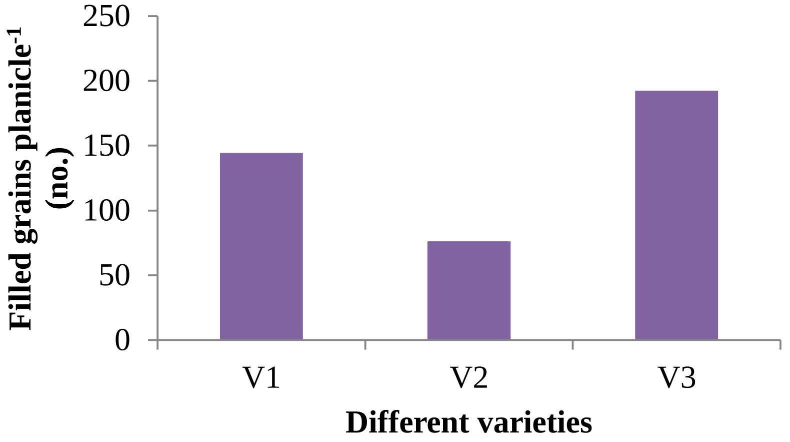
#### 4.2.4.3 Interaction effect of varietal variation and fertilizer management

Significant interaction between variety and fertilizer management was found on number of grains panicle$^{-1}$ (Table 05). The highest number of grains panicle$^{-1}$ (252.10) was recorded from the interaction of $V_3T_2$ which was statistically similar with $V_3T_1$, $V_3T_3$, $V_3T_4$ and $V_3T_5$. The lowest number of grains panicle$^{-1}$ (87.78) was recorded from the interaction of $V_2T_6$ which was statistically similar with $V_2T_2$, $V_2T_3$, $V_2T_4$ and $V_2T_5$.

### 4.2.5 Filled grain panicle$^{-1}$ (no.)

#### 4.2.5.1 Effect of varietal variation

Variety differed significantly in production of number of filled grains panicle$^{-1}$ (Figure 17). The highest number of filled grains panicle$^{-1}$ (192.50) was observed in BRRI dhan34 and the lowest number of filled grains panicle$^{-1}$ (76.11) was obtained in Raniselute. The result showed that BRRI dhan34 ($V_3$) produced 152.92 % higher filled grains panicle$^{-1}$ than Raniselute ($V_2$). Similar results were also found by several authors (Shiyam *et al.*, 2014; Hossain *et al.*, 2014; and Sarker *et al.*, 2013).

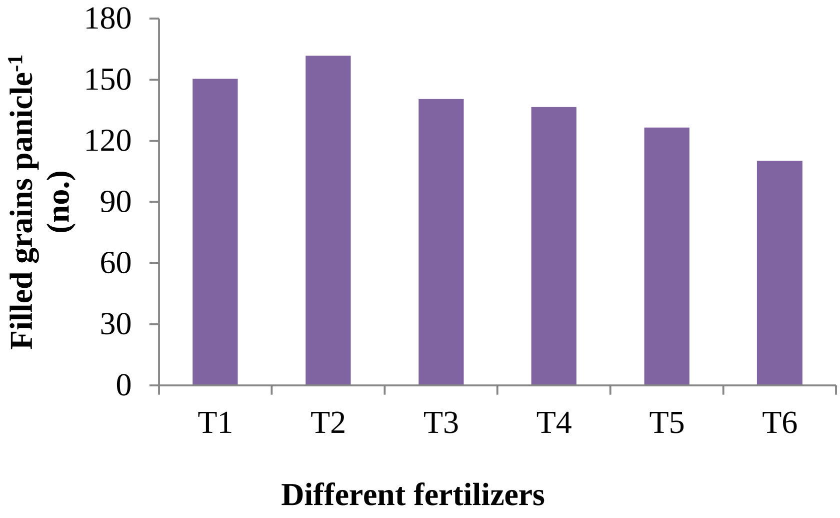



$V_1$: Kataribhog, $V_2$: Raniselute and $V_3$: BRRI dhan34

**Figure 17. Effect of varietal variation on the filled grains panicle$^{-1}$ of rice** (LSD $_{(0.05)}$ = 11.84)

#### 4.2.5.2 Effect of fertilizer management

Different fertilizer management showed significant variation on production of filled grains panicle$^{-1}$ (Figure 18). The figure showed that the lowest number of filled grains panicle$^{-1}$ (110.10) was obtained from $T_6$, whereas the highest number of filled grains panicle$^{-1}$ was obtained by the application of treatment $T_2$ (161.70) which is statistically similar with $T_1$. Treatment $T_2$ produced 46.87% higher number of filled grains panicle$^{-1}$ than treatment $T_6$.




$T_1$ = Recommended doses of NPKSZn
$T_2$ = 80% recommended doses of NPKSZn + Green Manure 3.5 ton ha$^{-1}$
$T_3$ = 60% recommended doses of NPKSZn + Green Manure 7 ton ha$^{-1}$
$T_4$ = 40% recommended doses of NPKSZn + Green Manure 10.5 ton ha$^{-1}$
$T_5$ = 20% recommended doses of NPKSZn + Green Manure 14 ton ha$^{-1}$
$T_6$ = Green Manure 17.5 ton ha$^{-1}$

**Figure 18. Effect of fertilizer management on the filled grains panicle$^{-1}$ of rice** (LSD $_{(0.05)}$ = 12.32)

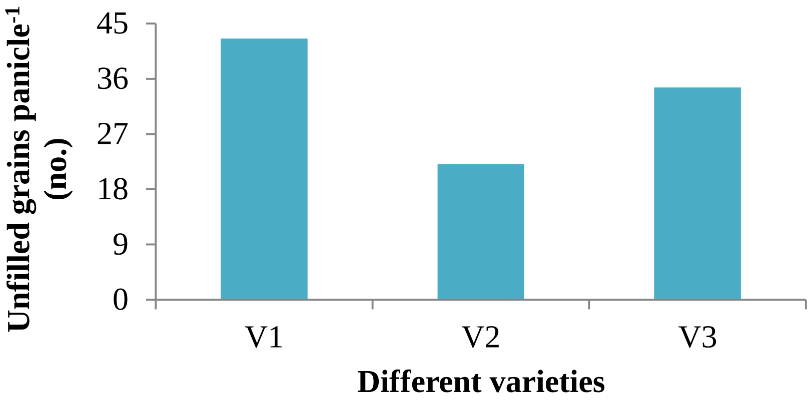
#### 4.2.5.3 Interaction effect of varietal variation and fertilizer management

Significant interaction between variety and fertilizer management was observed on filled grains panicle$^{-1}$ (Table 05). The highest number of filled grains panicle$^{-1}$ (212.80) was noted in the interaction of $V_3T_2$ which was statistically similar with $V_3T_1$ and $V_3T_3$. The lowest number of filled grains panicle$^{-1}$ (58.33) was obtained in the interaction treatment of $V_2T_6$ which was statistically similar with $V_2T_3$, $V_2T_4$ and $V_2T_5$.

### 4.2.6 Unfilled grain panicle$^{-1}$ (no.)

#### 4.2.6.1 Effect of varietal variation

A significant variation was observed among the varieties on the number of unfilled grains panicle$^{-1}$ (Figure 19). The highest number of unfilled grains panicle$^{-1}$ (42.55) was obtained in Kataribhog ($V_1$) and the lowest number of unfilled grains panicle$^{-1}$ (22.08) was obtained in Raniselute ($V_2$). BINA (1993) observed the similar result that the production of unfilled grains panicle differed with variety to variety.

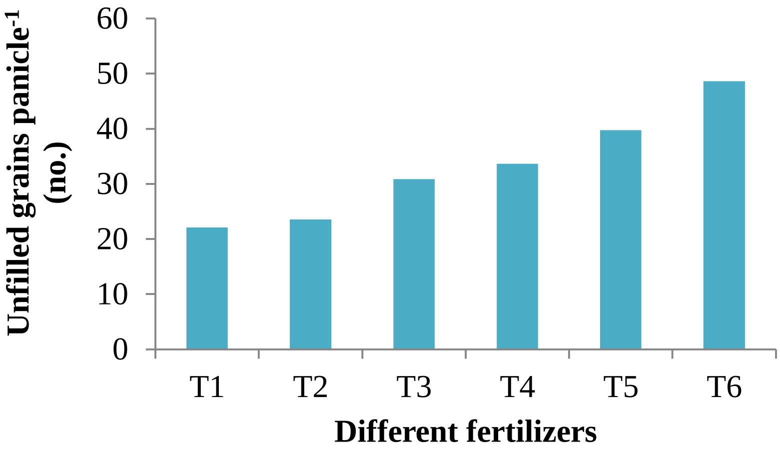



$V_1$: Kataribhog, $V_2$: Raniselute and $V_3$: BRRI dhan34

**Figure 19. Effect of varietal variation on the unfilled grains panicle$^{-1}$ of rice** (LSD $_{(0.05)}$ = 2.67)

#### 4.2.6.2 Effect of fertilizer management

Different fertilizer management had significant influence on the unfilled grains panicle$^{-1}$ (Figure 20). The figure showed that lowest (22.11) number of unfilled grain was obtained due to the application of treatment $T_1$ which was statistically similar with $T_2$. The highest (48.63) number of unfilled grain panicle$^{-1}$ was obtained due to $T_6$ treatment.




$T_1$ = Recommended doses of NPKSZn
$T_2$ = 80% recommended doses of NPKSZn + Green Manure 3.5 ton ha$^{-1}$
$T_3$ = 60% recommended doses of NPKSZn + Green Manure 7 ton ha$^{-1}$
$T_4$ = 40% recommended doses of NPKSZn + Green Manure 10.5 ton ha$^{-1}$
$T_5$ = 20% recommended doses of NPKSZn + Green Manure 14 ton ha$^{-1}$
$T_6$ = Green Manure 17.5 ton ha$^{-1}$

**Figure 20. Effect of fertilizer management on the unfilled grains panicle$^{-1}$ of rice** (LSD $_{(0.05)}$ = 4.07).

### 4.2.6.3 Interaction effect of varietal variation and fertilizer management

A significant interaction between variety and fertilizer management was observed on unfilled grains panicle (Table 05). The highest number of unfilled grains panicle$^{-1}$ (75.55) was found in $V_1T_6$ and the lowest number of unfilled grains panicle$^{-1}$ (15.00) was counted in the treatment of $V_2T_1$ which was statistically similar with $V_2T_2$.

**Table 05. Interaction effect of varietal variation and fertilizer management on effective tillers hill$^{-1}$, non-effective tillers hill$^{-1}$, panicle length, grains panicle$^{-1}$, filled grains panicle$^{-1}$ and unfilled grains panicle$^{-1}$ of rice**

| Treatment combinations | Effective tillers hill$^{-1}$ (no.) | Non-effective tillers hill$^{-1}$ (no.) | Panicle length (cm) | Grains panicle$^{-1}$ (no.) | Filled grain panicle$^{-1}$ (no.) | Un-filled grain panicle$^{-1}$ (no.) |
|---|---|---|---|---|---|---|
| $V_1T_1$ | 12.83 cd | 3.66 g-i | 26.19 fg | 197.7 c | 160.7 de | 27.67 fg |
| $V_1T_2$ | 14.66 ab | 3.33 g-i | 26.22 fg | 205.9 bc | 178.2 cd | 22.11 g |
| $V_1T_3$ | 12.00 de | 4.50 e-g | 25.41 h | 187.2 cd | 146.8 ef | 37.33 c-e |
| $V_1T_4$ | 11.78 d-f | 4.43 e-g | 25.05 i | 186.7 cd | 142.8 ef | 40.66 cd |
| $V_1T_5$ | 10.22 f-i | 6.00 cd | 25.92 g | 179.0 cd | 125.9 fg | 52.00 b |
| $V_1T_6$ | 9.67 hi | 6.33 bc | 24.92 i | 165.0 d | 112.0 gh | 75.55 a |
| $V_2T_1$ | 11.72 d-g | 5.81 c-f | 28.31 c | 114.9 e | 82.00 ij | 15.00 h |
| $V_2T_2$ | 10.00 hi | 4.66 d-g | 29.29 a | 105.3 ef | 94.11 hi | 20.78 gh |
| $V_2T_3$ | 9.277 h-j | 5.83 c-e | 28.92 b | 101.0 ef | 76.55 i-k | 22.33 g |
| $V_2T_4$ | 8.667 ij | 6.84 bc | 27.44 d | 92.89 ef | 77.89 i-k | 23.33 g |
| $V_2T_5$ | 7.89 jk | 7.50 b | 27.15 d | 90.11 ef | 67.78 jk | 24.67 g |
| $V_2T_6$ | 6.67 k | 9.99 a | 26.47 ef | 87.78 f | 58.33 k | 26.34 fg |
| $V_3T_1$ | 14.28 a-c | 2.50 hi | 25.05 i | 249.4 a | 208.9 ab | 23.67 g |
| $V_3T_2$ | 15.50 a | 2.16 i | 26.63 e | 252.1 a | 212.8 a | 27.67 fg |
| $V_3T_3$ | 13.17 b-d | 3.83 gh | 26.65 e | 235.8 a | 198.1 a-c | 32.89 ef |
| $V_3T_4$ | 12.50 d | 3.65 g-i | 26.42 ef | 241.0 a | 189.0 bc | 36.89 de |
| $V_3T_5$ | 10.81 e-h | 4.67 d-g | 26.69 e | 232.4 ab | 186.0 c | 42.56 cd |
| $V_3T_6$ | 10.17 g-i | 4.33 fg | 25.98 g | 192.9 c | 160.1 de | 44.00 c |
| **LSD $_{(0.05)}$** | **1.59** | **1.50** | **0.34** | **27.07** | **21.34** | **7.05** |
| **CV (%)** | **8.5** | **17.97** | **0.76** | **9.38** | **9.3** | **12.78** |

In a column, means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 5% level of probability

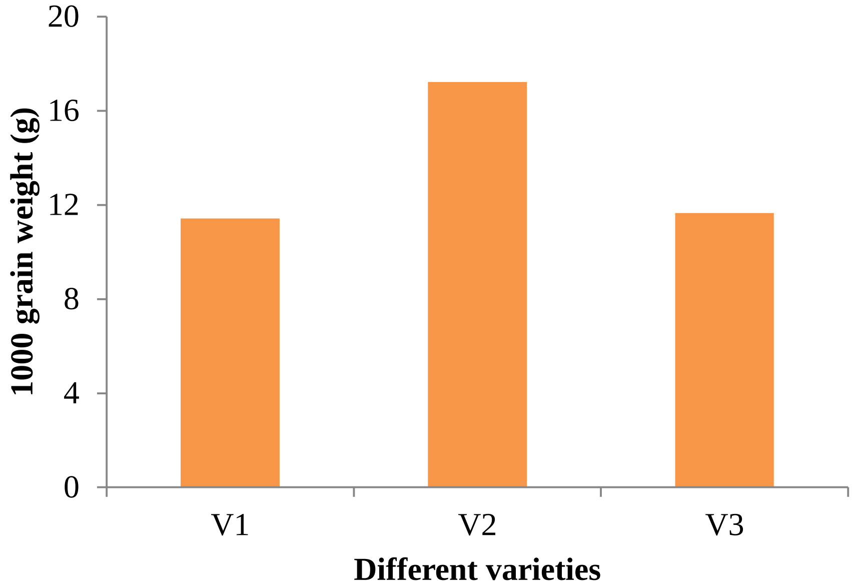
$V_1$: Kataribhog, $V_2$: Raniselute and $V_3$: BRRI dhan34

$T_1$ = Recommended doses of NPKSZn, $T_2$ = 80% recommended doses of NPKSZn + green manure 3.5 ton ha$^{-1}$, $T_3$ = 60% recommended doses of NPKSZn + green manure 7 ton ha$^{-1}$, $T_4$ = 40% recommended doses of NPKSZn + green manure 10.5 ton ha$^{-1}$, $T_5$ = 20% recommended doses of NPKSZn + green manure 14 ton ha$^{-1}$ and $T_6$ = green manure 17.5 ton ha$^{-1}$

#### 4.2.7 Weight of 1000–grains (g)

#### 4.2.7.1 Effect of varietal variation

Variety had significant effect on the weight of 1000-grains. The highest 1000 grain weight (17.22 g) was observed in Raniselute ($V_2$) and the lowest weight (11.43 g) was observed in Kataribhog ($V_1$) (Figure 21). The result showed that Raniselute produced 50.65% heavier seed than Kataribhog. The results agreed with the findings of Shiyam *et al.* (2014) and Sarker *et al.* (2013).

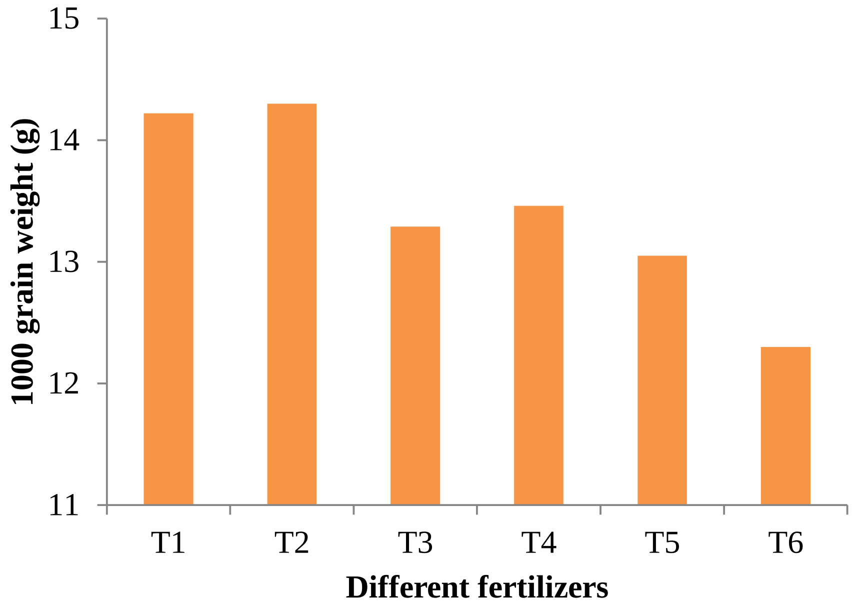



$V_1$: Kataribhog, $V_2$: Raniselute and $V_3$: BRRI dhan34

**Figure 21. Effect of varietal variation on the 1000 grain weight of rice** (LSD $_{(0.05)}$ = 0.79)

#### 4.2.7.2 Effect of fertilizer management

The weight of 1000 grains was significantly influenced by the different levels of fertilizer (Figure 22). The highest weight (14.30 g) of 1000-grains was recorded due to application of treatment $T_2$ followed by treatment $T_1$ (14.22 g) and $T_4$ (13.46 g). The lowest weight (12.30 g) of 1000-grain was recorded from the $T_6$ treatment. The results agreed with the findings of Mannan *et al.* (2010) and Manzoor *et al.* (2006).




$T_1$ = Recommended doses of NPKSZn
$T_2$ = 80% recommended doses of NPKSZn + Green Manure 3.5 ton $ha^{-1}$
$T_3$ = 60% recommended doses of NPKSZn + Green Manure 7 ton $ha^{-1}$
$T_4$ = 40% recommended doses of NPKSZn + Green Manure 10.5 ton $ha^{-1}$
$T_5$ = 20% recommended doses of NPKSZn + Green Manure 14 ton $ha^{-1}$
$T_6$ = Green Manure 17.5 ton $ha^{-1}$

**Figure 22. Effect of fertilizer management on the 1000 grain weight of rice** (LSD $_{(0.05)}$ = 0.95)

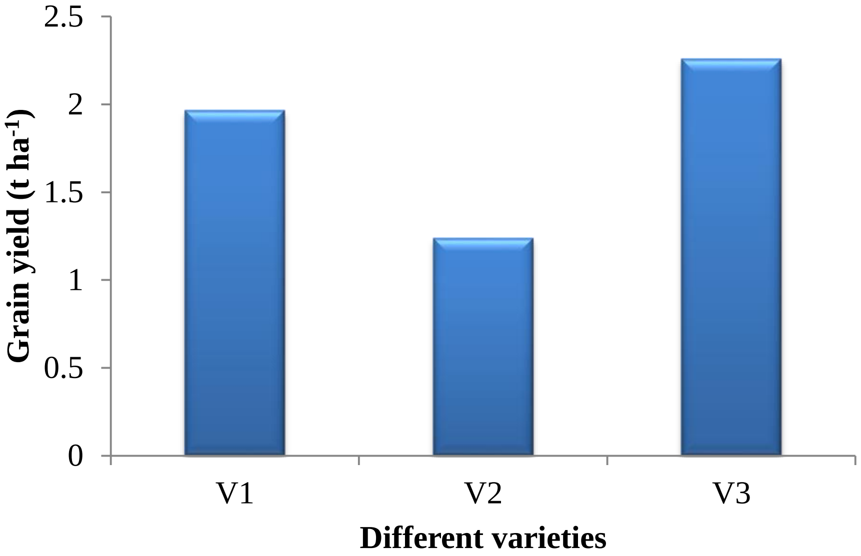
#### 4.2.7.3 Interaction effect of varietal variation and fertilizer management

A significant interaction between variety and fertilizer management was found on the weight of 1000-grains (Table 06). The maximum weight of 1000-grains (18.37 g) was obtained in the interaction of $V_2T_2$ treatment that was statistically similar with the interaction of $V_2T_1$, $V_2T_3$ and $V_2T_5$. The minimum weight of 1000-grains (10.57 g) was obtained in the interaction of $V_1T_6$ that was statistically similar with $V_1T_2$, $V_1T_3$, $V_1T_4$, $V_1T_5$, $V_3T_3$, $V_3T_4$, $V_3T_5$ and $V_3T_6$. The result also showed that Raniselute produced higher level of 1000-grains weight than other interactions irrespective of different levels of fertilizer.

### 4.2.8 Grain yield (t $ha^{-1}$)

#### 4.2.8.1 Effect of varietal variation

Varieties differed significantly in producing grain yield (Figure 23). Among the varieties, BRRI dhan34 showed its superiority in producing highest grain yield which was 82.26% and 15.31% higher than Raniselute and Kataribhog, respectively. However, BRRI dhan34 ($V_3$) produced the highest grain yield (2.26 t $ha^{-1}$) which was statistically different from others. The lowest grain yield (1.24 t $ha^{-1}$) was found in Raniselute ($V_2$). The results agreed with the findings of Hossain *et al.* (2014), Shiyam *et al.* (2014) and Sarker *et al.* (2013).

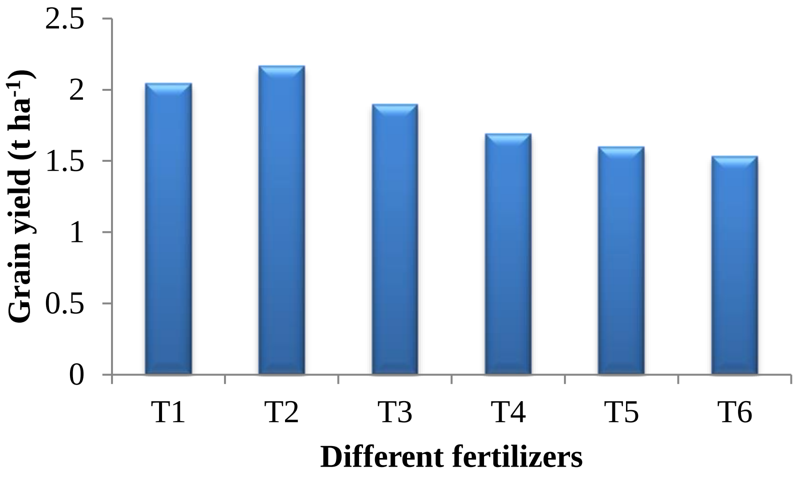



$V_1$: Kataribhog, $V_2$: Raniselute and $V_3$: BRRI dhan34

**Figure 23. Effect of varietal variation on the grain yield of rice** (LSD $_{(0.05)}$ = 0.17)

**4.2.8.2 Effect of fertilizer management**

Grain yield was significantly influenced by different sources of nitrogen (Figure 24). The maximum grain yield (2.17 t $ha^{-1}$) was obtained due to application of treatment $T_2$ followed by treatment $T_1$ (2.04 t $ha^{-1}$). The minimum grain yield (1.53 t $ha^{-1}$) was obtained due to application of treatment $T_6$ followed by treatment $T_4$ and $T_5$. Among the different levels of fertilizer, $T_2$ produced 41.83% higher grain than $T_6$ treatment. Improvement of yield component such as number of effective tillers $hill^{-1}$ and number of grains $panicle^{-1}$ in these treatments ultimately resulted in high yield of grains. The results agreed with the findings of Mannan *et al.* (2010), Kandil *et al.* (2010), Islam *et al.* (2008) and Manzoor *et al.* (2006).




$T_1$ = Recommended doses of NPKSZn
$T_2$ = 80% recommended doses of NPKSZn + Green Manure 3.5 ton $ha^{-1}$
$T_3$ = 60% recommended doses of NPKSZn + Green Manure 7 ton $ha^{-1}$
$T_4$ = 40% recommended doses of NPKSZn + Green Manure 10.5 ton $ha^{-1}$
$T_5$ = 20% recommended doses of NPKSZn + Green Manure 14 ton $ha^{-1}$
$T_6$ = Green Manure 17.5 ton $ha^{-1}$

**Figure 24. Effect of fertilizer management on the grain yield of rice** (LSD $_{(0.05)}$ = 0.16)

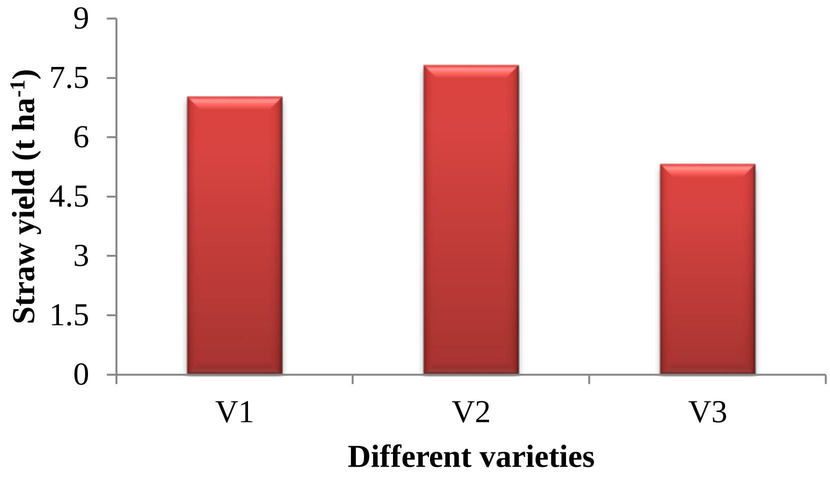
#### 4.2.8.3 Interaction effect of varietal variation and fertilizer management

Grain yield influenced significantly by the interaction of variety and fertilizer management (Table 06). Among the interaction treatments, the highest grain yield (2.67 t $ha^{-1}$) was recorded in the interaction of $V_3T_2$ followed by $V_3T_1$ (2.45 t $ha^{-1}$). The lowest grain yield (0.92 t $ha^{-1}$) was observed in $V_2T_6$ followed by $V_2T_4$ and $V_2T_5$.

### 4.2.9 Straw yield (t $ha^{-1}$)

#### 4.2.9.1 Effect of varietal variation

Straw yield differed significantly due to varietal variations (Figure 25). Raniselute ($V_2$) gave the highest straw yield (7.81 t $ha^{-1}$) and the lowest straw yield was found in BRRI dhan34 ($V_3$) (5.31 t $ha^{-1}$). The differences in straw yield among the varieties might be attributed to the genetic makeup of the varieties. Several researchers also obtained variable straw yield among the varieties (Chowdhury *et al.*, 1993; Kumar *et al.*, 1995; and Patel, 2000).

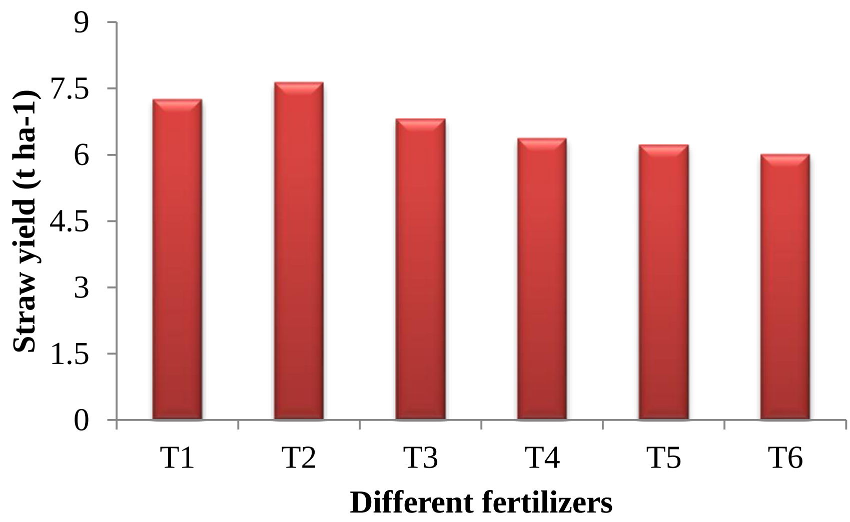



$V_1$: Kataribhog, $V_2$: Raniselute and $V_3$: BRRI dhan34

**Figure 25. Effect of varietal variation on the straw yield of rice** (LSD $_{(0.05)}$ = 0.47)

**4.2.9.2 Effect of fertilizer management**

Straw yield varied significantly with the different levels of fertilizer (Figure 26). Straw yield was recorded highest (7.64 t ha$^{-1}$) at treatment $T_2$ followed by treatment $T_1$ (7.25 t ha$^{-1}$). The lowest straw yield (6.00 t ha$^{-1}$) was found in $T_6$ treatment followed by $T_4$ and $T_5$.




$T_1$ = Recommended doses of NPKSZn
$T_2$ = 80% recommended doses of NPKSZn + Green Manure 3.5 ton ha$^{-1}$
$T_3$ = 60% recommended doses of NPKSZn + Green Manure 7 ton ha$^{-1}$
$T_4$ = 40% recommended doses of NPKSZn + Green Manure 10.5 ton ha$^{-1}$
$T_5$ = 20% recommended doses of NPKSZn + Green Manure 14 ton ha$^{-1}$
$T_6$ = Green Manure 17.5 ton ha$^{-1}$

**Figure 26. Effect of fertilizer management on the straw yield of rice** (LSD $_{(0.05)}$ = 0.62)

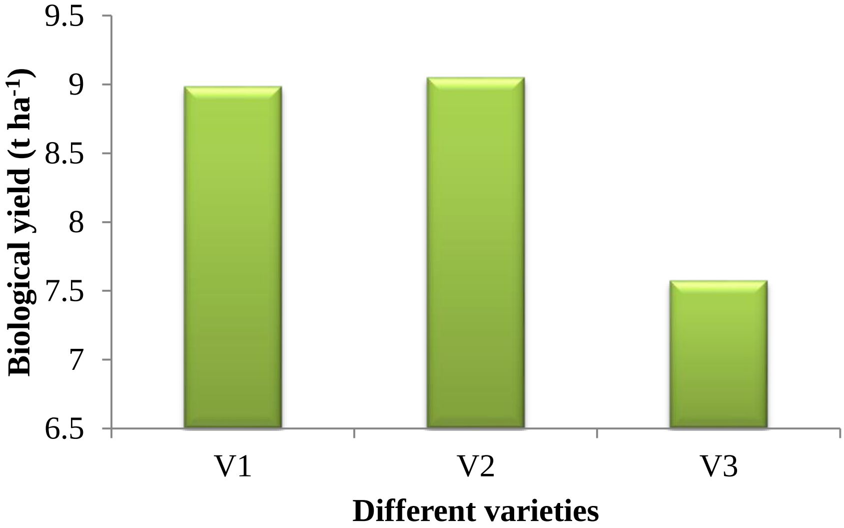
#### 4.2.9.3 Interaction effect of varietal variation and fertilizer management

There were observed a significant difference among the interactions of varietal variation and fertilizer management in respect of straw yield (Table 06). The maximum straw yield (8.80 t $ha^{-1}$) was found from the interaction of $V_2T_2$ followed by $V_2T_1$ and $V_2T_3$. The minimum straw yield (4.49 t $ha^{-1}$) was found from the interaction of $V_3T_6$ followed by $V_3T_3$, $V_3T_4$ and $V_3T_5$.

### 4.2.10 Biological Yield (t $ha^{-1}$)

#### 4.2.10.1 Effect of varietal variation

Significant variation in biological yield was observed due to varietal variations and it ranges from 7.57 - 9.05 t $ha^{-1}$ (Figure 27). The highest and lowest biological yield were obtained from Raniselute ($V_2$) and BRRI dhan34 ($V_3$), respectively. The biological yield of Raniselute was statistically similar with Kataribhog.

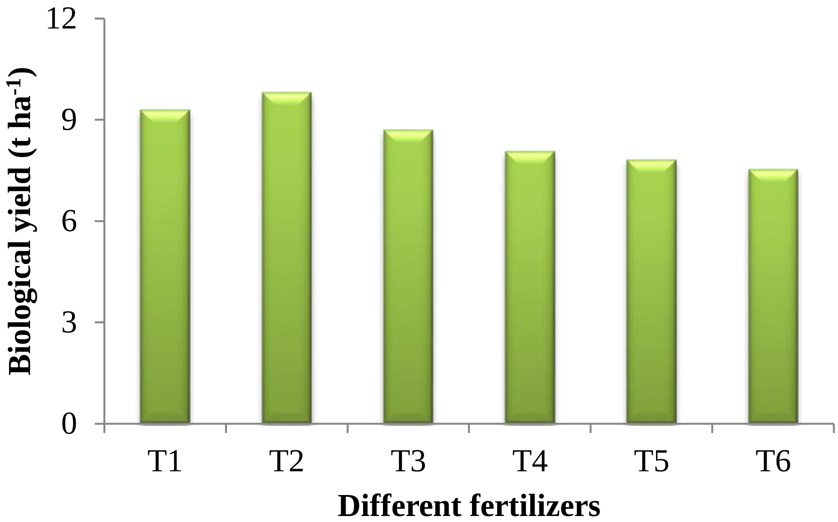



$V_1$: Kataribhog, $V_2$: Raniselute and $V_3$: BRRI dhan34

**Figure 27. Effect of varietal variation on the biological yield of rice** (LSD $_{(0.05)}$ = 0.63)

#### 4.2.10.2 Effect of fertilizer management

Biological yield differed significantly due to the different levels of fertilizer (Figure 28).Treatment $T_2$ produced the highest biological yield (9.80 t $ha^{-1}$) which was statistically similar with $T_1$ and the lowest biological yield (7.53 t $ha^{-1}$) was recorded at $T_6$ which was statistically similar with $T_4$ and $T_5$.




$T_1$ = Recommended doses of NPKSZn
$T_2$ = 80% recommended doses of NPKSZn + Green Manure 3.5 ton $ha^{-1}$
$T_3$ = 60% recommended doses of NPKSZn + Green Manure 7 ton $ha^{-1}$
$T_4$ = 40% recommended doses of NPKSZn + Green Manure 10.5 ton $ha^{-1}$
$T_5$ = 20% recommended doses of NPKSZn + Green Manure 14 ton $ha^{-1}$
$T_6$ = Green Manure 17.5 ton $ha^{-1}$

**Figure 28. Effect of fertilizer management on the biological yield of rice** (LSD $_{(0.05)}$ = 0.61)

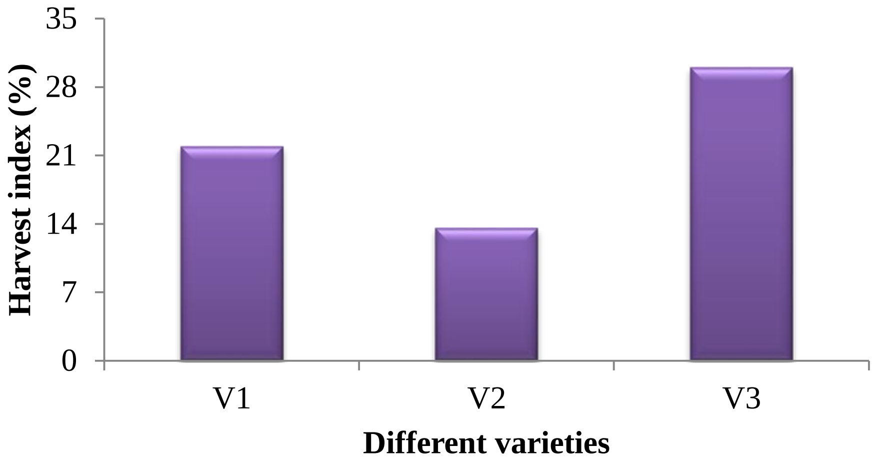
### 4.2.10.3 Interaction effect of varietal variation and fertilizer management

Significant variation in biological yield was observed in the interaction effect of varietal variation and fertilizer management (Table 06). The results showed that the interaction of $V_2T_2$ gave the highest biological yield (10.43 t $ha^{-1}$) which was statistically similar with $V_1T_1$, $V_1T_2$, $V_2T_1$ and $V_2T_3$ . The lowest biological yield (6.41 t $ha^{-1}$) was found in $V_3T_6$ interaction which was statistically similar with $V_3T_3$, $V_3T_4$ and $V_3T_5$.

## 4.2.11 Harvest Index

### 4.2.11.1 Effect of varietal variation

Significant difference was observed for harvest index (%) due to varietal variations (Figure 29). However, BRRI dhan34 ($V_3$) showed the maximum harvest index (29.99%) and the minimum harvest index (13.56%) was found in Raniselute ($V_2$). Sakoto and Muhammad (2014) also found the similar results in case of harvest index due to varietal variations.

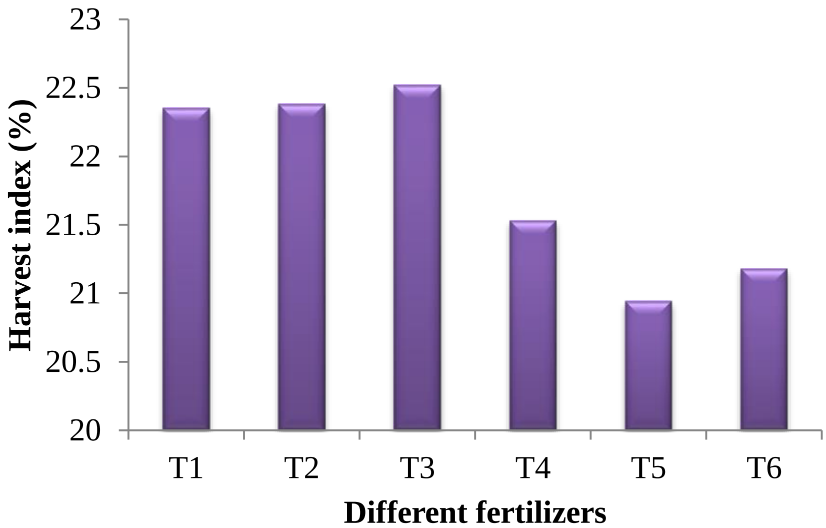



$V_1$: Kataribhog, $V_2$: Raniselute and $V_3$: BRRI dhan34

**Figure 29. Effect of varietal variation on the harvest index of rice** (LSD $_{(0.05)}$ = 0.60)

**4.2.11.2 Effect of fertilizer management**

Effect of different fertilizer management exerted non-significant variation on harvest index (Figure 30). The highest (22.38%) and lowest (20.94%) harvest index was obtained from $T_2$ and $T_5$, respectively.




$T_1$ = Recommended doses of NPKSZn
$T_2$ = 80% recommended doses of NPKSZn + Green Manure 3.5 ton ha$^{-1}$
$T_3$ = 60% recommended doses of NPKSZn + Green Manure 7 ton ha$^{-1}$
$T_4$ = 40% recommended doses of NPKSZn + Green Manure 10.5 ton ha$^{-1}$
$T_5$ = 20% recommended doses of NPKSZn + Green Manure 14 ton ha$^{-1}$
$T_6$ = Green Manure 17.5 ton ha$^{-1}$

**Figure 30. Effect of fertilizer management on the harvest index of rice** (LSD $_{(0.05)}$ = NS)

### 4.2.11.3 Interaction effect of varietal variation and fertilizer management

Harvest index was significantly influenced by the interaction effect of variety and fertilizer management (Table 06). The maximum harvest index (31.55%) was observed in $V_3T_3$ interaction which was statistically similar with interactions between $V_3$ and all other fertilizer levels. The minimum harvest index (11.46%) was found in $V_2T_6$ which was statistically similar with interactions between $V_2$ and all other fertilizer levels. Among the interactions, BRRI dhan34 ($V_3$) with all fertilizer levels showed highest harvest index than the interactions between Raniselute ($V_2$) and all fertilizer levels.

**Table 06. Interaction effect of varietal variation and fertilizer management on 1000 grain weight, grain yield, straw yield, biological yield and harvest index of rice**

| Treatment combinations | 1000 grain weight (g) | Grain yield (t $ha^{-1}$) | Straw yield (t $ha^{-1}$) | Biological yield (t $ha^{-1}$) | Harvest index (%) |
|---|---|---|---|---|---|
| **$V_1T_1$** | 12.33 cd | 2.17 b-e | 7.42 bc | 9.593 a-c | 22.72 b |
| **$V_1T_2$** | 12.04 c-e | 2.19 b-d | 7.57 bc | 9.760 ab | 22.48 b |
| **$V_1T_3$** | 11.80 c-e | 1.93 d-f | 7.32 b-d | 9.247 b-d | 20.87 b |
| **$V_1T_4$** | 11.10 c-e | 1.91 e-g | 6.82 c-e | 8.72 b-e | 21.98 b |
| **$V_1T_5$** | 10.73 de | 1.84 fg | 6.69 c-e | 8.53 c-e | 21.59 b |
| **$V_1T_6$** | 10.57 e | 1.75 f-h | 6.30 de | 8.05 e-g | 21.82 b |
| **$V_2T_1$** | 17.80 a | 1.51 hi | 8.26 ab | 9.770 ab | 15.41 c |
| **$V_2T_2$** | 18.37 a | 1.63 g-i | 8.80 a | 10.43 a | 15.71 c |
| **$V_2T_3$** | 16.93 ab | 1.43 i | 8.00 ab | 9.43 a-d | 15.15 c |
| **$V_2T_4$** | 17.60 a | 1.01 j | 7.38 bc | 8.40 d-f | 12.09 c |
| **$V_2T_5$** | 16.95 ab | 0.94 j | 7.20 b-d | 8.13 ef | 11.53 c |
| **$V_2T_6$** | 15.67 b | 0.92 j | 7.22 b-d | 8.14 ef | 11.46 c |
| **$V_3T_1$** | 12.53 c | 2.45 ab | 6.07 ef | 8.52 de | 28.92 a |
| **$V_3T_2$** | 12.50 c | 2.67 a | 6.55 c-e | 9.22 b-d | 28.95 a |
| **$V_3T_3$** | 11.13 c-e | 2.34 bc | 5.09 fg | 7.43 f-h | 31.55 a |
| **$V_3T_4$** | 11.67 c-e | 2.15 c-e | 4.90 g | 7.050 gh | 30.51 a |
| **$V_3T_5$** | 11.47 c-e | 2.02 d-f | 4.77 g | 6.793 h | 29.71 a |
| **$V_3T_6$** | 10.66 e | 1.93 d-f | 4.49 g | 6.41 h | 30.27 a |
| **LSD $_{(0.05)}$** | **1.64** | **0.28** | **1.08** | **1.06** | **4.35** |
| **CV (%)** | **7.33** | **9.24** | **9.63** | **7.47** | **11.94** |

In a column, means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 5% level of probability

$V_1$: Kataribhog, $V_2$: Raniselute and $V_3$: BRRI dhan34

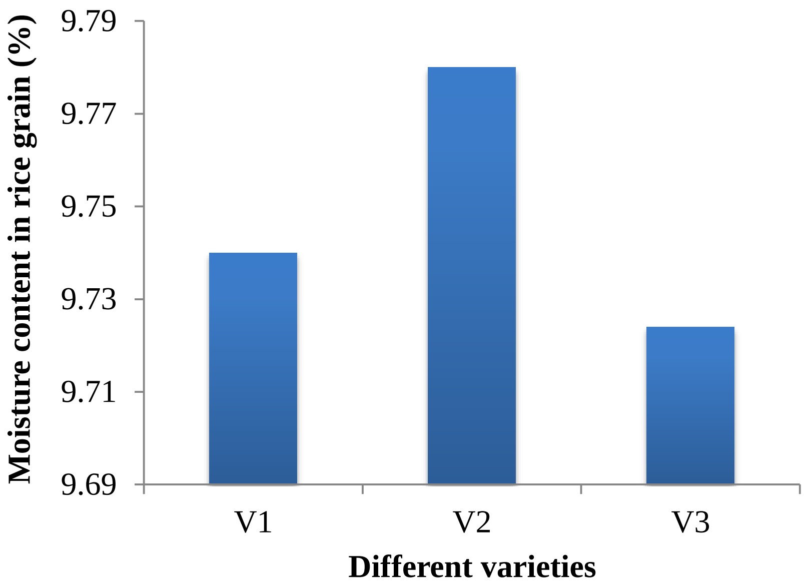
$T_1$ = Recommended doses of NPKSZn, $T_2$ = 80% recommended doses of NPKSZn + green manure 3.5 ton $ha^{-1}$, $T_3$ = 60% recommended doses of NPKSZn + green manure 7 ton $ha^{-1}$, $T_4$ = 40% recommended doses of NPKSZn + green manure 10.5 ton $ha^{-1}$, $T_5$ = 20% recommended doses of NPKSZn + green manure 14 ton $ha^{-1}$ and $T_6$ = green manure 17.5 ton $ha^{-1}$

### 4.3 Qualitative characteristics of aman rice

#### 4.3.1 Moisture content in rice grain (%)

##### 4.3.1.1 Effect of varietal variation

Non-significant variation was observed on moisture content in rice grain due to varietal variations (Figure 31). The highest (9.78%) and lowest (9.72%) moisture content in rice grain was observed in Raniselute ($V_2$) and BRRI dhan34 ($V_3$), respectively.

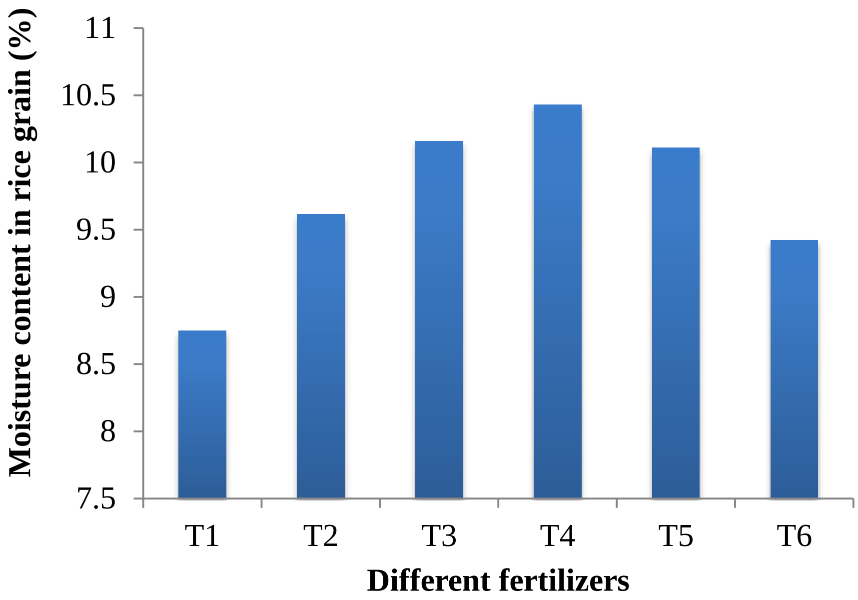



$V_1$: Kataribhog, $V_2$: Raniselute and $V_3$: BRRI dhan34

**Figure 31. Effect of varietal variation on the moisture content in rice grain** (LSD $_{(0.05)}$ = NS)

##### 4.3.1.2 Effect of fertilizer management

Significant variation was observed on moisture content in rice grain due to different levels of fertilizer (Figure 32). The highest moisture content in rice grain (10.43%) was observed in $T_4$ which was statistically similar with $T_3$ and the lowest moisture content in rice grain (9.42%) was observed in $T_6$.




$T_1$ = Recommended doses of NPKSZn
$T_2$ = 80% recommended doses of NPKSZn + Green Manure 3.5 ton $ha^{-1}$
$T_3$ = 60% recommended doses of NPKSZn + Green Manure 7 ton $ha^{-1}$
$T_4$ = 40% recommended doses of NPKSZn + Green Manure 10.5 ton $ha^{-1}$
$T_5$ = 20% recommended doses of NPKSZn + Green Manure 14 ton $ha^{-1}$
$T_6$ = Green Manure 17.5 ton $ha^{-1}$

**Figure 32. Effect of fertilizer management on the moisture content in rice grain** ($LSD_{(0.05)} = 0.30$)

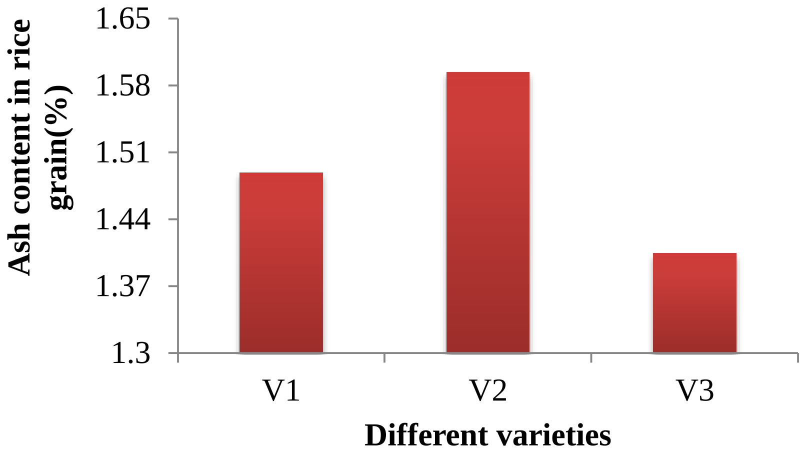
#### 4.3.1.3 Interaction effect of varietal variation and fertilizer management

Moisture content in rice grain was significantly influenced by the interaction effect of variety and fertilizer management (Table 07). The highest moisture content in rice grain (10.81%) was observed in $V_1T_4$ interaction which was statistically similar with $V_2T_3$, $V_2T_5$, $V_3T_4$ and $V_3T_5$; whereas the lowest moisture content in rice grain (8.43%) was found in $V_2T_1$ which was statistically similar with $V_1T_1$.

### 4.3.2 Ash content in rice grain (%)

#### 4.3.2.1 Effect of varietal variation

Significant variation was observed on ash content in rice grain due to varietal variations (Figure 33). The highest ash content in rice grain (1.59%) was observed in Raniselute ($V_2$) which was statistically similar with $V_1$ and lowest ash content in rice grain (1.40%) was observed in BRRI dhan34 ($V_3$) which was statistically similar with $V_1$.

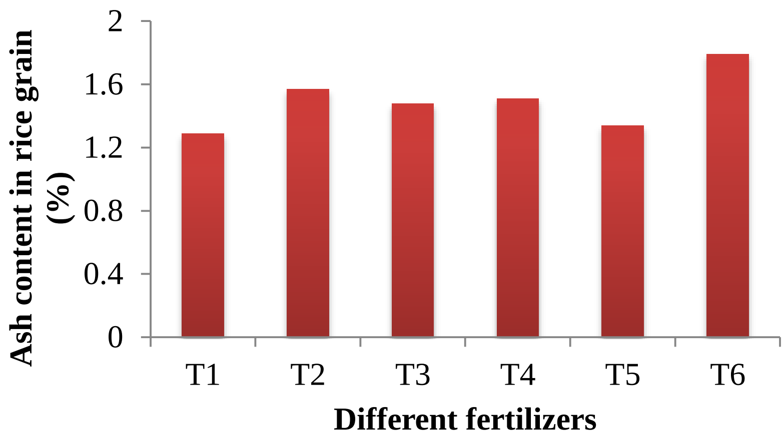



$V_1$: Kataribhog, $V_2$: Raniselute and $V_3$: BRRI dhan34

**Figure 33. Effect of varietal variation on the ash content in rice grain** (LSD $_{(0.05)}$ = 0.12)

### 4.3.2.2 Effect of fertilizer management

Significant variation was observed on ash content in rice grain due to different levels of fertilizer (Figure 34). The highest ash content in rice grain (1.79%) was observed in $T_6$ and the lowest ash content in rice grain (1.47%) was observed in $T_3$ which was statistically similar with $T_5$.




$T_1$ = Recommended doses of NPKSZn
$T_2$ = 80% recommended doses of NPKSZn + Green Manure 3.5 ton ha$^{-1}$
$T_3$ = 60% recommended doses of NPKSZn + Green Manure 7 ton ha$^{-1}$
$T_4$ = 40% recommended doses of NPKSZn + Green Manure 10.5 ton ha$^{-1}$
$T_5$ = 20% recommended doses of NPKSZn + Green Manure 14 ton ha$^{-1}$
$T_6$ = Green Manure 17.5 ton ha$^{-1}$

**Figure 34. Effect of fertilizer management on the ash content in rice grain** (LSD $_{(0.05)}$ = 0.07)

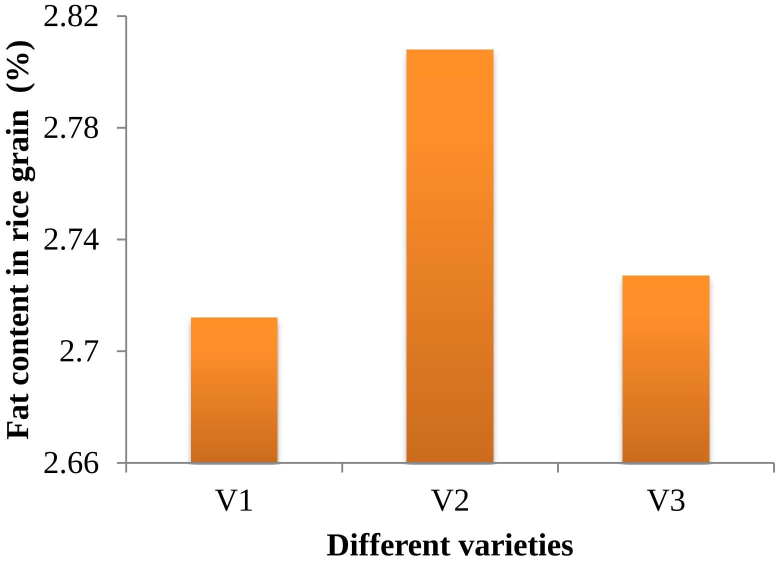
#### 4.3.2.3 Interaction effect of varietal variation and fertilizer management

Ash content in rice grain was significantly influenced by the interaction effect of variety and fertilizer management (Table 07). The highest ash content in rice grain (2.05%) was observed in $V_1T_4$ treatment which was statistically similar with $V_3T_6$ and the lowest ash content in rice grain (0.98%) was found in $V_3T_1$ which was statistically similar with $V_1T_1$ and $V_3T_5$.

### 4.3.3 Fat content in rice grain (%)

#### 4.3.3.1 Effect of varietal variation

Significant variation was observed on fat content in rice grain due to varietal variations (Figure 35). The highest fat content in rice grain (2.81%) was observed in Raniselute ($V_2$) and lowest fat content in rice grain (2.71%) was observed in Kataribhog ($V_1$) which was statistically similar with BRRI dhan34 ($V_3$).

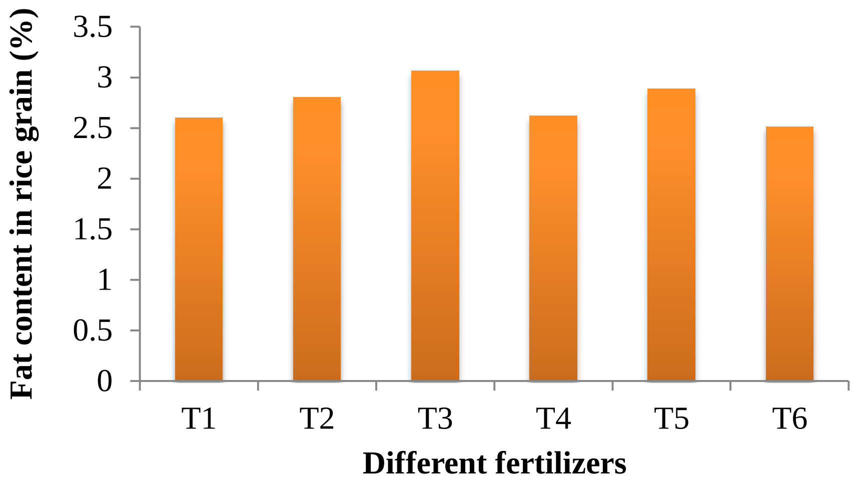



$V_1$: Kataribhog, $V_2$: Raniselute and $V_3$: BRRI dhan34

**Figure 35. Effect of varietal variation on the fat content in rice grain** (LSD $_{(0.05)}$ = 0.05)

#### 4.3.3.2 Effect of fertilizer management

Significant variation was observed on fat content in rice grain due to different levels of fertilizer (Figure 36). The highest fat content in rice grain (3.07%) was observed in $T_3$ and lowest fat content in rice grain (2.51%) was observed in $T_6$ which was statistically similar with $T_1$ and $T_4$.




$T_1$ = Recommended doses of NPKSZn
$T_2$ = 80% recommended doses of NPKSZn + Green Manure 3.5 ton $ha^{-1}$
$T_3$ = 60% recommended doses of NPKSZn + Green Manure 7 ton $ha^{-1}$
$T_4$ = 40% recommended doses of NPKSZn + Green Manure 10.5 ton $ha^{-1}$
$T_5$ = 20% recommended doses of NPKSZn + Green Manure 14 ton $ha^{-1}$
$T_6$ = Green Manure 17.5 ton $ha^{-1}$

**Figure 36. Effect of fertilizer management on the fat content in rice grain** (LSD $_{(0.05)}$ = 0.12)

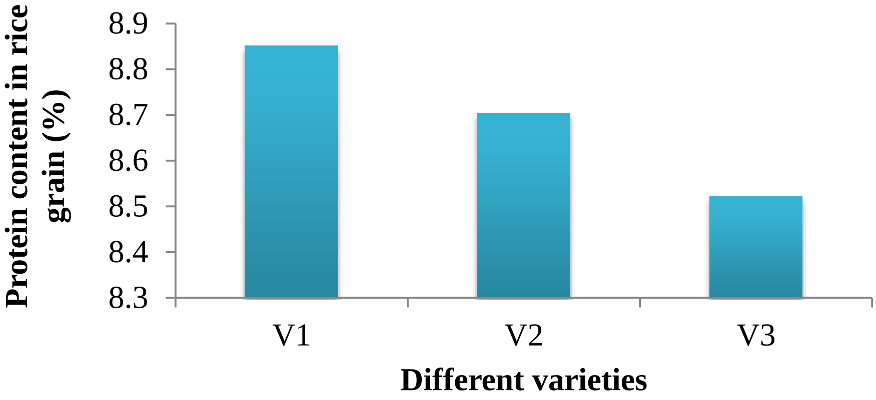
#### 4.3.3.3 Interaction effect of varietal variation and fertilizer management

Fat content in rice grain was significantly influenced by the interaction effect of variety and fertilizer management (Table 07). The highest fat content in rice grain (3.13%) was observed in $V_2T_2$ interaction which was statistically similar with $V_1T_3$, $V_2T_3$, $V_2T_5$, $V_3T_3$ and $V_3T_5$; the lowest fat content in rice grain (2.29%) was found in $V_3T_6$ which was statistically similar with $V_2T_1$.

### 4.3.4 Protein content in rice grain (%)

#### 4.3.4.1 Effect of varietal variation

Significant variation was observed on protein content in rice grain due to varietal variations (Figure 37). The highest protein content in rice grain (8.85%) was observed in Kataribhog ($V_1$) and lowest protein content in rice grain (8.52%) was observed in BRRI dhan34 ($V_3$).

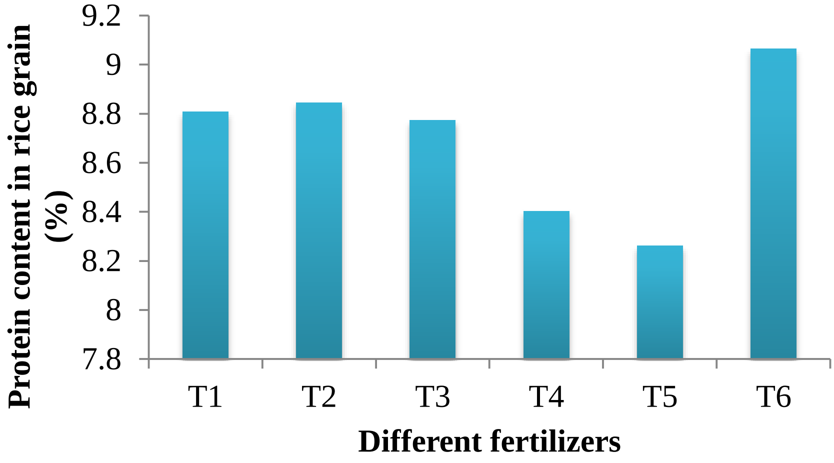



$V_1$: Kataribhog, $V_2$: Raniselute and $V_3$: BRRI dhan34

**Figure 37. Effect of varietal variation on the protein content in rice grain** (LSD $_{(0.05)}$ = 0.11)

#### 4.3.4.2 Effect of fertilizer management

Significant variation was observed on protein content in rice grain due to different levels of fertilizer (Figure 38). The highest protein content in rice grain (9.06%) was observed in $T_6$ which was statistically similar with $T_1$, $T_2$ and $T_3$; whereas the lowest protein content in rice grain (8.26%) was observed in $T_5$ which was statistically similar with $T_4$.




$T_1$ = Recommended doses of NPKSZn
$T_2$ = 80% recommended doses of NPKSZn + Green Manure 3.5 ton $ha^{-1}$
$T_3$ = 60% recommended doses of NPKSZn + Green Manure 7 ton $ha^{-1}$
$T_4$ = 40% recommended doses of NPKSZn + Green Manure 10.5 ton $ha^{-1}$
$T_5$ = 20% recommended doses of NPKSZn + Green Manure 14 ton $ha^{-1}$
$T_6$ = Green Manure 17.5 ton $ha^{-1}$

**Figure 38. Effect of fertilizer management on the protein content in rice grain** (LSD $_{(0.05)}$ = 0.30)

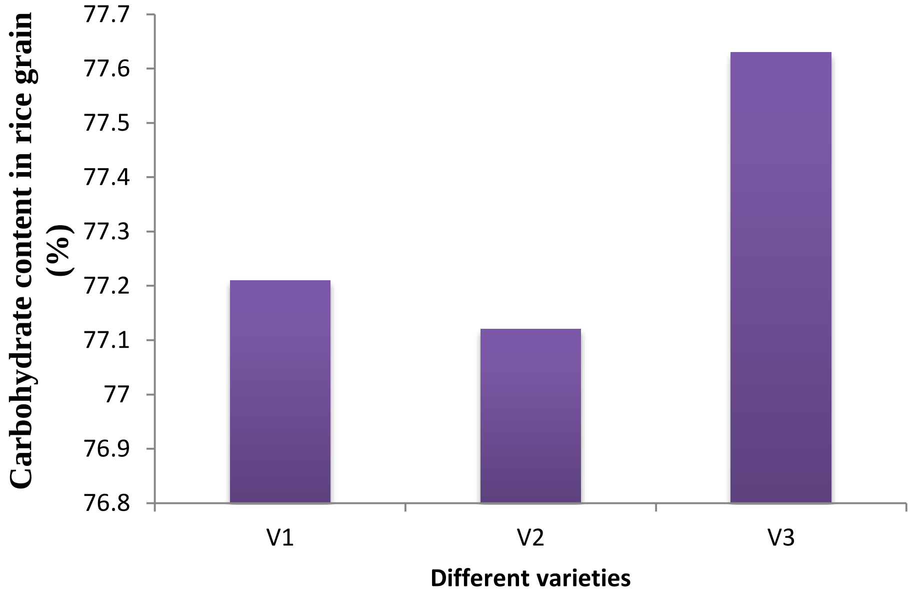
#### 4.3.4.3 Interaction effect of varietal variation and fertilizer management

Protein content in rice grain was significantly influenced by the interaction effect of variety and fertilizer management (Table 07). The highest protein content in rice grain (9.42%) was observed in $V_3T_6$ treatment which was statistically similar with $V_1T_2$, $V_1T_3$, $V_1T_4$, $V_2T_1$, $V_2T_2$, $V_2T_6$ and $V_3T_1$; whereas the lowest protein content in rice grain (7.76%) was found in $V_3T_4$ which was statistically similar with $V_2T_4$ and $V_2T_5$.

### 4.3.5 Carbohydrate content in rice grain (%)

#### 4.3.5.1 Effect of varietal variation

Significant variation was observed on carbohydrate content in rice grain due to varietal variations (Figure 39). The highest carbohydrate content in rice grain (77.63%) was observed in BRRI dhan34 ($V_3$) and lowest carbohydrate content in rice grain (77.12%) was observed in Raniselute ($V_2$) which was statistically similar with $V_1$.

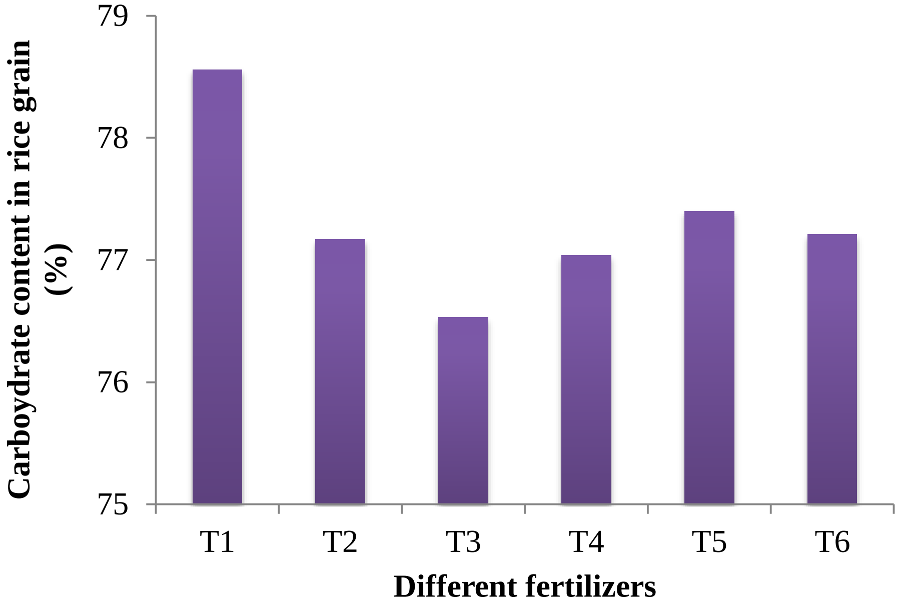



$V_1$: Kataribhog, $V_2$: Raniselute and $V_3$: BRRI dhan34

**Figure 39. Effect of varietal variation on the carbohydrate content in rice grain** (LSD $_{(0.05)}$ = 0.32)

### 4.3.5.2 Effect of fertilizer management

Significant variation was observed on carbohydrate content in rice grain due to different levels of fertilizer (Figure 40). The highest carbohydrate content in rice grain (78.56%) was observed in $T_1$ and lowest carbohydrate content in rice grain (76.53%) was observed in $T_3$ which was statistically similar with all other treatments except $T_1$ and $T_5$.




$T_1$ = Recommended doses of NPKSZn
$T_2$ = 80% recommended doses of NPKSZn + Green Manure 3.5 ton $ha^{-1}$
$T_3$ = 60% recommended doses of NPKSZn + Green Manure 7 ton $ha^{-1}$
$T_4$ = 40% recommended doses of NPKSZn + Green Manure 10.5 ton $ha^{-1}$
$T_5$ = 20% recommended doses of NPKSZn + Green Manure 14 ton $ha^{-1}$
$T_6$ = Green Manure 17.5 ton $ha^{-1}$

**Figure 40. Effect of fertilizer management on the carbohydrate content in rice grain** (LSD $_{(0.05)}$ = 0.79)

### 4.3.5.3 Interaction effect of varietal variation and fertilizer management

Carbohydrate content in rice grain was significantly influenced by the interaction effect of variety and fertilizer management (Table 07). The highest carbohydrate content in rice grain (79.24%) was observed in $V_1T_1$ interaction which was statistically similar with $V_2T_1$, $V_2T_4$, $V_3T_1$, $V_3T_2$ and $V_3T_4$; whereas the lowest carbohydrate content in rice grain (75.00%) was found in $V_1T_4$ which was statistically similar with $V_1T_3$, $V_2T_2$ and $V_2T_3$.

**Table 07. Interaction effect of varietal variation and fertilizer management on moisture content, ash content, fat content, protein content and carbohydrate content of rice**

| Treatment combinations | Moisture content (%) | Ash content (%) | Fat content (%) | Protein content (%) | Carbohydrate content (%) |
|---|---|---|---|---|---|
| **$V_1T_1$** | 8.72 ij | 1.09 gh | 2.51 f | 8.44 d-g | 79.24 a |
| **$V_1T_2$** | 9.75 d-f | 1.27 f | 2.51 f | 9.04 a-c | 77.43 b-e |
| **$V_1T_3$** | 10.28 bc | 1.33 f | 3.09 a | 9.13 a-c | 76.18 d-g |
| **$V_1T_4$** | 10.81 a | 2.05 a | 2.81 b-d | 9.35 ab | 75.00 g |
| **$V_1T_5$** | 9.66 e-g | 1.39 f | 2.77 c-e | 8.37 e-g | 77.82 bc |
| **$V_1T_6$** | 9.22 g-i | 1.81 bc | 2.59 ef | 8.79 c-f | 77.60 bc |
| **$V_2T_1$** | 8.43 j | 1.80 c | 2.49 fg | 9.04 a-c | 78.26 ab |
| **$V_2T_2$** | 9.95 b-e | 1.72 cd | 3.13 a | 9.11 a-c | 76.10 e-g |
| **$V_2T_3$** | 10.41 ab | 1.72 cd | 3.12 a | 8.87 b-e | 75.89 fg |
| **$V_2T_4$** | 10.19 b-d | 1.13 g | 2.52 f | 8.10 gh | 78.07 a-c |
| **$V_2T_5$** | 10.32 ab | 1.56 e | 2.94 a-c | 8.12 gh | 77.07 b-f |
| **$V_2T_6$** | 9.39 f-h | 1.64 de | 2.66 d-f | 8.99 a-c | 77.33 b-e |
| **$V_3T_1$** | 9.10 hi | 0.98 h | 2.80 b-d | 8.95 a-d | 78.18 ab |
| **$V_3T_2$** | 9.14 hi | 1.72 cd | 2.79 b-e | 8.39 e-g | 77.98 a-c |
| **$V_3T_3$** | 9.79 c-f | 1.38 f | 2.99 ab | 8.33 fg | 77.52 b-d |
| **$V_3T_4$** | 10.30 a-c | 1.36 f | 2.54 f | 7.76 h | 78.06 a-c |
| **$V_3T_5$** | 10.37 ab | 1.07 gh | 2.96 a-c | 8.30 fg | 77.32 b-e |
| **$V_3T_6$** | 9.66 e-g | 1.93 ab | 2.29 g | 9.42 a | 76.72 c-f |
| **LSD (0.05)** | **0.51** | **0.13** | **0.20** | **0.51** | **1.38** |
| **CV (%)** | **3.14** | **5.12** | **4.48** | **3.54** | **1.07** |

In a column, means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 5% level of probability

$V_1$: Kataribhog, $V_2$: Raniselute and $V_3$: BRRI dhan34

$T_1$ = Recommended doses of NPKSZn, $T_2$ = 80% recommended doses of NPKSZn + green manure 3.5 ton ha$^{-1}$, $T_3$ = 60% recommended doses of NPKSZn + green manure 7 ton ha$^{-1}$, $T_4$ = 40% recommended doses of NPKSZn + green manure 10.5 ton ha$^{-1}$, $T_5$ = 20% recommended doses of NPKSZn + green manure 14 ton ha$^{-1}$ and $T_6$ = green manure 17.5 ton ha$^{-1}$

# CHAPTER 5

# SUMMARY AND CONCLUSION

The experiment was carried out at the Agronomy research field, Sher-e-Bangla Agricultural University, Dhaka during the period from July to December, 2014 to determine the influence of green manure and chemical fertilizers on the growth, yield and quality of three varieties of aromatic aman rice. The experimental field belongs to the Agro-ecological zone (AEZ) of "The Modhupur Tract", AEZ-28. The soil of the experimental field belongs to the General soil type, Shallow Red Brown Terrace Soils under Tejgaon soil series. The experiment consisted of two factors. Factor A: Varieties (3 levels); $V_1$: Kataribhog, $V_2$: Raniselute and $V_3$: BRRI dhan34, and factor B: Fertilizer doses (6 levels); $T_1$: Recommended doses of NPKSZn, $T_2$: 80% recommended doses of NPKSZn + Green Manure 3.5 ton ha$^{-1}$, $T_3$: 60% recommended doses of NPKSZn + Green Manure 7 ton ha$^{-1}$, $T_4$: 40% recommended doses of NPKSZn + Green Manure 10.5 ton ha$^{-1}$, $T_5$: 20% recommended doses of NPKSZn + Green Manure 14 ton ha$^{-1}$ and $T_6$: Green Manure 17.5 ton ha$^{-1}$. The experiment was laid out following split-plot design with three replications where main plot was for variety (Factor A) and subplot was for fertilizer treatment (Factor B). There were 18 treatment combinations. The total numbers of unit plots were 54. The size of unit plot was 6 m$^2$ (3 m × 2 m). 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. Urea was top dressed in three equal splits on 15, 30 and 45 DAT.

Results revealed that green manure and chemical fertilizers, variety and their interactions had significant effect on plant growth characters at different days after transplanting. The tallest plant (148.10 cm at harvest), maximum leaf area hill$^{-1}$ (1376 cm$^2$ at harvest) and maximum dry matter weight hill$^{-1}$ (52.03 g at harvest) was observed in Raniselute ($V_2$). The shortest plant (139.70 cm at harvest), minimum leaf area hill$^{-1}$ (954.80 cm$^2$ at harvest) and minimum dry matter weight hill$^{-1}$ (35.58 g at harvest) was observed in BRRI dhan34 ($V_3$). At harvest, the highest and lowest number of tillers hill$^{-1}$ (15.60 and 11.15) was recorded from BRRI dhan34 and Raniselute, respectively.

The tallest plant (148.70 cm at harvest), maximum leaf area hill$^{-1}$ (1434 cm$^2$ at harvest), dry matter weight hill$^{-1}$ (50.67 g at harvest) and highest number of tillers hill$^{-1}$ (16.39 at harvest) were recorded from $T_2$ treatment. The shortest plant (137.6 cm at harvest), minimum leaf area hill$^{-1}$ (986.50 cm$^2$ at harvest), dry matter weight hill$^{-1}$ (34.72 g at harvest) and the lowest number of tillers hill$^{-1}$ (11.30) were recorded from $T_6$ treatment.

The tallest plant (152.10 cm at harvest), maximum leaf area hill$^{-1}$ (1689 cm$^2$ at harvest) and maximum dry matter weight hill$^{-1}$ (57.33 g at harvest) were found in $V_2T_2$ treatment. The shortest plant (131.00 cm at harvest), minimum leaf area hill$^{-1}$ (716.1 cm$^2$ at harvest) and minimum dry matter weight hill$^{-1}$ (22.33 g at harvest) was found in $V_3T_6$. At harvest, the highest and lowest number of tillers hill$^{-1}$ (19.44 and 9.89) was found in $V_3T_2$ and $V_2T_6$, respectively.

Significant difference was observed on yield contributing characters due to green manure and chemical fertilizers, variety and their interactions. BRRI dhan34 showed the highest number of effective tillers hill$^{-1}$ (12.74) and lowest number of effective tillers hill$^{-1}$ (9.04) were recorded from Raniselute. The highest and lowest number of effective tillers hill$^{-1}$ (13.39 and 8.83) were counted in $T_2$ and $T_6$, respectively. The interaction of $V_3T_2$ (15.50) was found best in producing effective tillers hill$^{-1}$.

The highest number of non-effective tillers hill$^{-1}$ (6.77) and longest panicle (27.93 cm) was recorded in Raniselute, whereas BRRI dhan34 produced the lowest number of non-effective tillers hill$^{-1}$ (3.52) and Kataribhog produced shortest panicle (25.62 cm). The highest number of non-effective tillers hill$^{-1}$ (6.89) and shortest panicle (25.79 cm) were counted from $T_6$ treatment, whereas the lowest number of non-effective tillers hill$^{-1}$ (3.39) and longest panicle (27.38 cm) was counted from $T_2$ treatment. The highest and lowest number of non-effective tillers hill$^{-1}$ (9.99 and 2.16) were found in the $V_2T_6$ and $V_3T_2$, respectively. The longest (29.29 cm) and shortest (24.92 cm) panicle were found in $V_2T_2$ and $V_1T_6$, respectively.

The highest number of grains panicle$^{-1}$ (233.90) and filled grains panicle$^{-1}$ (192.50) were observed in BRRI dhan34, whereas the lowest number of grains panicle$^{-1}$ (98.67) and filled grains panicle$^{-1}$ (76.11) were observed in Raniselute. The highest number of grains panicle$^{-1}$ (187.80) and filled grains panicle$^{-1}$ (161.70) were counted at $T_2$ treatment whereas the lowest number of grains panicle$^{-1}$ (148.60) and filled grains panicle$^{-1}$ (110.10) were counted at $T_6$ treatment. Interaction $V_3T_2$ produced the highest number of grains panicle$^{-1}$ (252.10) and filled grains panicle$^{-1}$ (212.80) whereas $V_2T_6$ produced the lowest number of grains panicle$^{-1}$ (87.78) and filled grains panicle$^{-1}$ (58.33).

Kataribhog produced the highest number of unfilled grains panicle$^{-1}$ (42.55) and lowest 1000 grain weight (11.43 g), whereas Raniselute produced the lowest number of unfilled grains panicle$^{-1}$ (22.08) and highest 1000 grain weight (17.22 g). $T_6$ produced the higher number of unfilled grains panicle$^{-1}$ (48.63) and lowest 1000 grain weight (12.30 g), whereas $T_1$ produced the lower number of unfilled grains panicle$^{-1}$ (22.11) and $T_2$ produced highest 1000 grain weight (14.30 g). $V_1T_6$ produced the highest number of unfilled grains panicle$^{-1}$ (75.55) and lowest 1000 grain weight (10.57 g), whereas $V_2T_1$ produced the lowest number of unfilled grains panicle$^{-1}$ (15.00) and $V_2T_2$ produced highest 1000 grain weight (18.37 g).

The maximum grain yield (2.26 t ha$^{-1}$), minimum straw yield (5.31 t ha$^{-1}$), lowest biological yield (7.57 t ha$^{-1}$) and highest harvest index (29.99%) was found in BRRI dhan34, whereas the minimum grain yield (1.24 t ha$^{-1}$), maximum straw yield (7.81 t ha$^{-1}$), highest biological yield (9.05 t ha$^{-1}$) and lowest harvest index (13.56%) were found in Raniselute. The maximum grain yield (2.17 t ha$^{-1}$), straw yield (7.64 t ha$^{-1}$) and biological yield (9.80 t ha$^{-1}$) were recorded in $T_2$ whereas the minimum grain yield (1.53 t ha$^{-1}$), straw yield (6.00 t ha$^{-1}$) and biological yield (7.53 t ha$^{-1}$) were recorded in $T_6$. No significant variation was observed in case of harvest index due to fertilizer management. The interaction of $V_3T_2$ produced the highest grain yield (2.67 t ha$^{-1}$) and the interaction of $V_2T_6$ produced the lowest grain yield (0.92 t ha$^{-1}$). The maximum straw yield (8.80 t ha$^{-1}$) and biological yield (10.43 t ha$^{-1}$) were recorded in $V_2T_2$, whereas the minimum straw yield (4.49 t ha$^{-1}$) and biological yield (6.41 t ha$^{-1}$) were recorded in $V_3T_6$. The highest (31.55%) and lowest (11.46%) harvest index were recorded in $V_3T_3$ and $V_2T_6$, respectively.

Significant difference was observed on qualitative characteristics due to green manure and chemical fertilizers, variety and their interactions. In case of moisture percentage, variety showed non-significant variations. The highest ash content (1.59%), highest fat content (2.81%) and lowest carbohydrate content (77.12%) were observed in Raniselute, whereas the lowest ash content (1.40%) and highest carbohydrate content

(77.63%) were observed in BRRI dhan34. The lowest fat content (2.71%) were observed in Kataribhog. The highest (8.85%) and lowest (8.52%) protein content were observed in Kataribhog and BRRI dhan34, respectively.

The highest (10.43%) and lowest (8.75%) moisture percentage were observed in $T_4$ and $T_1$, respectively. The highest (1.79%) and lowest (1.29%) ash content were observed in $T_6$ and $T_1$, respectively. The highest (3.07%) and lowest (2.51%) fat content were observed in $T_3$ and $T_6$, respectively. The highest (9.06%) and lowest (8.26%) protein content were observed in $T_6$ and $T_5$, respectively. The highest (78.56%) and lowest (76.53%) carbohydrate content were observed in $T_1$ and $T_3$, respectively.

The highest moisture content (10.81%) and ash content (2.05%) were observed in $V_1T_4$ whereas the lowest moisture content (8.43%) and ash content (0.98%) were observed in $V_2T_1$ and $V_3T_1$, respectively. The highest (3.13%) and lowest (2.29%) fat content were observed in $V_2T_2$ and $V_3T_6$, respectively. The highest (9.42%) and lowest (7.76%) protein content were observed in $V_3T_6$ and $V_3T_4$, respectively. The highest (79.24%) and lowest (75.00%) carbohydrate content were observed in $V_1T_1$ and $V_1T_4$, respectively.

Reviewing above the results of the present study, it might be concluded that 80% recommended doses of NPKSZn + Green Manure 3.5 ton $ha^{-1}$ along with BRRI dhan34 showed the higher yield (2.67 t $ha^{-1}$) than other tested varieties of aromatic aman rice.

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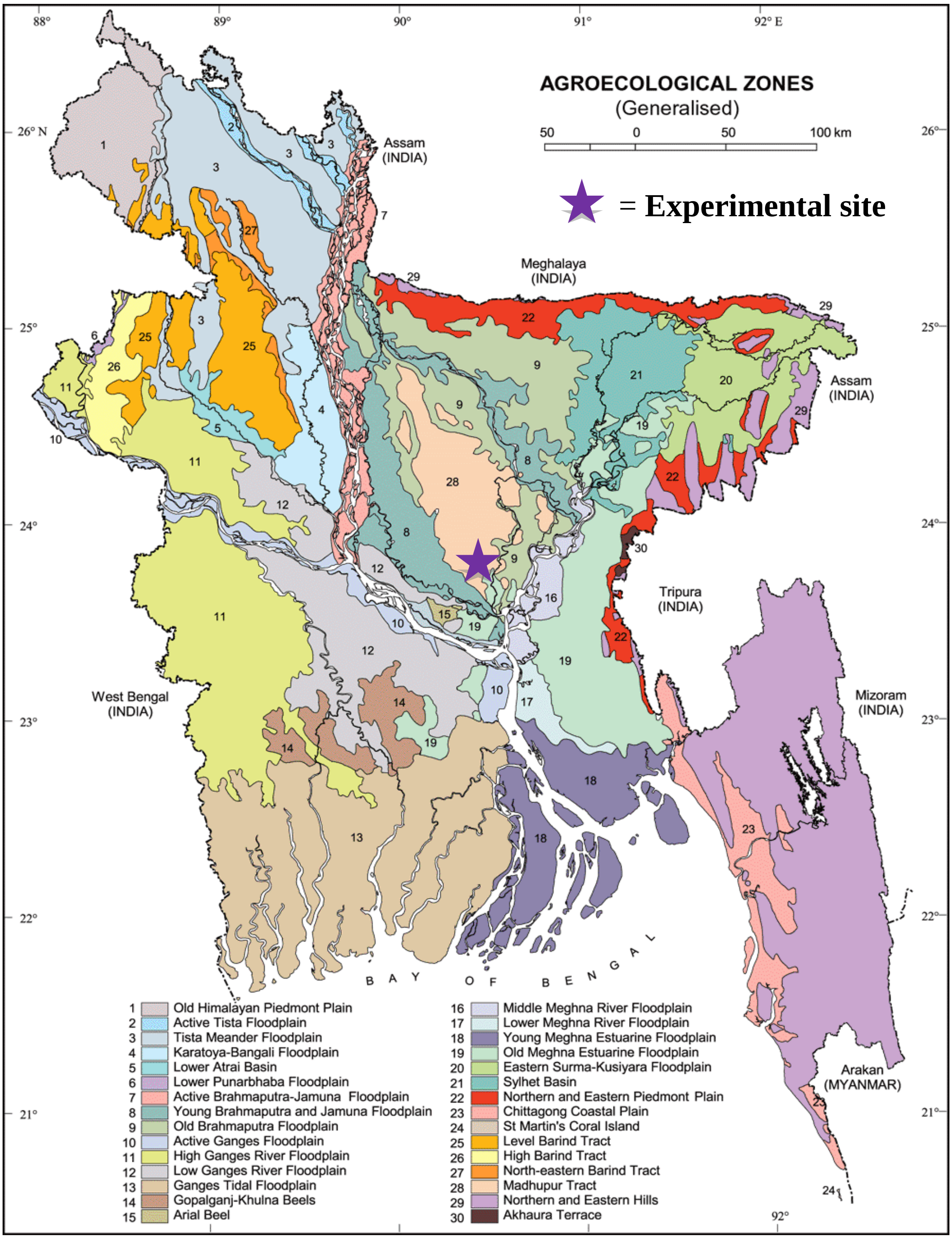
# APPENDICES

## Appendix I. Map showing the experimental site under study



## Appendix II. Characteristics of soil of experimental field

### A. Morphological characteristics of the experimental field

| Morphological features | Characteristics |
|---|---|
| Location | Sher-e-Bangla Agricultural University Agronomy research field, Dhaka |
| AEZ | AEZ-28, Modhupur Tract |
| General Soil Type | Shallow Red Brown Terrace Soil |
| Land type | High land |
| Soil series | Tejgaon |
| Topography | Fairly leveled |

### B. The initial physical and chemical characteristics of soil of the experimental site (0 - 15 cm depth)

| Physical characteristics | |
|---|---|
| **Constituents** | **Percent** |
| Sand | 26 |
| Silt | 45 |
| Clay | 29 |
| Textural class | Silty clay |
| **Chemical characteristics** | |
| **Soil characters** | **Value** |
| pH | 5.6 |
| Organic carbon (%) | 0.45 |
| Organic matter (%) | 0.78 |
| Total nitrogen (%) | 0.03 |
| Available P (ppm) | 20.54 |
| Exchangeable K (me/100 g soil) | 0.10 |

**Appendix III. Monthly meteorological information during the period from July to December, 2014**

| Year | Month | Air temperature ($^0C$) | | Relative humidity (%) | Total rainfall (mm) |
|---|---|---|---|---|---|
| | | Maximum | Minimum | | |
| 2014 | July | 32.10 | 23.20 | 76.31 | 241 |
| | August | 31.02 | 15.27 | 74.41 | 158 |
| | September | 31.46 | 14.82 | 73.20 | 161 |
| | October | 30.18 | 14.85 | 67.82 | 137 |
| | November | 28.10 | 11.83 | 58.18 | 47 |
| | December | 25.00 | 9.46 | 69.53 | 0 |

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

**Appendix IV. Layout for experimental field.**

Total number of unit plots: 18 × 3 = 54
Unit plot size: 3 m×2 m = 6 $m^2$
The main plot and unit plots were separated by 1m and 0.5m, respectively.

| | | | | | | |
|---|---|---|---|---|---|---|
| Replication 1 | $V_1T_1$ | $V_1T_2$ | $V_1T_3$ | $V_1T_4$ | $V_1T_5$ | $V_1T_6$ |
| | $V_2T_6$ | $V_2T_5$ | $V_2T_4$ | $V_2T_3$ | $V_2T_2$ | $V_2T_1$ |
| | $V_3T_3$ | $V_3T_1$ | $V_3T_5$ | $V_3T_2$ | $V_3T_6$ | $V_3T_4$ |
| Replication 2 | $V_2T_1$ | $V_2T_2$ | $V_2T_3$ | $V_2T_4$ | $V_2T_5$ | $V_2T_6$ |
| | $V_1T_6$ | $V_1T_5$ | $V_1T_4$ | $V_1T_3$ | $V_1T_2$ | $V_1T_1$ |
| | $V_3T_4$ | $V_3T_6$ | $V_3T_2$ | $V_3T_5$ | $V_3T_1$ | $V_3T_3$ |
| Replication 3 | $V_1T_3$ | $V_1T_2$ | $V_1T_1$ | $V_1T_6$ | $V_1T_4$ | $V_1T_5$ |
| | $V_3T_5$ | $V_3T_4$ | $V_3T_6$ | $V_3T_1$ | $V_3T_3$ | $V_3T_2$ |
| | $V_2T_2$ | $V_2T_3$ | $V_2T_5$ | $V_2T_6$ | $V_2T_1$ | $V_2T_4$ |

**Appendix V. Analysis of variance of the data on plant height (cm) of rice as influenced by combined effect of different varieties and fertilizer management**

| Source of variation | df | Mean square of plant height (cm) at different days after transplanting (DAT) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 15 | 30 | 45 | 60 | 75 | 90 | At harvest |
| **Replication** | 2 | 89.23 | 199.60 | 71.18 | 26.74 | 2578.18 | 287.86 | 5.78 |
| **Variety(A)** | 2 | 1340.71** | 3350.90* | 1568.68* | 1243.26* | 892.32* | 509.34$^{NS}$ | 321.27* |
| **Error** | 4 | 33.20 | 12.38 | 23.99 | 69.89 | 21.08 | 1057.87 | 60.06 |
| **Fertilizer management(B)** | 5 | 44.28* | 164.18* | 193.96** | 238.83** | 198.12** | 267.16* | 146.92* |
| **Variety (A) X Fertilizer management(B)** | 10 | 36.33* | 33.34* | 30.62** | 46.06** | 33.11* | 18.98* | 9.69* |
| **Error** | 30 | 16.06 | 58.36 | 34.43 | 51.68 | 17.19 | 64.97 | 75.77 |

** Significant at 1% level of significance
*Significant at 5% level of significance
$^{NS}$ Non significant

**Appendix VI. Analysis of variance of the data on leaf area hill$^{-1}$ (cm$^2$) of rice as influenced by combined effect of different varieties and fertilizer management**

| Source of variation | df | Mean square of leaf area hill$^{-1}$ (cm$^2$) at different days after transplanting (DAT) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 15 | 30 | 45 | 60 | 75 | 90 | At harvest |
| **Replication** | 2 | 513.67 | 161116.98 | 36899.32 | 23289.22 | 22261.43 | 19312.91 | 35445.04 |
| **Variety(A)** | 2 | 4657.34* | 1317151.34* | 609218.07* | 827814.96* | 827753.86** | 825514.49* | 820896.62** |
| **Error** | 4 | 339.46 | 7161.91 | 18331.84 | 30506.06 | 28398.64 | 20344.53 | 14183.21 |
| **Fertilizer management(B)** | 5 | 6184.56** | 608143.85* | 305647.22** | 309680.75** | 309768.83** | 308945.85* | 307350.50** |
| **Variety (A) X Fertilizer management(B)** | 10 | 4180.86** | 122906.21$^{NS}$ | 16742.37** | 10296.44** | 10285.72** | 10196.95* | 10034.49* |
| **Error** | 30 | 211.85 | 62590.67 | 30561.09 | 20642.24 | 12984.50 | 10207.72 | 8301.11 |

** Significant at 1% level of significance
*Significant at 5% level of significance
$^{NS}$ Non significant

**Appendix VII. Analysis of variance of the data on dry matter weight hill$^{-1}$ (g) of rice as influenced by combined effect of different varieties and fertilizer management**

| Source of variation | df | Mean square of dry matter weight hill$^{-1}$ (g) at different days after transplanting (DAT) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 15 | 30 | 45 | 60 | 75 | 90 | At harvest |
| Replication | 2 | 0.06 | 0.15 | 3.59 | 47.70 | 13.085 | 32.78 | 32.56 |
| Variety(A) | 2 | 0.95$^{NS}$ | 125.87* | 243.91* | 1182.38* | 1198.452* | 1192.81** | 1217.67* |
| Error | 4 | 0.46 | 8.60 | 12.89 | 18.24 | 23.414 | 18.39 | 18.50 |
| Fertilizer management(B) | 5 | 10.42* | 60.14** | 216.16* | 312.52* | 317.844* | 315.96** | 315.31** |
| Variety (A) X Fertilizer management(B) | 10 | 2.32* | 1.77* | 13.41$^{NS}$ | 32.23* | 31.654* | 31.84* | 31.47* |
| Error | 30 | 0.14 | 1.66 | 7.85 | 19.09 | 17.307 | 14.00 | 12.60 |

** Significant at 1% level of significance
*Significant at 5% level of significance
$^{NS}$ Non significant

**Appendix VIII. Analysis of variance of the data on number of tillers hill$^{-1}$ (No.) of rice as influenced by combined effect of different varieties and fertilizer management**

| Source of variation | df | Mean square of number of tillers hill$^{-1}$ (No.) at different days after transplanting (DAT) | | | | | |
|---|---|---|---|---|---|---|---|
| | | 15 | 30 | 45 | 60 | 75 | At harvest |
| Replication | 2 | 1.06 | 1.06 | 1.13 | 1.13 | 5.75 | 4.82 |
| Variety(A) | 2 | 37.70* | 110.71* | 42.78* | 42.78* | 60.35* | 92.42* |
| Error | 4 | 3.91 | 1.22 | 1.95 | 1.95 | 0.73 | 2.8 |
| Fertilizer management(B) | 5 | 7.12** | 41.69** | 52.88* | 52.88* | 42.76** | 31.69* |
| Variety (A) X Fertilizer management(B) | 10 | 4.05** | 4.56* | 2.42* | 2.42* | 2.13* | 2.45* |
| Error | 30 | 0.73 | 2.17 | 1.97 | 1.97 | 1.92 | 1.62 |

** Significant at 1% level of significance
*Significant at 5% level of significance
$^{NS}$ Non significant

**Appendix IX. Analysis of variance of the data on effective tiller hill$^{-1}$(No.), ineffective tiller hill$^{-1}$ (No.), panicle length (cm), grains panicle$^{-1}$ (No.), filled grain panicle$^{-1}$ (No.) and unfilled grain panicle-$^{1}$ (No.) of rice as influenced by combined effect of different varieties and fertilizer management**

| Source of variation | df | Mean square value | | | | | |
|---|---|---|---|---|---|---|---|
| | | Effective tiller hill$^{-1}$ (No.) | Ineffective tiller hill$^{-1}$ (No.) | Panicle length (cm) | Grains panicle$^{-1}$ (No.) | Filled grain panicle$^{-1}$ (No.) | Unfilled grain panicle$^{-1}$ (No.) |
| Replication | 2 | 4.03 | 2.56 | 0.02 | 56.52 | 91.72 | 16.56 |
| Variety(A) | 2 | 67.31** | 48.70* | 25.79** | 84894.69* | 61549.53* | 1918.99** |
| Error | 4 | 1.78 | 5.86 | 0.02 | 532.52 | 163.66 | 8.31 |
| Fertilizer management(B) | 5 | 28.76** | 15.07** | 2.73** | 1904.20* | 2939.26** | 905.77** |
| Variety (A) X Fertilizer management(B) | 10 | 1.26* | 1.33* | 1.53* | 208.20* | 141.90* | 223.42* |
| Error | 30 | 0.91 | 0.8 | 0.04 | 263.63 | 163.78 | 17.86 |

** Significant at 1% level of significance
*Significant at 5% level of significance
$^{NS}$ Non significant

**Appendix X. Analysis of variance of the data on 1000 grain weight (g), grain yield (t ha$^{-1}$), straw yield (t ha$^{-1}$), biological yield (t ha$^{-1}$) and harvest index (%) of rice as influenced by combined effect of different varieties and fertilizer management**

| Source of variation | df | Mean square value | | | | |
|---|---|---|---|---|---|---|
| | | 1000 grain weight (g) | Grain yield (t ha$^{-1}$) | Straw yield (t ha$^{-1}$) | Biological yield (t ha$^{-1}$) | Harvest index (%) |
| Replication | 2 | 2.69 | 0.14 | 0.00 | 0.14 | 8.03 |
| Variety(A) | 2 | 193.46* | 4.95* | 29.35* | 12.57** | 1214.37** |
| Error | 4 | 0.74 | 0.03 | 0.26 | 0.47 | 0.42 |
| Fertilizer management(B) | 5 | 5.10** | 0.59** | 3.64* | 7.13** | 4.22* |
| Variety (A) X Fertilizer management(B) | 10 | 0.39** | 0.03* | 0.17* | 0.25** | 6.45* |
| Error | 30 | 0.97 | 0.03 | 0.42 | 0.41 | 6.79 |

** Significant at 1% level of significance
*Significant at 5% level of significance
$^{NS}$ Non significant

**Appendix XI. Analysis of variance of the data on moisture content (%), ash, content (%), fat content (%), protein content (%) and carbohydrate content (%) of rice as influenced by combined effect of different varieties and fertilizer management**

| Source of variation | df | Mean square value | | | | |
|---|---|---|---|---|---|---|
| | | Moisture content (%) | Ash content (%) | Fat content (%) | Protein content (%) | Carbohydrate content (%) |
| **Replication** | 2 | 0.21 | 0.003 | 0.22 | 0.02 | 0.23 |
| **Variety(A)** | 2 | $0.02^{NS}$ | 0.16* | 0.05* | 0.49** | 1.33* |
| **Error** | 4 | 0.01 | 0.02 | 0.00 | 0.01 | 0.12 |
| **Fertilizer management(B)** | 5 | 3.41** | 0.29** | 0.39** | 0.81** | 4.11** |
| **Variety (A) X Fertilizer management(B)** | 10 | 0.43** | 0.34** | 0.12** | 0.65** | 3.05** |
| **Error** | 30 | 0.09 | 0.01 | 0.02 | 0.10 | 0.68 |

** Significant at 1% level of significance
*Significant at 5% level of significance
$^{NS}$ Non significant

# PLATES

Plate 1. Transplanting of rice seedling

Plate 2. Vegetative stage of rice plant

Plate 3. Panicle emergence

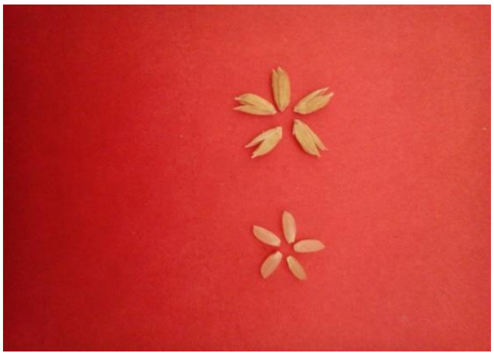

Plate 4. Harvesting


Plate 5. Protein distillation chamber

Plate 6. Fat extraction process

Grains of Kathiribhog

Grains of Raniselute



Grains of BRRI dhan34

Plate 7. Pictorial view of grains of  different rice varieties