AGRONOMIC CHARACTERIZATION OF LONG GRAIN TRANSPLANTED AMAN RICE GENOTYPES

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CERTIFICATE

This is to certify that thesis entitled, "**AGRONOMIC CHARACTERIZATION OF LONG GRAIN TRANSPLANTED AMAN RICE GENOTYPES**" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE in AGRONOMY**, embodies the result of a piece of bonafide research work carried out by **FARIHA AFIA BONNI ,** Registration No. **17-08178** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated: June, 2018
Place: Dhaka, Bangladesh

Prof. Dr. Parimal Kanti Biswas
Supervisor

Dedicated

To My

Beloved Parents

&

Teachers

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The Author

AGRONOMIC CHARACTERIZATION OF LONG GRAIN TRANSPLANTED AMAN RICE GENOTYPES

ABSTRACT

The field experiment was conducted at the experimental farm of Sher-e-Bangla Agricultural University (SAU), Dhaka, during the period from July 2017 to December 2017 to study the performance of different rice genotypes in Aman season under the Modhupur Tract (AEZ-28). The experiment consisted of 15 rice genotypes viz. (i) SAU ADL1, (ii) SAU ADL2, (iii) SAU ADL3, (iv) SAU ADL4, (v) SAU ADL5, (vi) SAU ADL6, (vii) SAU ADL7, (viii) SAU ADL8, (ix) SAU ADL9, (x) SAU ADL10, (xi) SAU ADL11, (xii) SAU ADL12, (xiii) SAU ADL13, (xiv) SAU ADL14 (xv) SAU ADL15 along with a local check variety (xvi) Kataribhog. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications of each treatment. The plant height was observed at harvest where SAU ADL14. produced the tallest plant (196.59 cm) and SAU ADL8 gave the shortest plant height (95.10 cm) At harvest, the maximum tiller number hill^{-1} was observed in the SAU ADL5 (9.80)and the lowest (4.80) was from SAU ADL14. The highest plant dry matter hill^{-1} (67.72 g) at harvest was found in SAU ADL15 and the lowest was found in SAU ADL 13.. At 90 DAT, maximum SPAD value was recorded for SAU ADL11 (46.03) and the minimum SPAD value was also recorded for SAU ADL8 (35.13). The genotypes SAU ADL10, SAU ADL14, SAU ADL15, SAU ADL1, SAU ADL2, SAU ADL3, SAU ADL4, SAU ADL5 and SAU ADL8 needed longest time for flowering (80 days). On the contrary, the genotype SAU ADL 9 needed shortest time (70 days) for flowering .The highest effective tiller hill^{-1} (9.27) were recorded for the genotype SAU ADL9 and minimum effective tillers hill^{-1} were recorded in SAU ADL12 (5.88).The longest panicle length (31.61 cm) was recorded for the genotype SAU ADL12 and the shortest panicle length was recorded in SAU ADL8. The highest number of filled grains panicle^{-1} was obtained from SAU ADL9 (138.78) which was statistically similar with SAU ADL1, SAU ADL3 and SAU ADL12. The lowest number of filled grains panicle^{-1} was found in the SAU ADL10 (34.12) which was statistically similar with SAU ADL6 and SAU ADL8.The maximum 1000 grains weight (41.99 g) was counted in the SAU ADL4 and the minimum number of grains weight was counted in kataribhog (11.45 g). The maximum grain yield (2.88 t ha^{-1}) was recorded in SAU ADL1 that similar to SAU ADL14. The lowest grain yield (0.43 t ha^{-1}) was obtained from SAU ADL8 which was statistically similar to SAU ADL10 (0.62) and SAU ADL4 (0.89). The highest straw yield (10.24 t ha^{-1}) was recorded in SAU ADL1. The minimum straw yield (1.67 t ha^{-1}) was obtained from SAU ADL 8. The highest and lowest biological yield were recorded for SAU ADL1 and SAU ADL8 respectively. The highest harvest index was obtained from the genotype SAU ADL 9 (35.67%) and the lowest harvest index (11.47%) was found from SAU ADL10. So, it may be concluded that grain yield of SAU ADL1 and SAU ADL14 were superior and higher yielder than Kataribhog (local check)

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LIST OF ACRONYMS

AEZ	=	Agro-Ecological Zone
As	=	Arsenic
et al.	=	And others
@	=	At the rate of
BRRI	=	Bangladesh Rice Research Institute
BBS	=	Bangladesh Bureau of Statistics
cm	=	Centimeter
Cd	=	Cadmium
cv.	=	Cultivar
CV%	=	Percentage of coefficient of variance
^{0}C	=	Degree Celsius
DAT	=	Days After Transplanting
g	=	Gram (g)
HI	=	Harvest Index
IRRI	=	International Rice Research Institute
kg	=	Kilogram
LSD	=	Least Significant Difference
mm	=	Millimeter
MP	=	Muriate of Potash
N	=	Nitrogen
NPK	=	Nitrogen, Phosphorus and Potassium
NS	=	Non-significant
No.	=	Number
Pb	=	Lead
ha^{-1}	=	Per hectare
%	=	Percent
q	=	Quintal
SAU	=	Sher-e-Bangla Agricultural University
SPAD	=	Soil Plant Analytical Development
i.e.	=	That is
$t\ ha^{-1}$	=	Ton per hectare
TSP	=	Triple Super Phosphate
Zn	=	Zinc
viz.	=	Videlicet (namely)
Wt.	=	Weight

CHAPTER 1

INTRODUCTION

Bangladesh is an agro-based country with a large population. Most of the people of the country depend on agriculture. The agriculture of our country is governed by intensive rice cultivation. Rice (*Oryza sativa* L.) is the staple food crop in Bangladesh and it ranks 4th position of the world (BBS, 2017). About two million people are adding every year in Bangladesh which will be 30 million over the next 20 years. Thus, to meet up the food supply for this over population, Bangladesh needs 37.26 million tons of rice for the year 2020 (BRRI, 2011). Rice is the most essential cereal crop with exceptional agricultural and economic importance as being a staple food for half of the world's population (Misratia *et al.*, 2015) and it is one of the world's most essential staple cereal food crop growing in at least 114 countries under diverse condition (Anis *et al.*, 2016). Rice covers about 75% of cropped area of Bangladesh with annual production of 34.71 million tons from 11.39 million hectares of land which contributes 15% of the country's GDP (BBS, 2017). It provides about 75% of the calories and 55% of the protein in the average daily diet of the people of Bangladesh and contributes 18% to GDP (Bhuiyan *et al.*, 2002). Currently Bangladesh have become self-sufficient in rice production, there is a lot of scope to export quality rice. Aromatic rice is used in many ways like polau, biriani, khir, finny, jarda etc. Its export can bring a considerable amount of foreign exchange for the nation (Khalil *et al.*, 2016; Rashid *et al.*, 2016).

In Bangladesh more than four thousand local landraces of rice were grown in different parts of the country. Some of these e.g. Kataribhogh, Kalizira, Basmati etc. have very nice quality i.e. fineness, aroma, test, and protein contents. These are generally low yielding (Gangaiah and Prasad, 1999). The aromatic rice of some special group which is considered best in quality is the most highly valued rice commodity in Bangladesh agricultural market having small grain, pleasant aroma and soft texture upon cooking (Dutta *et al.*, 1998). In recent years cultivation of aromatic fine rice is becoming popular due to its high price and export potential (Gangaiah and Prasad, 1999).

The scented fine quality rice (aromatic rice) popularly known as Basmati rice in India and Pakistan, Jasmine rice in Thailand and Kataribhog rice in Bangladesh. They are characterized by pleasant aroma, long slender grains, extreme grain elongation in cooking and soft texture of cooked rice. The aromatic odor is due to the presence of 2-acetyl-1-pyrroline. Aromatic rice has 15 times more 2-acetyl-1-pyrroline than non-aromatic rice.

The demand for aromatic rice in recent years has increased to a great extent for both internal consumption and export.

Most of the scented rice varieties in Bangladesh are of traditional type, photoperiod sensitive, and cultivated during the Aman season. Majority of these indigenous aromatic rice cultivars are low yielding but its higher price and low cost of cultivation generate higher profit margins compared to other varieties. Aroma development in rice grain is influenced by both genetic and environmental factors. The biochemical basis of aroma was identified as 2-acetyl-1-pyrroline (Tanchotikul and Hsieh ,1991). Most of the rice varieties have been developed traditionally by selection, hybridization and back crossing with locally adapted high-yielding lines. The conventional methods of plant selection for aroma are not easy because of the large effects of the environment and the low narrow sense heritability of aroma. More recently molecular markers, such as SNPs and simple sequence repeats (SSRs), which are genetically linked to fragrance and have the advantage of being inexpensive, simple, rapid and only requiring small amounts of tissue, have been developed for the selection of fragrant rice (Cordeiro *et al.,* 2002). Moreover, an allele specific amplification (ASA) assay allows discrimination between fragrant and non-fragrant rice varieties and identifies homozygous fragrant, homozygous non-fragrant and heterozygous nonfragrant individuals in a population segregating for fragrance (Louis *et al.,* 2005). SSR or microsatellite markers behave as a co-dominant marker which was used for this study to select rice lines having aroma with fine grain and good seed yield.

Depending on the aroma and fineness, two types of rice varieties viz. aromatic (fine) and nonaromatic (coarse) rice are producing in Bangladesh. The market price of aromatic rice is much higher than non-aromatic rice due to its best quality traits like scent (aroma), fineness, taste etc. The production of aromatic rice in Bangladesh during 2013 is approximately 0.30 million tons from 0.16 million ha of land which is so far from the national average, and hence the yield needs to be increased by 53.3% (Mahamud *et al.,* 2013).

Plant breeders are concerned that many of the minor scented varieties will be lost because of low productivity and poor market support (Singh *et al.*, 1997a). Breeding efforts are continuing to develop aromatic rice varieties having improved plant type; 100 -115 cm tall, 115-130 days life cycle, yielding 4-5 t ha^{-1}. Grain quality includes grain size 6-7 mm long with 1.5-2.0 mm breadth, cooked rice elongation 1.5-2.0 times and 20-24 per cent amylose content (Das and Baqui, 2000). Agronomy department of Sher-e-Bangla Agricultural University has been working for several years on aromatic rice and have some potential lines having desired aromatic characteristics to export in international market.

Only a few studies are found in literature evaluating the quality characteristics of traditional rice (Wickramasinghe and Noda, 2008). However, the available information is not sufficient enough to gain an overall idea on the quality characteristics of the grain and their potential applications in future varietal improvement program. This demands more elaborated studies to identify the diversity of grain quality characteristics of traditional rice varieties.

Considering the above facts of long slender grain aromatic rice in Bangladesh this study has been undertaken with the following objectives:

- To characterize the agronomic parameters of the studied lines
- To select the suitable long grain aromatic lines
- To compare the best performing aromatic lines with existing check variety

CHAPTER 2

REVIEW OF LITERATURE

Rice has wide adaptability in different environmental conditions. Yield of different rice variety is depend on the morphological parameters such as plant height, effective tiller hill^{-1}, percent filled grain and grain size as well as by environmental factors. The physiological parameters like dry matter accumulation, translocation of assimilate area also important to determine yield potentiality. Considering the above points, available literature was reviewed relevant to the present study are reviewed below with followings.

2.1 Growth parameters

2.1.1 Plant height

Islam *et al.* (2013) evaluated the performance of local aromatic rice cultivars viz. Kalijira, Khaskani, Kachra, Raniselute, Morichsail and Badshabhog and showed that plant height increased progressively reaching a maximum or peak at 78 days after transplanting (DAT) and the highest plant height (116.00 cm) was found in the variety Morichsail and the lowest (63.70 cm) in Khaskani.

Kabir *et al*. (2004) reported that Bigunbitchi produced the tallest plant (66.52 cm) at 35 days after transplanting and 50 days after transplanting (83.52 cm), whereas chinigura- l produced the tallest plants at harvest (148.20 cm).

Khisha (2002) observed that plant height was significantly influenced by variety. He found the tallest plant (129.94 cm) in Bina dhan, which significantly higher than those of Sonarbangla-1 and BRRI dhan29.

Honarnejad (1995) observed that plant height was significantly and negatively correlated with tillers plant^{-1} and positively with days from transplanting to first panicle emergence. Plant height varied from 182.5 to 206.2 cm for *Oryza rufipogon*, 60.1 to 74.9 cm for

Minghui-63 and 186.9 to 199.8 cm for hybrids (Song *et al.*, 2009). Yuan (2010) suggested the plant height for rice is about 100 cm; with Culm length of 70 cm. Hybrids have higher plant height as compared to HYV (Ghosh. 2001).

Naher *et al*. (1999) reported in year round rice transplanting experiment in Bangladesh, that the transplanting dates showed significant differences in plant height. May to August planting showed taller plants whereas October and November planting produced smaller plant.

2.1.2 Number of tillers hill^{-1}

Sumon (2015) appreciated the response of green manure and chemical fertilizer on growth, yield and quality of aromatic rice varieties in Aman season. He noticed 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) in BRRI dhan34 (V_3) which was 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).

Roy *et al.* (2014) conducted an experiment to evaluate the growth, yield and yield attributing features of 12 indigenous Boro rice varieties collected from South-Western regions of Bangladesh such as; Nayon moni, Tere bale, Bere ratna, Ashan boro, Kajol lata, Koijore, Kali boro, Bapoy, Latai balam, Choite boro, GS one and Sylhety boro. They stated that tiller numbers in most of the treatments increased exponentially up to harvest.

Shahidullah *et al.* (2009) stated thirty aromatic rice genotypes to identify the tillering patterns and to explore its relationship with grain yield. They found much variation in tillering dynamics among the genotypes and added that nineteen genotypes reached to peak population around 40 days after transplantation (DAT), when after tiller numbers started to reduce; 10 of them showed tillering climax at 50 DAT and only Kalijira Tapl-73 at 60 DAT. Maximum number of tillers varied from 136 (Khazar) to 455m^{-2} (Chinigura). The highest rate of tiller mortality was reported 49.29% in Chinigura and lowest in Jesso balam (10.10%).

*Wopereis et al. (*2009) reported that just after the node of the main stem come the tillers also called secondary stem, which can in turn produce tertiary tillers. The group of tillers produced by a single plant constitute a rice hill. Tillering ability is a function of the variety, but is also influenced by growing conditions and crop management practices.

Hossain *et al.* (2008b) reported that the total number of tillers hill-1 ranged from 8.8 to 12.5. Maximum number tillers hill^{-1} (12.5) was obtained from Chinigura and it was similarly followed by Radliunupagal. The highest number of fertile tillers hill $^{-1}$ (10.5) was found in Badshabhog, which was statistically similar to Kataribhog (Philippines), Chinigura and Radhunipagal.

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

Dingkuhn & Kropff (1996) stated that tillering of rice depends on the genotypes and on resources available for growth; tillering beyond a sustainable number it is corrected by senescence. For achieving high yield, plant architecture must be changed to make an ideotype with only 3-4 tillers bearing large number of grains in the panicle.

Peng *et al.* (1994) conducted that tillering of rice plays a vital role as tiller number per plant as high as 40 and tiller senescence rate as high as 50% can be observed and also conducted that a low-tillering new plant type bears the advantage of higher nitrogen use efficiency compared to a high-tillering rice cultivar, when both of them are grown with high N supply. Conversely, excessive tillering leads to high tiller abortion, poor grain setting, small panicle size and further reduced grain yield (Peng *et al.*, 1994; Ahmad *et al.*, 2005). Therefore, excessive branching is often considered expensive (Dun *et al*., 2006), as formation of low productive tillers becomes investment loss for a plant. Study of tillering pattern of rice genotypes is a crucial need for better selection and improvement. Morpho and physiological aspects of tillering dynamics in modern rices (inbred & hybrid cultivars) were investigated by several workers (Lafarge *et al.*, 2004; Rashid & Khan, 2006). However, aromatic rices are yet not properly addressed in this avenue. The objective of the present research was the detail investigation of tillering patterns of thirty aromatic rice genotypes and to explore relationship with yield and yield components.

Miller *et al.* (1991) reported that rice tillering is a principal determinant for panicle production and as a consequence affects total yield (Gallagher & Biscoe, 1978). Yoshida (1981) observed that the substantial variability noticed in responses of rice varieties to tillering is closely related to plasticity with respect to environmental conditions

2.1.3 Dry matter

Jian Chang *et al*. (2006) reported that highest total dry matter weight at maturity (>22 t ha^{-1}). Mahdavi *et al.* (2004) reported that the photosynthetic potentials of improved genotypes were greater as reflected by their TDM production. TDM had positive correlation with grain yield.

Chandra and Das (2000) found that dry matter production of culms and leaves were significantly positively associated with grain yield and leaf area index. Sharma and Haloi (2001) observed that the check variety Kunkuni Joha consistently maintained a high rate of dry matter production at all growth stages and high dry matter accumulation at the panicle in initiation stage.

2.1.4 SPAD value

Gholizadeh *et al.* (2017) made regression analysis between SPAD readings and leaf N content. Positive significant linear relationships were observed between attributes. They also proved the correlation between the two stages of SPAD readings and grain yield (kg ha^{-1}) to verify their relationship. The test illustrated that SPAD values were positively and significantly correlated with rice grain yield at both growth stages.

Ashrafuzzaman *et al.* (2009) reported and noticed that high yielding genotypes also showed higher chlorophyll content in rice cultivars. Hassan *et al.* (2009) reported a linear and positive relationship of SPAD values with total chlorophyll, chlorophyll-a and leaf nitrogen % indicating the dependence of SPAD values with chlorophyll and nitrogen content of leaf at flowering. Hossain *et al.* (2007) noticed that the biological yield had significant correlation to chlorophyll of leaves. When chlorophyll of leaves increase, the amount of photosynthetic assimilates increase and is stored in shoot of plant. But, when chlorophyll content of flag leaf is high, the photosynthetic assimilates transported to kernel and flag leaf role in production of biological yield is lower than other leaves. Similarly, Swain *et al.* (2006) also found highly significant and positive relation between total chlorophyll content at all the growth stages and grain number m^{-2}.

Hussain *et al.* (2000) stated that the chlorophyll meter indicates the need of a nitrogen top dressing that would result greater agronomic efficiency of nitrogen fertilizer than commonly pre-application of nitrogen. It was well established that SPAD based nitrogen management needs considerably lower amount of nitrogen than the standard nitrogen management practices without any yield losses (Ali, 2005; Miah and Ahmed, 2002). Considering the above facts, this study was undertaken to evaluate the traditional rice varieties in respect of chlorophyll content, SPAD value and nitrogen use efficiency.

Miah *et al.* (1997) reported that chlorophyll pigments play an important role in the photosynthetic process as well as biomass production. Genotypes maintaining higher leaf chlorophyll-a and chlorophyll-b during growth period may be considered potential donor for the ability of producing higher biomass and photosynthetic capacity. Higher photosynthesis rate is supported by leaf chlorophyll content in leaf blades. The chlorophyll meter or SPAD (Soil plant analysis development) offers a new strategy for synchronizing N application with actual crop demand in rice (Peng *et al.*, 1996; Balasubramanian *et al.*, 1999).

2.1.5 Days to first and 50% flowering

Mante (2016) noticed that the number of days from seeding to 50% heading was significantly influenced by both crop establishment and variety. However, no interaction effect between the factors was observed. Significant differences among varieties were also observed. Basmati 385 flowered earlier (68.83 DAS) followed by Basmati 370 and kasturi with 72.49 and 75.49 DAS respectively. On the other hand, kalinayan flowered late with 91.58 days. This finding is compatible with that of Salas (1999) claiming that Basmati 370 flowered in 62 DAT and 72 DAT for kasturi. The difference in days to flower can be attributed to the genetic make-up of the varieties tested.

Jewel *et al.* (2011) evaluated, twenty-six (26) aromatic rice genotypes for agronomic characteristics and aroma detection. Stated that days to 50% flowering, the period ranged from 90 days to 145 days. PSB RC18 (IR51672-62-2-1-1-2-3) was found to be required more days whereas Basmati 370 took fewer days and the mean value was 127.07. The period of maturity of 26 germplasm ranged from 127 to 167 days. Basmati 370 was observed to be the earliest maturing, whereas, YN96-5021 took maximum time to mature and the mean value for this trait was 155 days.

Ashrafuzzaman *et al.* (2009) evaluated the growth performance and grain quality of six aromatic rice varieties BR34, BR38, Kalizira, Chiniatop, Kataribhog and Basmati grown under rainfed conditions and reported that number of days required to 50% flowering differed significantly among the studied varieties. The lowest number of days required to 50% flowering was found in Chiniatop (81.33 days), which is statistically indifferent from Kataribhog (82.33 days). The maximum number of days required to 50% flowering was for Kalizira (86.67 days).

Sathya *et al.* (1999) studied eight quantitative traits in rice (*Oryza sativa*). Days to 50% flowering was the principal character responsible for grain yield per plant followed by 1000-grain weight, plant height and harvest index as they had positive and significant association with yield.

Sharma (1981) revealed that the number of days required for scented rice to reach to flowering stage vary from variety to variety and the location. The duration is affected by climatic factors and noticed that scented rice variety Kadamphool flowered in 70 days while BDT 1010 flowered in 77 days. Again, Fernandez *et al.*, (1979) stated that the panicle flower beginning at the top, middle and lower thirds, occurring in the 1, 2 and 3rd day after panicle exertion (heading) in a tropical environment.

2.2 Yield and yield contributing characters

2.2.1 Number of effective tillers hill^{-1}

Mante (2016) noticed that non-productive tiller was significantly influenced by crop establishment and varieties tested. Interactions among treatments were highly significant. Basmati 385 and kasturi transplanted in both cultivations obtained the highest number of non-productive tillers followed by Basmati 370 with 2.7, 2.63, 2.60, 2.40 and 2.37.

Islam *et al.* (2016a) evaluated the effect of integrated nutrient management on the performance of three transplant Aman rice varieties. Results revealed that the highest number of effective tillers hill^{-1} (8.62) was found in BRRI dhan31 variety whereas the lowest one (7.81) was observed in BRRI dhan39 variety. The results are in agreement with those reported by Chowdhury *et al.* (1993) who stated that effective tillers hill^{-1} was the genetic makeup of the variety which was primarily influenced by heredity.

Sarkar *et al.* (2014) evaluated yield and quality of aromatic fine rice as affected by variety and nutrient management and noticed that the variation in plant height, number of effective tillers hill^{-1} and number of grains panicle^{-1} among the varieties were probably due to heredity or varietal characters.

Metwally *et al.* (2012) stated that aromatic rice varieties significantly varied in panicle number m^{-2} in the two seasons. Plants of IR77510 variety markedly produced the highest panicle number m^{-2} at harvest in the two seasons. Plants of IR 65610 and IR 71137 varieties produced the lowest panicle number m^{-2} in the first and second seasons, respectively. The increase in panicle number m^{-2} may be due to increase in tillers number m^{-2}.

Jewel *et al.* (2011) evaluated twenty-six (26) aromatic rice genotypes for agronomic characteristics and aroma detection. Noticed that number of effective tillers per plant ranged from 9 to 20 and significant variation was found among the genotypes. IR71144-393-2-2-3-1 had the maximum number of effective tillers and Binadhan7 had the lowest.

Hossain *et al.* (2008a) appreciated the effect of different nitrogen levels on the performance of four aromatic rice varieties in transplanted Aman (monsoon) season as BRRI dhan38, Kalizira, Badshabhog and Tulsimala. Bearing tillers was found to be highest from the variety Kalizira, which was statistically similar with Badshabhog. The highest number of non- bearing tillers was produced by Badshabhog, which was followed by Tulsimala whereas Kalizira produced the lowest number of non-bearing tillers. The reduction of number of tillers was due to tiller mortality in the vegetative stages. Hossain *et al.* (2008b) stated that number of panicles was the result of the number of tillers produced and the proportion of effective tillers, which survived to produce panicle.

Sikdar *et al.* (2006) reported that variety had significant effect on effective tillers $hill^{-1}$.The results indicated that Badshabhog and Tulshimala the highest number of effective tillers $hill^{-1}$ (6.38). Kalizira produced the lowest number of effective tillers $hill^{-1}$ (6.20). The reasons for difference in producing effective tillers $hill^{-1}$ might be due to the variation in genetic make-up of the variety that might be influenced by heredity. This was confirmed by BRRI (1991) who stated that effective tillers $hill^{-1}$ varied with variety.

Hossain *et al.*, (2005) observed the highest number of fertile tillers $hill^{-1}$ was observed in BRRI dhan37 (11.4) and it was similarly followed by Radhunipagal, Badshabhog, Chinigura, BRRI dhan38 and the lowest fertile tillers $hill^{-1}$was obtained from Kalizera (8.7) which was statistically similar to Kataribhog. Kusutani *et al.* (2000) and Dutta *et al.* (2002) stated that the genotypes, which produced higher number of effective tillers per hill and higher number of grains per panicle also showed higher grain yield in rice.

Siddique *et al.*, (2002) studied some rice varieties included JPS, SWAT-1, DILROSH -97, PARC-3, IETI-13711, IRRI-4, GOMAL-6 and DMAL-7. The data were recorded on number of tillers hill^{-1} plant height, number of panicles plant^{-1}, 1000-grain weight, straw yield, biological and grain yield and harvest index. The analysis for all the parameters studied number of tiller plant^{-1} and number of panicles plant^{-1}.

Yoshida *et al.*, (1999) reported that the plant length and the specific leaf area showed a strong negative and positive significant correlation, respectively, with maximum tiller number.

2.2.2 Number of ineffective tillers hill^{-1}

Islam *et al.* (2016a) stated that the highest number of noneffective tillers hill^{-1} (6.44) was observed in BRRI dhan39 rice variety and the lowest one (4.26) was found in BRRI dhan31 variety.

Chakma (2006) observed that variety had significant effect on the number of non- bearing tillers hill^{-1}. He also found that Bina dhan-5 had the highest non- bearing tillers hill^{-1} (8.61) while the lowest was observed in BINA dhan-6 (6.83).

Islam (1995) in a study with the cultivars *viz.* BR10. BR11. BR22 and BR23 found that the highest number of nonbearing tillers hill^{-1} was produced by cultivar BRl1 and the lowest number was produced by the cultivar BR10.

2.2.3 Panicle length

Islam *et al.* (2016a) found the longest panicle (25.17 cm) in BRRI dhan41 and the shortest one (23.72 cm) was obtained from BRRI dhan39 variety. This variation as assessed might be mainly due to genetic characteristics which are influenced by heredity.

Malik *et al.* (2014) evaluated the effect of different levels of nitrogen on growth and yield attributes of different varieties of Basmati Rice (*Oryza sativa L*.). They reported that length of Panicle also differs in different varieties. The maximum panicle length of 31.73 cm in case of Pusa Basmati -1 at an optimal dose of Nitrogen - 120.

Hoque *et al.* (2013) investigated the performance of aromatic varieties on the growth and yield of aromatic rice and found that the differences among the varieties in respect of panicle length were statistically significant. The longest panicle of aromatic rice varieties was found in Chinigura (22.53 cm), Rata (22.50 cm) and Chandramukhi (22.43 cm). The shortest panicle was observed in Kalizira (17.00 cm).

Islam *et al.* (2013) observed that panicle length recorded was the highest (23.25 cm) in the variety Morichsail and the variety Kalijira produced lowest panicle length (20.03 cm). They showed a simple linear regression using panicle length as independent variable and yield as dependent variable showed a positive but non-significant relationship. The value of R^2 (0.59) indicates that about 60% variation in yield could be explained by the variation in panicle length.

Mia and Shamsuddin (2011) determined the physio-morphological attributes in relation to yield potential of modern and aromatic rice varieties and reported that the variety Binasail recorded the longest panicle and BRRIdhan 32 showed the lowest. The result also showed that there was no significant difference in Binasail, Ukunmadhu and Kataribhough but BRRI dhan32 showed significantly the shorter panicle compared to others.

Sharma and Dadhich (2003) conducted a field experiment in Rajshthan, India during the rainy season of 1997 using rice cultivars Mahi Sugandha, Pusa Basmati-1 and Basmati-370 and supplied with 0, 40, 80 and 120 kg N ha^{-1}, to determine the effects of nitrogen on the yield of the crops. The Pusa Basmati-1 produced the maximum panicle length (25.1 cm)

Sarkar *et al*. (2001) conducted a field experiment during the kharif 1995 in Vest Bengal, India to evaluate the performance of 3 rice cultivars (IET 12199, IET 10664 and IET 15914) treated with 5 diflèrent nitrogen fertilizer levels (0, 40, 80,120 and 160 kg ha^{-1}).

IET 12199, treated with 80 kg N ha^{-1} gave the highest values for panicle length (25.77 cm); IET 10664 and IET 15914 also performed well.

Freitas *et al*. (2001) conducted a field experiment in Mococa, Sao, Paulo. Bazil during 1997-98 and 1998-99 to evaluate the response of three new rice cultivars (IAC-101, IAC-102 and IAC 104) grown under irrigated conditions N fertilizer was applied as urea (at the rate of 0, 50, 100 and 150 kg ha^{-1}) 33% at seedling transplantation. and 33% at 20 and 40 days. They found that panicle length of three cultivars was significantly affected by N treatments.

The panicle length increased significantly with the increasing level of nitrogen from 0 to 75 kg ha^{-1} (Azad *et al*., 1995). Panicle m^{-2}, panicle length incre ased due to application of 60 kgN ha^{-1} (Singh and Singh, 1993).

Idris and Matin (1990) concluded that the rate of nitrogen application influenced panicle length positively. Increasing N levels increased panicle length significantly (Rafey *et al*., 1989). Sharma and Mishra (1986) found that the maximum length of panicle was recorded with higher nitrogen level. The application of different levels of nitrogen on rice increased panicle length significantly (Awan *et al*., 1984).

2.2.4 Filled grains panicle^{-1}

Malik *et al.* (2014) conducted an experiment during rainy season at crop research farm Allahabad agriculture institute (Deemed university) to evaluate the effect of different levels of nitrogen on growth and yield attributes of different varieties of Basmati Rice (*Oryza sativa L*.). Number of filled grains were also influenced in different varieties. The maximum number of filled grains were found in Pusa Basmati -1106.10 at the nitrogen dose of -120. Number of filled grains were also influenced in different varieties. The maximum number of filled grains were found in Pusa Basmati -1 at the nitrogen dose of -120. The rice yield revealed that the crop responded significantly with the varieties and Nitrogen application.

Jian Ching *et al*. (2006) found that super-high-yielding rice had more spikelets panicle-1 and higher filled-grain percentage (>90%) than the high-yielding rice. Shrirame and Muly (2003) concluded that grain yield was significantly correlated with number of filled grains panicle^{-1}.Srivasta and Triphati (1998) found that the increase in grain yield in local cheek variety in comparison to hybrid might be attributed to the increased fertile grain panicle^{-1}. Mishra and Pandey (1998) reported that panicle length, number of filled grains panicle^{-1} and 1000 seed weight had contributed for increased grain yield. BRRI (1994) conducted an experiment to observe the performance of BR 14. Pujam. BR5 and Tulsimala. They observed that Tulsimala produced the highest number of spikelets panicl^{-1} and BR 14 produced the lowest number of spikelets panicle^{-1}. Anonymous (1994) reported that the number of filled grains panicle^{-1} influenced significantly due to variety. The results were also supported by Singh and Gangwer (1989).

2.2.5 Unfilled grains per panicle

Islam *et al.* (2013) noticed that the undesirable traits, number of unfilled grains panicle^{-1} was important one and played a vital role in yield reduction. Effect of variety on the number of unfilled grains panicle^{-1} was highly significant. Morichsail produced the lowest number of unfilled grains panicle^{-1} (11.17) which contributed highest grain yield of that variety. Murthy *et al.* (2004) observed different number of filled and unfilled grains panicle^{-1} for different variety. Singh and Gangwer (1989) conducted an experiment with rice cultivars C-14-8, CR-10009, IET-5656 and IET-6314 and reported that grain number panicle^{-1}, 1000-grain weight were higher for C-14-8 than those of any other three varieties. Rafey *et al*. (1989) carried out an experiment with three different rice cultivars and reported that weight of 1000 grain differed among the cultivars studied. Shamsuddin *et al*. (1988) also stated that panicle number hill-1 and 1000-grain weight differed significantly among the varieties. Kamal *et al*. (1988) evaluated BR3, IR20, and Pajam 2 and found that number of grain panicle-1 were 107.6, 123.0 and 170.9 respectively, for the varieties.

2.2.6 Weight of 1000-grains

Mondal *et al.* (2005) studied 17 modern cultivars of transplant aman rice and reported that 1000-grain weight differed significantly among the cultivars studied. On the other hand, Sathya *et al.* (1999) reported that 1000-grain weight, days to 50% flowering, plant height and harvest index had positive and significant association with yield. Ashraf *et al.* (1999) also reported that 1000-grain weight, an important yield-determining component, is a genetic character least influenced by environment.

BRRI (1997) reported that weight of 1000- grains of Halio, Tilockachari, Nizershail and Latisail were 26.5 g, 27.7 g, 25.2 g and 25 g respectively. Wen and Yang (1991) reported that higher 1000 - grain weight by using one seeding hill^{-1} than with four seeding hill^{-1}.

Lockhart and Wiseman (1988) showed that higher number of tillers reduces the number, size and weight of grain. Thousand-grain weight, an important yield determining component, is a genetic character least influenced by environment (Asraf *et al*., 1999).

2.2.7 Grain yield

Islam *et al.* (2016b) investigated genetic variability among 113 aromatic and fine local rice genotypes of which five were exotic in origin and reported that plants with high panicles have high number of filled grains thereby increasing rice yield.

Mante (2016) reported that significant differences were observed in the different varieties tested. Basmati 370 obtained the highest yield of 4.51 ton/ha followed by Kasturi, 3.21 ton/ha. Kalinayan and Basmati 385, on the other hand, produced the low yield of 2.78 and 2.77 t ha^{-1}, respectively. The high yield of the transplanted Basmati 370 can be due to its high produced tiller count, relatively high filled grains and heavier grain weight.

Kibria *et al.* (2008) investigeted the yield potential of local aromatic variety Kalizira, a segregating population (developed from a cross between Y-1281 and Kalizira) and reported that correlation studies between aroma and grain yield revealed that aroma is negatively correlated with grain yield.

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

Oad *et al.* (2002) reported that rice grain yield was interrelated with all agronomical and physiological traits including plant height, total dry matter, leaf area index, relative growth rate, crop growth rate, 1000-grain weight, panicle length and number of panicle plant $^{-1}$. Sharama and Singh (2002) found that total dry matter and photosynthetic rate had very high direct and indirect effects on grain yield.

Indian consumers value aroma most, followed by elongation after cooking (Singh *et al.*, 1997). Thus historical and socio-cultural factors of a particular region play an important role in defining what consumers consider as quality rice.

Shobha Rani *et al.* (1996) stated that strong preference exists for the long grain aromatic Basmati rice in the middle east countries while the same is sometimes considered as contaminant in the West. Bangladesh, Nigeria and Liberia consume parboil rice, while glutinous rice is the staple food in parts of Thailand and Laos.

Yap (1987) reported that quality preferences are different in different countries. Aging is considered a desired phenomenon in tropical Asia but the same is not preferred in other countries such as Japan, Australia, Korea, parts of China and Italy where they consume soft and sticky Japonica rice.

2.2.8 Straw yield

Rejaul (2005) stated that straw yield was 13 significantly affected due to varieties. The highest straw yield (5.64 t ha^{-1}) was observed in BRRI dhan29. The tiller plants and total tillers might be contributed for higher straw yield of BRRI dhan29. The lowest straw yield (5.43 t ha^{-1}) was obtained from BRRI dhan28.

Patel (2000) studied the varietal performance of Kranti and 1R36 and observed that Kranti produced significantly higher straw yield than IR 36. The mean straw yield increases with Kranti over IR36 was 10%.

2.2.9 Biological yield

Islam *et al.* (2016a) reported that the highest biological yield (12.49 t ha^{-1}) was recorded from the BRRI dhan31 and the lowest one (10.25 t ha^{-1}) was obtained from BRRI dhan39 rice variety.

Islam *et al.* (2013) observed that the highest biological yield (9.46 t ha^{-1}) was obtained from the variety Kachra and the lowest biological yield (3.87 t ha^{-1}) was recorded from the variety Kalijira. From the result, it was observed that biological yield differed due to combined effect of grain yield and straw yield. Plotting grain yield against biological yield gave a significant positive linear relationship which indicates that as biological yield increased, grain yield also increased

2.2.10 Harvest Index

Hoque *et al.* (2013) reported that harvest index is a vital character having physiological importance. They observed that BRRI dhan50 produced the highest harvest index (0.44%) which was followed by Kataribhogh (0.34%). The lowest harvest index was found in Chandramukhi and Chinigura (0.30 %). Jian Chang *et al*. (2006) found that super-high-yielding rice had more harvest index (51%) than the high- yielding rice.

Kusutani *et al.* (2000) highlighted the contribution of high harvest index to yields. High yield is determined by physiological process leading to a high net accumulation of photosynthates and their partitioning (Miah *et al.*, 1996).

Shriame and Muley (2003) found that grain yield exhibited a very strong positive correlation with harvest index. Butogele *et at. (*1996) observed that medium grain cultivars had a higher harvest index and physiological efficiency.

2.3 Physico-chemical characteristics

2.3.1 Grain length and breadth

Hossain *et al.* (2008b) observed that grains of short to medium length usually, but not always, break than long grains during milling. Highest grain length (5.2mm) and length breadth ratio (2.3) was obtained from Kataribhog (Philippines). Begum (2006) reported that grain length had significant and negative correlation with grain width; significant and positive correlation with length width ratio. Grain width had significant and negative correlation with length width ratio.

Gupta and Agarwal (2000) opined that the morphological traits like grain length, L/B ratio, grain size etc. appeared to be quite stable and could therefore, be used as primary diagnostic characters for classifying paddy varieties.

2.3.2 Grain size and shape

Rita and Sarawgi (2008) opined that kernel shape and L/B ratio are important features for grain quality assessment. Sharma (2002) mentioned that the aromatic cultivars possessed a slender shape compared with the medium-slender shape of non-aromatic cultivars.

Cruz and Khush (2000) reported that .Kernel appearance, shape, size, nutritional value and other cooking parameters are reported to be essential for assessing the quality of rice from one group of consumers to another.

Tomar and Nanda (1985) did not find any association between kernel size and shape. It had significant negative association between grain width and grain length width ratio. It had significant positive correlation between grain length and grain width.

IRRI (1980) stated that the L/B ratio of above 3 is generally considered as slender. Adair *et al.* (1973) reported grain size and shape are the first criteria for the quality of rice that breeders consider in developing new varieties for commercial production.

2.3.3 Grain weight and husk weight

Liu *et at*. (2016) observed that the measurement of the thousand kernel weight includes weighing and counting the kernels. Weight data is obtained from scales and traditional methods based on manual counting are used to count the kernels.

Rice husks have been attracted as value added material towards waste utilization and cost reduction in domestic and industrial processing. Rice husk (RH) is widely available in rice producing countries like China and India which contributes 33% and 22% of global rice production respectively, as by-product of the rice milling. RH content ranges from 16-25% of paddy (Della *et al*., 2002; Giddel *et al*., 2007; Soltani *et al*., 2015).

Every year approximately 500 million tonne paddy produced by world and 120 million tonnes of paddy produced by India, it gives around 24 million tonnes of RH per year (Shwetha *et al*., 2014).

Rice husk ash (RHA) is the by-product of RH, when it burnt in ambient atmosphere.20 million tonnes produced per year by world (Koteswara and Pranav, 2011; Soltani *et al*., 2015).

2.4 Organoleptic characteristic

2.4.1 Aroma

Sakthivel *et al.* (2009) reported that aroma is a much-valued quality factor for rice. Various volatile aroma compounds, with 2-acetyl 1-pyrroline being the principal aromatic compound, have been identified in cooked rice grains of varieties originated from diverse regions. Jezussek *et al.* (2002) also supported this.

Islam *et al.* (2008) investigated the influence of spacing on the qualitative characters of aromatic rice and reported that the highest aroma (3.26) was recorded from Kalizira and the lowest aroma (1.28) was recorded from Badshabhog. They explained that Varietals differences regarding aroma might be due to their difference in genetic make-up.

Hossain *et al.* (2008b) observed that the variety Kalizera, Badshabhog contained higher level of aroma among the tested varieties, while, rests of the varieties had moderate type aroma.

Bourgis *et al.* (2008); Kovach *et al.* (2009) and Hashemi *et al.* (2013) reported that out of several volatile flavour compounds, which contribute to rice aroma, 2- acetyl-1-pyrroline (2-ACP) has been identified as the principal compound for distinctive fragrance in Basmati and Jasmine rice. Sood and Siddiq, 1978 added that the sensory or chemical methods to determine the rice fragrance involve smelling leaf tissue and grains after heating with water or reacting with KOH or I2- KI8 solutions.

Singh *et al.* (1997) reported that in addition to field factors there are other factors like storage conditions, milling and processing methods, cooking methods, parboiling etc. which might influence the aroma. These factors must be standardized to harness maximum aroma from rice.

Dutta *et al.* (1998) reported that aroma varied among the varieties. Varietal differences regarding grain protein content and aroma might be due to their difference in genetic make-up. Juliano and Duff (1991) reported that aroma development is influenced by both genetic and environmental factors

Cruz *et al.* (1989) reported that aroma is best developed when aromatic rice is grown in areas where the weather is cooler during maturity. Efferson (1985) informed that scented or aromatic rice was preferred in some areas of Asia and draws a premium price in certain specialty markets. The Middle East consumers preferred rices with strong aroma.

Efferson (1985) reported that scented or aromatic rice is preferred in some areas of Asia and draws a premium price in certain specialty markets. The Middle East consumers prefer rices with strong aroma. They feel that rice without a distinctive aroma is like food without salt. For consumers in Europe, a trace of aroma is an objectionable trait, because for them any scent signals spoilage and contamination

Buttery *et al.* (1982) isolated and identified 2-acetyl-l-pyrroline as an important compound contributing to the aromatic odor. They suggested that 2-acetyl-l-pyrroline was a major contributor to the popcorn-like aroma in several of the Asian aromatic rice varieties.

Buttery *et al.* (1983a) determined the concentration for 10 varieties of rices. The range of concentration was from 6 ppb to 90 ppb with the milled rice. They found that the unmilled rice (brown rice) had concentrations of 2-acetyl-pyrroline from 100 ppb to 200 ppb. They explained that the surface layer constituents of rice grain play an important role in the formation of cooked rice aroma. An odor threshold of 2-acetyl-1 pyrroline was determined using a trained panel of 16 judges. The panel could consistently detect 7 ppb. The threshold level appeared to be 0.1 ppb. It is amazing that the human nose can detect such low levels. The result would suggest that it takes very little 2-acetyl-1-pyrroline to contribute to the odor of aromatic rice.

Buttery *et al.* (1983b) analysed Pandan leaves and found that the major volatile component was 2-acetyl-1- pyrroline. They found a high correlation between the 2-acetyl-l-pyrroline in Pandan leaves and aromatic rice. The concentration of 2-acetyl-1- pyrroline in Pandan leaves was 10 times greater than aromatic rice and 100 times greater than non-aromatic rice. The concentration of 2-acetyl-1- pyrroline was lower in aged aromatic rice. Aromatic rice had 15 times more 2-acetyl-1-pyrroline than non-aromatic rice.

Sood and Siddiq (1978) stated that the aroma of rice plays a role in its consumer acceptability. More than 100 compounds that contribute to the aroma of rice have been identified. Some of these volatile compounds contribute to consumer acceptance of certain types of rice, whereas other compounds contribute to consumer rejection. The popcorn-like smell of aromatic rice stemming primarily from its 2-acetyl-1-pyrroline (2-AP) content is preferred by many consumers. Several methods are used to detect aroma like biting kernels, smelling vegetative tissue after warming or soaking in KOH and eating cooked rice

Kadam and Patanker (1938) reported that the scent aroma is due to presence of large number of compounds in endosperm in specific proportion. The biochemical basis of aroma was identified as 2-acetyl-1-pyrroline.

CHAPTER 3
MATERIALS AND METHODS

The experiment was conducted at the Agronomy Field, Sher-e-Bangla Agricultural University, Dhaka-1207 during the period from July 2017 to December 2017.

3.1 Site description

3.1.1 Geographical location

The experimental area was situated at 23°77′N latitude and 90°33′E longitude at an altitude of 8.6 meter above the sea level (Anon., 2004).

3.1.2 Agro-ecological region

The experimental field belongs to the Agro-ecological zone of “The Modhupur Tract”, AEZ-28 (Anon., 1988a). This was a region of complex relief and soils developed over the Modhupur clay, where floodplain sediments buried the dissected edges of the Modhupur Tract leaving small hillocks of red soils as ‘islands’ surrounded by floodplain (Anon., 1988b). The experimental site was shown in the map of AEZ of Bangladesh in Appendix I.

3.1.3 Climate

The area has sub-tropical climate, characterized by high temperature, high relative humidity and heavy rainfall with occasional puffy winds in Kharif season (April-September) and scanty rainfall associated with moderately low temperature during the October-December.

3.1.4 Soil

The soil of the experimental site belongs to the general soil type, Shallow Red Brown Terrace Soils under Tejgaon Series. Top soils were clay loam in texture, olive-gray with common fine to medium distinct dark yellowish-brown mottles. Soil pH ranged from 5.6

and had organic matter 0.78% (Appendix II). The experimental area was flat having available irrigation and drainage system and above flood level.

3.2 Details of the experiment

3.2.1 Treatments

Single factor experiment was conducted to screened aromatic Aman rice genotypes.

Treatments included in the experiment were as follows:

I. SAU ADL1	II. SAU ADL2
III. SAU ADL3	IV. SAU ADL4
V. SAU ADL5	VI. SAU ADL6
VII. SAU ADL7	VIII. SAU ADL8
IX. SAU ADL9	X. SAU ADL10
XI. SAU ADL11	XII. SAU ADL12
XIII. SAU ADL13	XIV. SAU ADL14
XV. SAU ADL15	XVI. Kataribhog

3.2.2 Experimental design

The experiment was laid out in a RCB design with three replications. There were sixteen treatments. The total numbers of unit plots were 48. The size of unit plot was 3.0 m b× 2.0 m. The distances between plot to plot and replication to replication were 0.50 m and 0.75 m, respectively. The layout of the experiment has been shown in Appendix III.

3.3 Planting material

Fifteen selected rice genotypes along with Kataribhog were used as planting material.

3.3.1 Description of Kataribhog

Kataribhog is a local cultivar of aromatic rice grown in Aman season. It is a tall stature, photosensitive cultivar and lodged with higher management package. It takes around 140 days to mature. It is considered as a low yield potential aromatic cultivar.

3.4 Crop management

3.4.1 Seedling raising

3.4.1.1 Seed collection

Seeds of a local aromatic Aman rice genotype was collected from an NGO named Suranjana from where other specific lines were selected from the lot through various field observation by the Agronomy department of Sher-e-Bangla Agricultural University. The selected materials were named as SAU ADL (Sher-e- Bangla Agricultural University Agronomy Department Line) having chronological numerical as SAU ADL1, SAU ADL2, SAU ADL3, SAU ADL4, SAU ADL5, SAU ADL6, SAU ADL7, SAU ADL8, SAU ADL9, SAU ADL10, SAU ADL11, SAU ADL12, SAU ADL13, SAU ADL14 and SAU ADL15. Kataribhog was collected from local market.

3.4.1.2 Seed sprouting

Seeds were selected by following specific gravity method. Seeds were immersed into water in a bucket for 24 hours. These were then taken out of water and kept tightly in gunny bags. The seeds started sprouting after 48 hours which were suitable for sowing in 72 hours.

3.4.1.3 Preparation of seedling nursery

A common procedure was followed in raising seedlings in the seedbed. The seedbed was prepared by puddling with repeated ploughing followed by laddering. Weeds were removed and irrigation was gently provided to the bed as and when necessary. No fertilizer was used in the nursery bed.

3.4.1.4 Seed sowing

Sprouted seeds were sown on the seedbed on 3th July 2017 for raising nursery seedlings. The sprouted seeds were sown as uniformly as possible.

3.4.2 Preparation of experimental land

The experimental field was first ploughed on 26th July 2017 with the help of a tractor drawn disc plough, later on 30th July 2017 the land was irrigated and prepared by three successive ploughings and cross ploughings with a tractor drawn plough and subsequently leveled by laddering. All weeds and other plant residues of previous crop were removed from the field. Immediately after final land preparation, the field layout was made on 1st August 2017 according to experimental specification. Individual plots were cleaned and finally leveled with the help of wooden plank so that no water pocket could remain in the puddled field.

3.4.3 Fertilizer application

The experimental area was fertilized with 120, 80, 80 and 20 kg ha^{-1} of N, P_2O_5, K_2O and S applied in the form of urea, triple super phosphate (TSP), muriate of potash (MP) and gypsum respectively. The entire amounts of triple super phosphate, muriate of potash and gypsum were applied as basal dose at final land preparation. Urea was top-dressed in three equal installments, after seedling recovery, during the vegetation stage and at 7 days before panicle initiation.

3.4.4 Transplanting of seedlings

For nursery seedlings 30 days old seedlings were uprooted carefully on 2st August, 2017 and were kept in soft mud in shade**.** The seedbeds were made wet by application of water in previous day before uprooting the seedlings to minimize mechanical injury of roots. Seedlings were then transplanted with 20 cm × 20 cm spacing on the well-puddled plots.

3.4.5 Intercultural operations

3.4.5.1 Weeding

The crop was infested with some weeds during the early stage of crop establishment. Three hand weeding were done for every method, first weeding was done at 10 days transplanting followed by second weeding at 15 days after first weeding. Third weeding was done 15 days after second weeding.

3.4.5.2 Application of irrigation water

Irrigation water was added to each plot as and when necessary. All the plots were kept irrigated and dried 7 days before harvesting.

3.4.5.3 Plant protection measures

Plants were infested with rice stem borer (*Scirphophaga incertolus*) and leaf hopper (*Nephotettix nigropictus*) to some extent which were successfully controlled by applying Diazinone @ 10 ml/10 liter of water for 5 decimal lands on 3rd September and by Ripcord @ 10 ml/10 liter of water on 15th September and 19th October, 2017 . Crop was protected from birds and rats during the grain filling period. Field trap and foxtoxin poisonous bait was used to control the rat. For controlling the birds watching was done properly, especially during morning and afternoon.

3.5 Harvesting and post-harvest operation

The rice plant was harvested depending upon the maturity of plant. Harvesting was done manually from each plot. Harvesting was started at 106 days and continued up to 138 days. Maturity of crop was determined when 80% of the grains become matured. Twelve pre-selected hills per plot from which different data were collected and 1m^2 areas from middle portion of each plot was separately harvested and bundled, properly tagged and then brought to the threshing floor for recording grain and straw yield. Threshing was done using pedal thresher. The grains were cleaned and sun dried to a moisture content of 12%. Straw was also sun dried properly. Finally grain and straw yields plot^{-1} were determined and converted to ton ha^{-1}.

3.6 Recording of data

Experimental data were determined from 20 days of growth duration and continued until harvest. The followings data were determined during the experiment.

A. Crop growth characters

i. Plant height (cm) at 20 days interval and at harvest

ii. Number of tillers hill^{-1} at 20 days interval and at harvest

iii. Plant dry weight at 20 days interval

iv. Days to 50% flowering

v. SPAD value at 50 DAT and 90 DAT

B. Yield and other crop characters

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

ii. Number of ineffective tillers hill^{-1}

iii. Length of panicle (cm)

iv. Number of filled grains panicle^{-1}

v. Number of unfilled grains panicle^{-1}

vi. Weight of 1000-grains

vii. Grain yield

viii. Straw yield

ix. Biological yield

x. Harvest index

C. Grain quality characteristics

i. Grain length and grain breath

ii. Grain length and grain breath ratio

iii. Grain weight and husk weight

iv. Aroma**.**

3.7 Detailed procedures of recording data

A brief outline of the data recording procedure followed during the study is given below:

A. Crop growth characters

i. Plant height (cm)

Plant height was measured at 20,40, 60, 80 DAT and at harvest. The height of the plant was determined by measuring the distance from the soil surface to the tip of the leaf height before heading, and to the tip of panicle after heading.

ii. Number of tillers hill^{-1}

Number of tillers hill^{-1} were counted at 20, 40, 60 DAT and at harvest from ten randomly pre-selected hills and was expressed as number hill^{-1}. Only those tillers having three or more leaves were used for counting.

iii. Dry weight of plant (g)

The sub-samples of 2 hills plot^{-1} was uprooted from predetermined line which were oven dried until constant level. From which the weight of above ground dry matter were recorded at 50,70 and 90 DAT. Dry weight was measured in g.

iv. Time of flowering

Time of flowering (days) was recorded when about 50% of the panicle within a plot emerged.

v. SPAD value

The SPAD-502 chlorophyll meter (Minolta Camera Co., Japan) is a simple, portable, diagnostic and nondestructive light weight device used to estimate leaf chlorophyll content (Minolta, 1989). The computed values by this device represents the whole content of chlorophyll (a, b) in plant, (Feibo *et al.*, 1998; Ichie *et al.*, 2002; Ramesh *et al.*, 2002). Ten plants per treatment were selected randomly and SPAD values at 50 DAT and 70 DAT were recorded from the fully matured leaves counted from the top of the plants, the youngest fully expanded leaf.

B. Yield and other crop characters

i. Effective tillers hill^{-1}

The panicles which had at least one grain was considered as effective tillers. The number of effective tillers of 10 hills was recorded and expressed as effective tillers number hill^{-1}.

ii. Ineffective tiller hill^{-1}

The tillers having no panicle was regarded as ineffective tillers. The number of ineffective tillers of 10 hills was recorded and was expressed as ineffective tiller number hill^{-1}.

iii. Panicle length

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

vi. Filled grains panicle^{-1}

Grain was considered to be filled if any kernel was present there in. The number of total filled grain present on 10 panicles were recorded and finally averaged.

v. Unfilled grains panicle^{-1}

Unfilled grain means the absence of any kernel inside in and such grain present on each of 10 panicles were counted and finally averaged.

vi. Weight of 1000-grains

One thousand cleaned dried seeds were counted randomly from each sample and weighed by using a digital electric balance at the stage the grain retained 14% moisture and the mean weight were expressed in gram.

vii. Grain yield

Grain yield was determined from the central 3.6 m^2 area of each plot removing the borders lines and expressed as t ha^{-1} and adjusted with 12% moisture basis. Grain moisture content was measured by using a digital moisture tester.

viii. Straw yield

Straw yield was determined from the central 3.6 m^2 area of each plot removing the borders lines. After separating of grains, the sub-samples were sun dried to a constant weight and finally converted to t ha^{-1}.

ix. Biological yield

Grain yield and straw yield were all together regarded as biological yield. Biological yield was calculated with the following formula.

Biological yield (t ha^{-1}) = Grain yield (t ha^{-1}) + Straw yield (t ha^{-1})

x. Harvest index

It denotes the ratio of economic yield (grain yield) to biological yield and was calculated with following formula (Donald, 1963; Gardner *et al.*, 1985).

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

C. Grain quality characteristics

i. Grain length

The grain length was measured as the distance from the base of the lowermost glume to the tip (apiculus) of the fertile lemma or palea.

ii. Grain breadth

To obtain the grain breadth, it was measured as the distance across the fertile lemma and palea at the widest point using the callipers at post-harvest stage.

iii. Grain Classification

Ten de-husked entire brown rice grains were measured using digital slide calipers and based on the L/B ratio, size and shape was classified according to the method described by Cruz and Khush (2000) and IRRI standards.

Size classification:

Scale	Size category	Length in mm
1	Very long	More than 7.50
3	Long	6.61 to 7.50
5	Medium or intermediate	5.51 to 6.60
7	Short	Less than or equal to 5.50

Shape classification:

Scale	Shape	L/B ratio
1	Slender	Over 3.0
5	Medium	2.1 to 3.0

9	Bold	2.0 or less than 2.0

iv. Aroma

A simple laboratory technique to evaluate rices for presence of aroma was developed at IRRI (1971). One gram of freshly harvested milled rice was placed into centrifuge tube (50 ml round bottom). About 20 ml distilled water was added. The tubes are then covered with aluminum foil. The samples are placed in a boiling water bath for 10 minutes. The cooked samples were allowed to cool and the presence of aroma was determined for every sample. The samples are scored as strongly aromatic, moderately aromatic, slightly aromatic and non-aromatic. A strongly scented variety is used as check for comparison.

3.8 Statistical analysis

All the collected data were analyzed following the analysis of variance (ANOVA) technique using CROPSTAT package and the mean differences were adjudged by LSD technique (Gomez and Gomez, 1984).

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Growth parameters

4.1.1 Plant height

The plant height of aman rice genotypes was significantly affected by different genotypes at 20, 40, 60 and 80 days after transplanting (DAT) and at harvest (Appendix IV and Table 1).

At 20 DAT, the genotype SAU ADL15 produced the tallest plant (62.00 cm) which was statistically similar with SAU ADL14 (57.29 cm) and the genotype SAU ADL8 gave the shortest plant height (36.87 cm) and that was statistically similar with the genotypes SAU ADL4 ,SAU ADL6, SAU ADL7 (39.20 cm, 39.53 cm and 41.80 cm respectively)

At 40 DAT, SAU ADL15 produced the tallest plant (103.33 cm) which is statistically similar with SAU ADL2 (98.71 cm), SAU ADL9 (95.23 cm), SAU ADL14 (93.83 cm) and SAU ADL8 gave the shortest plant (58.83 cm) and that was statistically similar with the genotypes SAU ADL4 (65.96cm).

At 60 DAT, SAU ADL 14 produced the tallest plant (150.71 cm) which was statistically similar with SAU ADL15, SAU ADL2 and SAU ADL10 (150.53 cm, 150.19 cm and 146.64 cm respectively). The genotype SAU ADL8 gave the shortest plant height (78.63 cm).

At 80 DAT, the highest plant height (185.15 cm) was recorded in SAU ADL2 similar to SAU ADL7, SAU ADL15, SAU ADL14, SAU ADL10, SAU ADL9 and SAU ADL1wherewas the shortest plant height (96.65) was recorded in SAU ADL8 that is similar to SAU ADL4 (106.96 cm)

At harvest, SAU ADL14 produced the tallest plant (196.59 cm) and SAU ADL8 gave the shortest plant height (95.10 cm). The second tallest plant was produced by SAU ADL2

(194.78 cm) which was statistically similar with SAU ADL15 (188.99 cm) and SAU ADL 1(186.30 cm). Long stature of plant is responsible for lodging. Hossain *et al.* (2008a) also observed lodging of local aromatic rice varieties at maturity stage due to higher plant height during evaluation of the yield and quality performance of some aromatic rice varieties of Bangladesh. But some local genotypes showed no lodging criteria and SAU ADL8 produced short stature plant at harvest.

Table 1. Plant height of Aman rice genotypes and Kataribhog at different crop growth stages

Treatments	Plant height (cm) at				
	20 DAT	**40 DAT**	**60 DAT**	**80 DAT**	**At harvest**
SAU ADL1	50.23 cd	86.63 cd	138.23 b-d	170.97 a-c	186.30 a-c
SAU ADL2	49.80 cd	98.71 ab	150.19 ab	185.15 a	194.78 a
SAU ADL3	43.87 e-h	82.74 de	129.21 de	157.59 bc	160.00 ef
SAU ADL4	39.20 hi	65.96 fg	96.44 f	106.95 fg	107.27 h
SAU ADL5	50.00 cd	72.87 ef	107.53 f	134.48 de	156.03 ef
SAU ADL6	39.53 g-i	70.91 f	97.44 f	130.61 e	112.78 gh
SAU ADL7	41.80 f-i	86.49 cd	137.88 c-e	183.11a	153.13 f
SAU ADL8	36.87 i	58.83 g	78.63 g	96.65 g	95.10 i
SAU ADL9	48.27 c-e	95.23 a-c	136.85 c-e	173.41 ab	177.25 b-d
SAU ADL10	45.93 d-f	92.24 b-d	146.64 a-c	174.30ab	175.37 cd
SAU ADL11	48.060 c-e	72.66 ef	98.55 f	116.43 ef	120.97 g
SAU ADL12	44.91 d-g	72.87 ef	96.97 f	123.67 ef	112.81 gh
SAU ADL13	52.00 bc	87.00 cd	125.87 e	151.79 cd	166.21 df
SAU ADL14	57.29 ab	93.85 a-c	150.71 a	178.43 a	196.59 a
SAU ADL15	62.00 a	103.33 a	150.53 a	179.12 a	188.99 a
Kataribhog	43.60 e-h	74.68 ef	105.90 f	134.71 de	155.05 ef
$LSD_{(0.05)}$	5.55	10.65	12.19	19.66	11.91
CV (%)	7.07	7.77	6.00	7.87	4.65

Variation in plant height might be due to the differences in their genetic make-up. Similar result was reported by Shamsuddin *et al.* (1988), Hossain *et al.* (1991) and Khatun (2001) who also observed variable plant heights among the varieties.

4.1.2 Number of tillers hill^{-1}

Number of tillers hill^{-1} varied significantly among scented Aman rice genotypes and kataribhog at 20 DAT, 40 DAT, 60 DAT and at harvest (Appendix V and Table 2).

At 20 DAT, the maximum tiller numbers hill^{-1} was observed in the genotype SAU ADL11 (4.60) that was statistically similar with SAU ADL8 (4.13) and the minimum tiller numbers hill^{-1} was obtained from SAU ADL6 (1.87).

At 40 DAT, the maximum tiller numbers hill^{-1} was found in the local genotype SAU ADL8 (14.80) which was statistically similar with SAU ADL1, SAU ADL10, SAU ADL9, SAU ADL, Kataribhog, SAU ADL11, SAU ADL3, SAU ADL12, SAU ADL5 ,SAU ADL2 and the lowest tiller numbers hill^{-1} was obtained from SAU ADL14 and that was statistically similar with SAU ADL15, SAU ADL4, SAU ADL13 and SAU ADL6.

At 60 DAT, the highest tiller numbers hill^{-1} was found in the genotypes SAU ADL8 (11.00) and SAU ADL5(11.00) which were statistically similar with Kataribhog, SAU ADL11, SAU ADL12, SAU ADL4, SAU ADL9, SAU ADL3 and the minimum tiller numbers hill^{-1} was obtained from SAU ADL14 (6.20) and that was statistically similar with SAU ADL15, SAU ADL2, SAU ADL15,SAU ADL1, SAU ADL13, SAU ADL10 and SAU ADL6.

At harvest, the maximum tiller numbers hill^{-1} was observed in the genotype SAU ADL5 (9.80) that similar to Kataribhog (9.13). The minimum tiller numbers hill^{-1} was obtained from SAU ADL14 that similar to SAU ADL13. This result was in consistent to Hossain *et al.* (2005) observed the lowest number of total tillers hill^{-1} in Kalizira (9.8) which was statistically similar to Kataribhog at harvest. The variation in number of total tillers hill^{-1}

as assessed might be due to varietal character. Similar result was also reported by Jisan *et al.* (2014).

Table 2. Tillers hill^{-1} of Aman rice genotypes and Kataribhog at different crop growth stages

Treatments	Tillers hill^{-1} (no) at			
	20 DAT	**40 DAT**	**60 DAT**	**Harvest**
SAU ADL1	3.13 ef	13.47 ab	8.07 c-e	6.73 ef
SAU ADL2	2.67 fg	11.27a-c	6.27 e	6.27 f
SAU ADL3	3.33 c-e	12.33 a-c	9.00 a-c	7.00 d-f
SAU ADL4	3.40 c-e	10.53 bc	9.40 a-c	6.87 d-f
SAU ADL5	3.27 de	11.93 a-c	11.00 a	9.80 a
SAU ADL6	1.87 h	11.13 bc	8.13 c-e	7.73 c-e
SAU ADL7	2.53 g	13.20 ab	8.53 b-d	6.93 d-f
SAU ADL8	4.13 ab	14.80 a	11.00 a	6.80 d-f
SAU ADL9	3.87 bc	13.27 ab	9.13 a-c	6.87 d-f
SAU ADL10	3.80 b-d	13.33 ab	8.13 c-e	7.53 c-e
SAU ADL11	4.60 a	12.53 a-c	10.33 ab	8.00 b-d
SAU ADL12	3.20 ef	12.33 a-c	9.80 ab	8.47 bc
SAU ADL13	3.67 b-e	11.13 bc	8.13c-e	6.00 fg
SAU ADL14	3.60 b-e	9.27 c	6.20 e	4.80 g
SAU ADL15	3.87 bc	10.20 bc	6.87 de	7.20 d-f
Kataribhog	2.47 g	12.60 a-c	10.93 a	9.13 ab
$LSD_{(0.05)}$	0.58	3.58	2.071	1.22
CV(%)	10.39	17.78	14.10	10.05

Variable effect of variety on number of tillers hill^{-1} was also reported by Shahidullah *et al.* (2009) stated thirty aromatic rice genotypes to identify the tillering patterns and to explore its relationship with grain yield. They found much variation in tillering dynamics among the genotypes and added that nineteen genotypes reached to peak population around 40 days after transplantation (DAT), when after tiller numbers started to reduce; 10 of them showed tillering climax at 50 DAT and only Kalijira Tapl-73 at 60 DAT. Maximum number of tillers varied from 136 (Khazar) to 455m^{-2} (Chinigura). The highest rate of tiller mortality was reported 49.29% in Chinigura and lowest in Jesso balam (10.10%).

4.1.3 Plant dry matter

Plant dry matter varied significantly among Aman rice genotypes and kataribhog at 50 DAT, 70 DAT and 90 DAT . (Appendix VI and Table 3).

Table 3. Plant dry matter of local aromatic Aman rice genotypes and Kataribhog at different crop growth stages

Treatments	Plant dry weight (g) $hill^{-1}$ at		
	50 DAT	70 DAT	90 DAT
SAU ADL1	18.73 c-e	27.01 gh	52.97 b
SAU ADL2	23.93 ab	51.13 a-e	30.60 d
SAU ADL3	18.25 c-e	49.31 b-e	42.51 c
SAU ADL4	19.35 b-e	41.16 ef	31.46 d
SAU ADL5	20.75 bc	40.72 ef	46.22 bc
SAU ADL6	23.71 ab	60.51 ab	31.70 d
SAU ADL7	22.25 bc	24.54 h	41.64 c
SAU ADL8	8.61 f	34.37 f-h	29.85 d
SAU ADL9	15.23 de	39.23 e-g	37.17 cd
SAU ADL10	20.46 bc	57.26 a-d	32.37 d
SAU ADL11	14.79 e	44.75 d-f	43.22 c
SAU ADL12	17.79 c-e	47.82 c-e	52.74 b
SAU ADL13	19.86 b-d	62.01 a	29.75 d
SAU ADL14	27.24 a	32.54 f-h	43.27 c
SAU ADL15	24.12 ab	59.34 a-c	67.72 a
Kataribhog	27.51 a	33.63 f-h	45.18 bc
LSD $_{(0.05)}$	4.84	12.60	9.17
CV (%)	14.41	17.14	13.37

-

At 50 DAT, the maximum dry matter hill^{-1} was observed in the rice genotype Kataribhog (27.51 g) that was statistically similar with SAU ADL14, SAU ADL15, SAU ADL2 and SAU ADL6 (27.24 g, 24.12 g, 23.93 g and 23.71 g respectively) and the minimum dry matter hill^{-1} was obtained from SAU ADL8 (8.61 g)

At 70 DAT, the maximum dry matter hill^{-1} was found in the genotype SAU ADL13 (62.01 g) that similar to SAU ADL6, SAU ADL15, SAU ADL6 and SAU ADL2 and the lowest dry matter was obtained from SAU ADL7 and that was statistically similar with SAU ADL1, SAU ADL14, SAU ADL8 and Kataribhog.

At 90 DAT, the highest dry matter hill^{-1} was found in the genotype SAU ADL15 (67.72 g) and the lowest dry matter hill^{-1} was obtained from SAU ADL13 (29.75 g) and that was statistically similar with SAU ADL8, SAU ADL2, SAU ADL4,SAU ADL6, SAU ADL10 and SAU ADL9.

4.1.4 SPAD value

Chlorophyll pigments play an important role in the photosynthetic process as well as biomass production. Genotypes maintaining higher leaf chlorophyll-a and chlorophyll-b during growth period may be considered potential donor for the ability of producing higher biomass and photosynthetic capacity. Higher photosynthesis rate is supported by leaf chlorophyll content in leaf blades (Miah et al., 1997). The chlorophyll meter or SPAD (Soil plant analysis development) offers a new strategy for synchronizing N application with actual crop demand in rice (Peng et al., 1996; Balasubramanian et al., 1999). Significant difference was observed for SPAD values at grain filling stage among local aromatic Aman rice genotypes and kataribhog (Appendix VII and Table 4).

At 50 DAT, maximum SPAD values were recorded for SAU ADL13 (43.03) which was statistically similar with all other treatments except SAU ADL3 and SAU ADL8. The minimum SPAD value was obtained from SAU ADL3 (36.69) which was statistically similar with SAU ADL8, SAU ADL1, SAU ADL14, SAU ADL10, SAU ADL7 and SAU ADL12.

Table 4. SPAD value of Aman rice genotypes and Kataribhog at grain filling stage

Treatments	SPAD value	
	50 DAT	**90DAT**
SAU ADL1	38.71 a-c	35.99 e
SAU ADL2	41.72 ab	40.87 a-e
SAU ADL3	36.69 c	39.80 c-e
SAU ADL4	42.82 ab	45.59 ab
SAU ADL5	41.99ab	39.97 b-e
SAU ADL6	42.35 ab	43.84 a-c
SAU ADL7	40.81 a-c	39.97 b-e
SAU ADL8	38.60 bc	35.13 e
SAU ADL9	41.68 ab	37.92 de
SAU ADL10	39.23 a-c	37.07 e
SAU ADL11	42.53 ab	46.03 a
SAU ADL12	40.90 a-c	45.44 a-c
SAU ADL13	43.03 a	42.96 a-d
SAU ADL14	39.01 a-c	39.80 c-e
SAU ADL15	41.21 ab	43.65 a-d
Kataribhog	41.59 ab	39.90 b-e
LSD $_{(0.05)}$	4.34	5.76
CV (%)	6.38	8.46

At 90 DAT, maximum SPAD values were recorded for SAU ADL11 (46.03) which was statistically similar with SAU ADL34, SAU ADL12, SAU ADL6, SAU ADL15, SAU ADL13, SAU ADL2. The minimum SPAD value was also recorded for SAU ADL8 (35.13) which was statistically similar with SAU ADL1, SAU ADL10, SAU ADL9, SAU ADL14, SAU ADL3, SAU ADL5, SAU ADL7, Kataribhog and SAU ADL2.

Difference in the SPAD value in the genotypes might be due to their genetic make-up. This result was in agreement with Hossain *et al.* (2009) who also found significant differences among the genotypes for SPAD values. Hassan *et al.* (2009) reported a linear and positive relationship of SPAD values with total chlorophyll, chlorophyll-a and leaf nitrogen % indicating the dependence of SPAD values with chlorophyll and nitrogen content of leaf at flowering.

4.1.5 Days to first flowering and 50% flowering

The significant difference was observed for days to first flowering (Appendix VII and Table 5). The local aromatic genotypes SAU ADL2, SAU ADL3, SAU ADL4, SAU ADL8, SAU ADL10, SAU ADL15 needed longest time for flowering (76 days) which was statistically similar with SAU ADL11, SAU ADL13, SAU ADL5, SAU ADL12, SAU and SAU ADL1. On the contrary, local aromatic SAU ADL 9 needed shortest time (66 days) for flowering.

The significant difference was obtained from days to 50% flowering (Appendix VII and Table 5). The genotypes SAU ADL10, SAU ADL14, SAU ADL15, SAU ADL1, SAU ADL2, SAU ADL3, SAU ADL4, SAU ADL5 and SAU ADL8 needed longest time for flowering (80 days). On the contrary, the genotype SAU ADL 9 needed shortest time (70 days) for flowering . This variation might be due to the genotypic variation of screened genotypes. This was supported by (Sathya *et al.*, 1999) who studied of eight quantitative traits in rice (*Oryza sativa*). Days to 50% flowering was the principal character responsible for grain yield per plant followed by 1000-grain weight, plant height and harvest index as they had positive and significant association with yield.

Ashrafuzzaman *et al.* (2009) evaluated the growth performance and grain quality of six aromatic rice varieties BR34, BR38, Kalizira, Chiniatop, Kataribhog and Basmati grown under rainfed conditions and reported that number of days required to 50% flowering differed significantly among the studied varieties. The lowest number of days required to 50% flowering was found in Chiniatop (81.33 days), which was statistically indifferent from Kataribhog (82.33 days). The maximum number of days required to 50% flowering was for Kalizira (86.67 days).

Table 5. First flowering and 50% flowering of Aman rice genotypes and Kataribhog

Treatment	First Flowering (days)	50% Flowering (days)
SAU ADL1	74.00 a-c	80.00 a
SAU ADL2	76.00 a	80.00 a
SAU ADL3	76.00 a	80.00 a
SAU ADL4	76.00 a	80.00 a
SAU ADL5	74.67 a-c	80.00 a
SAU ADL6	70.00 d	76.67 c
SAU ADL7	70.00 d	76.00 d
SAU ADL8	76.00 a	80.00 a
SAU ADL9	66.00 e	70.00 e
SAU ADL10	76.00 a	80.00 a
SAU ADL11	75.00 ab	79.00 b
SAU ADL12	74.33 a-c	79.00 b
SAU ADL13	74.67 a-c	79.00 b
SAU ADL14	73.33 bc	80.00 a
SAU ADL15	76.00 a	80.00 a
Kataribhog	72.18 cd	76.51 c
$LSD_{(0.05)}$	2.36	0.32
CV (%)	1.94	0.24

4.2 Yield and yield contributing characters

4.2.1 Number of effective tillers hill^{-1}

There was significant difference among the studied genotypes and Kataribhog for number of effective tillers hill^{-1} (Appendix VII and Table 6) and it was found that highest effective tillers hill^{-1} (9.27) were recorded for the genotype SAU ADL9. SAU ADL 15 also produced second highest tillers hill^{-1} which was statistically similar with Kataribhog, SAU ADL4. On the contrary, minimum effective tillers hill^{-1} were recorded in SAU ADL12 (5.88) which was statistically similar with SAU ADL5, SAU ADL14,SAU ADL2, SAU ADL8, SAU ADL1, SAU ADL13 and SAU ADL6. Sikdar *et al.* (2006) reported that variety had significant effect on effective tillershill^{-1}. The results indicated that Badshabhog and Tulshimala the highest number of effective tillers hill^{-1} (6.38). Kalizira produced the lowest number of effective tillers hill^{-1} (6.20). The reasons for difference in producing effective tillers hill^{-1} might be due to the variation in genetic make-up of the variety that might be influenced by heredity.

Table 6. Effective and ineffective tillers hill^{-1} of Aman rice genotypes and Kataribhog

Treatments	Effective tillers (no. hill^{-1})	Ineffective tillers (no. hill^{-1})
SAU ADL1	6.53 e	0.43 e
SAU ADL2	6.27 e	0.28 e
SAU ADL3	7.20 c-e	1.4bc
SAU ADL4	8.40 b-d	1.13bc
SAU ADL5	6.07 e	0.80 d
SAU ADL6	6.53 e	1.47 b
SAU ADL7	7.13 c-e	1.3 bc
SAU ADL8	6.27 e	0.73 d
SAU ADL9	9.27 a	1.20 bc
SAU ADL10	6.80 de	0.40 e
SAU ADL11	7.20 c-e	0.733 d
SAU ADL12	5.88 e	2.87 a
SAU ADL13	6.47 e	0.28 e
SAU ADL14	6.13 e	0.53 de
SAU ADL15	9.94 b	0.40 e
Kataribhog	8.89 bc	1.37 bc
$LSD_{(0.05)}$	1.73	0.30
CV (%)	12.33	18.49

The results were in agreement with those reported by Sarkar *et al.* (2014) who evaluated yield and quality of aromatic fine rice as affected by variety and nutrient management and noticed that the variation in plant height, number of effective tillers hill^{-1} and number of grains panicle^{-1} among the varieties were probably due to heredity or varietal characters.

4.2.2 Number of ineffective tillers hill-1

Ineffective tillers hill^{-1} significantly varied among the rice genotypes (Appendix VII and Table 6). The maximum ineffective tillers hill^{-1} (2.87) was observed in SAU ADL12 and minimum ineffective tillers hill^{-1} (0.28) was recorded from SAU ADL13. The results were in agreement with those reported by Islam *et al.* (2016a) who stated that the highest number of noneffective tillers hill^{-1} (6.44) was observed in BRRI dhan39 rice variety and the lowest one (4.26) was found in BRRI dhan31 variety.

Chakma (2006) observed that variety had significant effect on the number of non- bearing tillers m^{-2}. He also found that Bina dhan-5 had the highest non- bearing tillers m^{-2} (8.61) while the lowest was observed in Bina dhan-6 (6.83).

4.2.3 Panicle length

There was significant difference observed among the genotypes and Kataribhog for panicle length (Appendix VII and Figure 1) and it was found that the longest panicle length (31.61 cm) was recorded for the genotype SAU ADL12 which was statistically similar with SAU ADL1, SAU ADL13, SAU ADL7, SAU ADL2, SAU ADL15 and SAU ADL9. On the other contrary, the shortest panicle length was recorded in SAU ADL8 (22.94 cm) which was statistically similar with SAU ADL3, SAU ADL6, SAU ADL11and Kataribhog, SAU ADL11.

Hoque *et al.* (2013) investigated the performance of aromatic varieties on the growth and yield of aromatic rice and found that the differences among the varieties in respect of panicle length were statistically significant. The longest panicle of aromatic rice varieties was found in Chinigura (22.53 cm), Rata (22.50 cm) and Chandramukhi (22.43 cm). The shortest panicle was observed in Kalizira (17.00 cm).

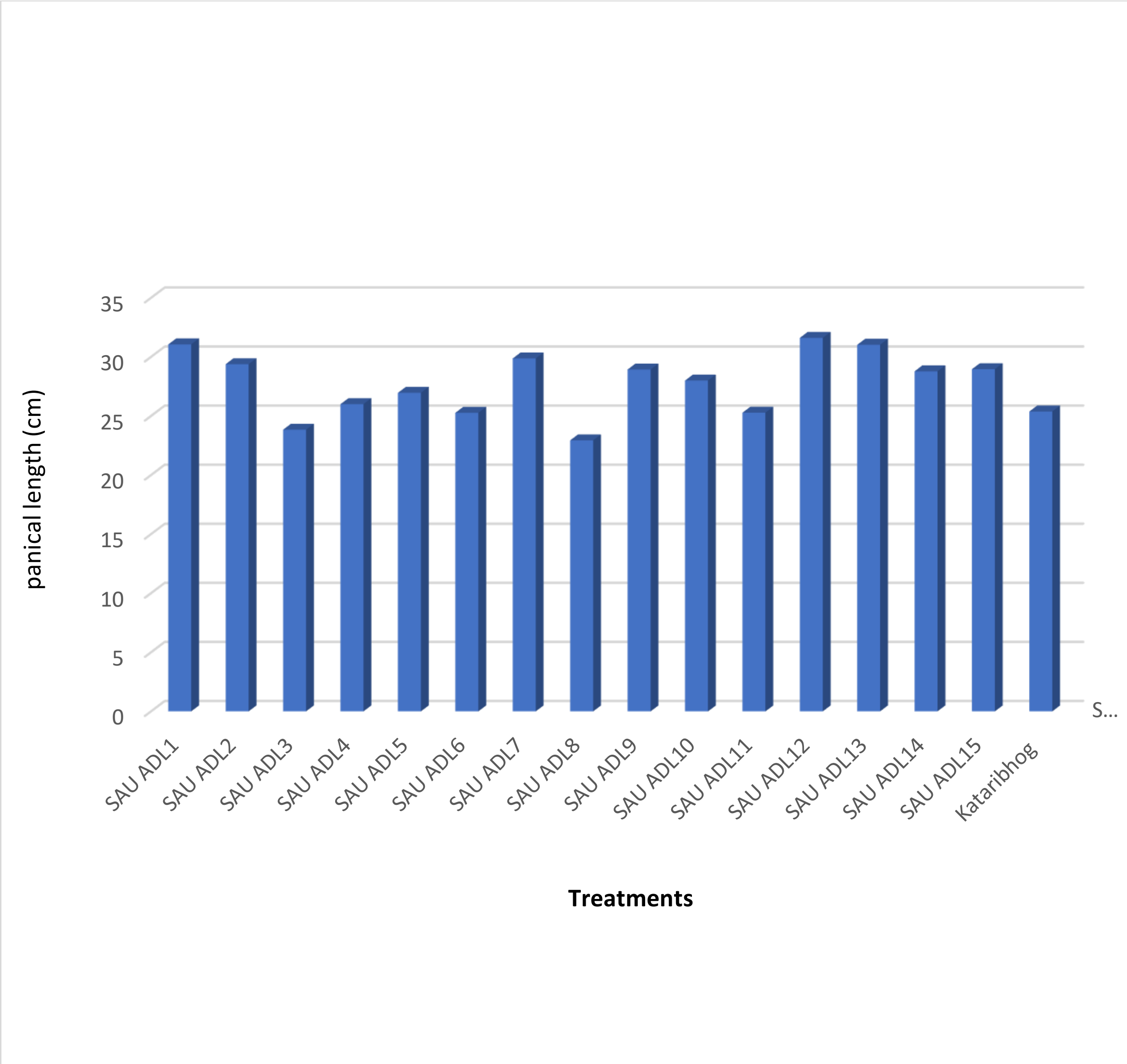

Figure 1. Panicle length of Aman rice genotypes and Kataribhog

4.2.4 Filled grains panicle^{-1}

The filled grains panicle^{-1} differed significantly for variation of the genotypes (Appendix VIII and Table 7). The highest number of filled grains panicle^{-1} was obtained from SAU ADL9 (138.78) which was statistically similar with SAU ADL1, Kataribhog, SAU ADL3 and SAU ADL12. The lowest number of filled grains panicle^{-1} was found in the SAU ADL10 (34.12) which was statistically similar with SAU ADL6 and SAU ADL8.

Table 7. Filled grains panicle^{-1}, unfilled grains panicle^{-1} and 1000 grain weight of Aman rice genotypes and Kataribhog

Treatments	Filled grains panicle^{-1}(no.)	Unfilled grains panicle^{-1}(no.)	1000 grains weight (g)
SAU ADL1	136.00 a	32.32f	32.26 de
SAU ADL2	105.57 cd	49.27 c-f	34.06 b-d
SAU ADL3	122.60 a-c	34.47 f	35.72 b
SAU ADL4	95.42 de	63.73 a-d	41.99 a
SAU ADL5	79.27 ef	64.73 a-d	28.64 fg
SAU ADL6	35.37 g	76.53 ab	33.07 cd
SAU ADL7	79.00 ef	59.76 b-e	35.01 bc
SAU ADL8	51.23 g	77.03 ab	24.10 h
SAU ADL9	138.78 a	45.20 ef	30.03 ef
SAU ADL10	34.12 g	81.17 a	27.27 gh
SAU ADL11	70.90 f	65.97 a-c	40.61 a
SAU ADL12	120.77 a-c	37.07 f	31.71 de
SAU ADL13	110.57 b-d	35.13 f	31.95 de
SAU ADL14	99.05 d	39.49 f	29.94 ef
SAU ADL15	105.00 cd	39.73 f	33.05 cd
Kataribhog	125.53 ab	47.63 d-f	11.45 i
LSD $_{(0.05)}$	18.97	17.94	2.56
CV (%)	12.06	20.26	4.89

This variation might be due to genetic features of the varieties. These results were in consistent to those of Anonymous (1994), Singh and Gangwer (1989) who noticed that the number of filled grains panicle^{-1} influenced significantly due to variety.

Mishra and Pandey (1998) reported that panicle length, number of filled grains panicle^{-1} and 1000 seed weight had contributed for increased grain yield.

4.2.5 Unfilled grains panicle^{-1}

The unfilled grains panicle^{-1} was significantly differed among genotypes and Kataribhog (Appendix VII and Table 8). The highest number of unfilled grains panicle^{-1} (81.17) was counted in the SAU ADL10 and the lowest number of unfilled grains panicle^{-1} was counted in SAU ADL1(32.32).

Islam *et al.* (2013) noticed that the undesirable traits, number of unfilled grains panicle^{-1} was important one and played a vital role in yield reduction. Effect of variety on the number of unfilled grains panicle^{-1} was highly significant. Morichsail produced the lowest number of unfilled grains panicle^{-1} (11.17) which contributed highest grain yield of that variety.

This variation in number of unfilled grains panicle^{-1} might be due to genetic features of the varieties. This result was also supported by Murthy *et al.* (2004) who reported differences in number of sterile spikelets panicle^{-1} due to varietal differences.

4.2.6 Weight of 1000-grain

The grains weight was significantly differed among the genotypes and Kataribhog (Appendix VII and Table 7). The maximum number of grains weight (41.99 g) was counted in the SAU ADL4 that similar to SAU ADL11 and the minimum grains weight was counted in kataribhog (11.45 g). This variation in grains weight might be due to genetic features of the varieties. This result was also supported by Lockhart and Wiseman (1988) who showed that higher number of tillers reduces the number, size and weight of grain. Thousand-grain weight, an important yield determining component, is a genetic character least influenced by environment (Asraf *et al.,* 1999).

Mondal *et al.* (2005) studied 17 modern cultivars of transplant aman rice and reported that 1000-grain weight differed significantly among the cultivars studied. On the other hand, Sathya *et al.* (1999) reported that 1000-grain weight, days to 50% flowering, plant height and harvest index had positive and significant association with yield.

4.2.7 Grain yield

Grain yield was significantly affected by the genotypes (Appendix IX and figure 2). The maximum grain yield (2.88 t ha^{-1}) was recorded in SAU ADL1 that similar to SAU ADL14. The second highest yield (2.67 t ha^{-1}) was found in SAU ADL13 that similar to SAU ADL15.

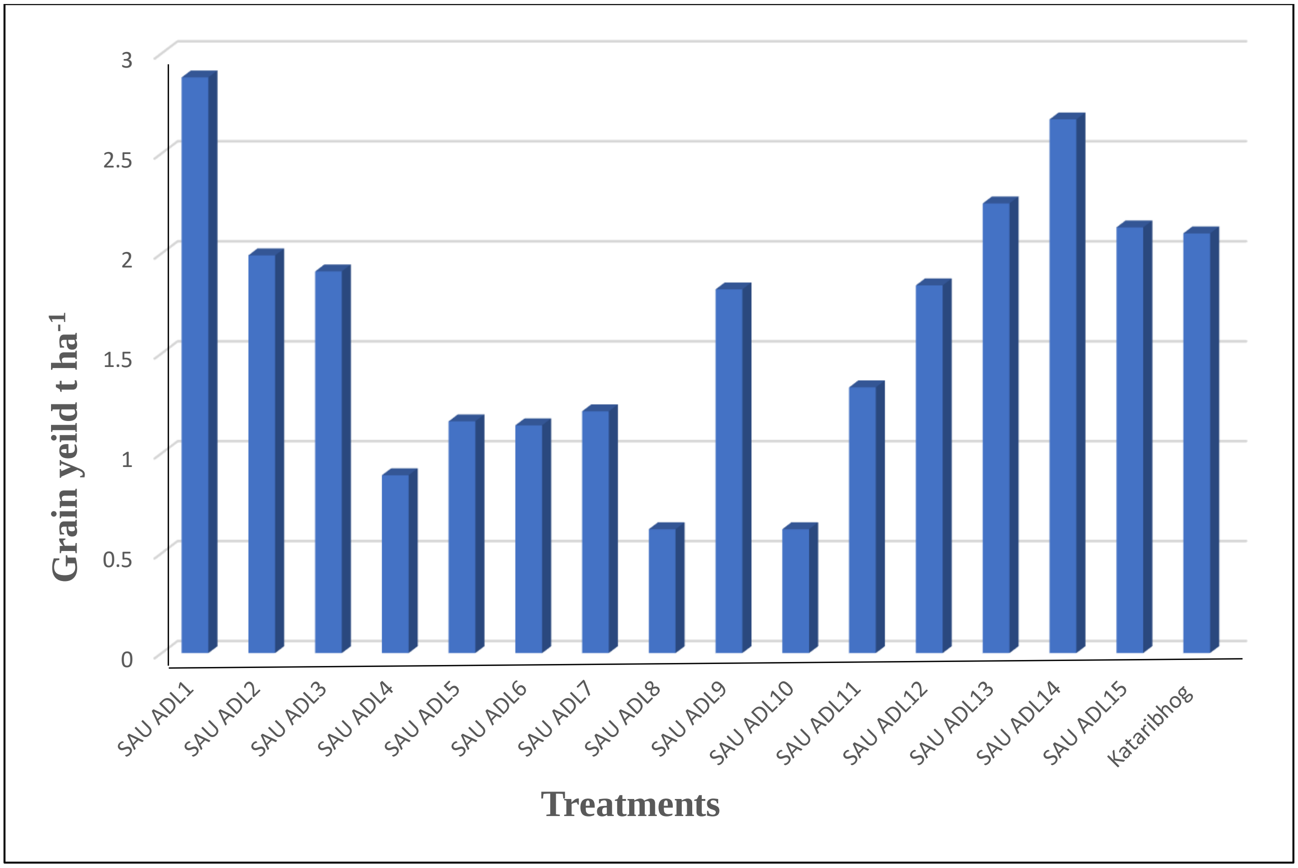

Figure 1. Grain yield of Aman rice genotypes and Kataribhog

The minimum grain yield (0.43 t ha^{-1}) was obtained from SAU ADL78 which was statistical similar to SAU ADL10 (0.62) and SAU ADL4 (0.89). The lowest yield might be due to the highest unfilled grains $panicle^{-1}$, more ineffective tiller, lowest harvest index and lower 1000-grain weight.

Kibria *et al.* (2008) investigated the yield potential of local aromatic variety Kalizira, a segregating population (developed from a cross between Y-1281 and Kalizira) and reported that correlation studies between aroma and grain yield revealed that aroma is negatively correlated with grain yield. Strong preference exists for the long grain aromatic Basmati rice in the middle east countries while the same is sometimes considered as contaminant in the West (Shobha Rani et *al.*, 1996). Bangladesh, Nigeria and Liberia consume parboil rice, while glutinous rice is the staple food in parts of Thailand and Laos. This result also supported by Islam *et al.* (2016b) who investigated genetic variability among 113 aromatic and fine local rice genotypes of which five were exotic in origin and reported that plants with high panicles have high number of filled grains thereby increasing rice yield.

4.2.8 Straw yield

Straw yield was significantly affected among the s Aman rice genotypes (Appendix VIII and Table 8). The highest straw yield (10.24 t ha^{-1}) was found in SAU ADL1. The lowest straw yield (1.67 t ha^{-1}) was obtained from SAU ADL 8 .This might be due to the higher plant height and higher number of tillers $hill^{-1}$ of the genotype.

The differences in straw yield might be attributed to the genetic make-up of the genotypes. These results uphold with the findings of Patel (2000) and Om *et al.* (1999) where they concluded that straw yield differed significantly among the varieties.

4.2.9 Biological yield

Significant variation in biological yield was found among the Aman rice genotypes (Appendix IX and Table 8). The highest and lowest biological yield were recorded for SAU ADL1 and SAU ADL8 respectively.

The most genotypes gave higher biological yield than check variety Kataribhog except SAU ADL4, SAU ADL2, SAU ADL1 and SAU ADL8. The differences in biological yield might due to genetic make-up of screened genotypes.

Table 8. Straw yield, biological yield and harvest index of local aromatic Aman rice genotypes and Kataribhog

Treatments	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest Index %
SAU ADL1	10.24 a	13.13 a	21.45 f-h
SAU ADL2	7.12 b	9.11 b	21.91 fg
SAU ADL3	4.90 f-h	6.80 d	28.10 b
SAU ADL4	5.09 e-h	5.98 d	14.90 j
SAU ADL5	4.49 gh	5.65 d	19.74 g-i
SAU ADL6	4.63 f-h	5.77 d	19.21 hi
SAU ADL7	4.34 h	5.55 d	21.20 f-h
SAU ADL8	1.67 i	2.10 e	24.65 de
SAU ADL9	4.80 f-h	6.62 d	35.67 a
SAU ADL10	5.27 e-h	5.10 d	11.47 k
SAU ADL11	5.60 d-g	6.93 cd	18.30 i
SAU ADL12	4.94 f-h	6.78 d	25.64 cd
SAU ADL13	5.78 c-f	8.31 b	26.98 bc
SAU ADL14	6.644 b-d	9.31 b	28.63 b
SAU ADL15	6.22 b-e	8.35bc	25.31 c-e
Kataribhog	6.91 bc	9.00 b	23.24 ef
$LSD_{(0.05)}$	2.40	3.63	8.24
CV (%)	13.28	11.80	5.96

4.2.9 Harvest index

Harvest index is a vital character having physiological importance. It reflects translocation on alternatively dry matter partitioning of a given genotype to the economic parts. Harvest index of traditional tall varieties is about 0.3 and 0.5 for improved short varieties (Youshida, 1981).

Significant difference was observed for harvest among Aman rice genotypes (Appendix IX and Table 8). The highest harvest index was obtained from the genotype SAU ADL 9 (35.67%). The lowest harvest index (11.47%) was found from SAU ADL10.

4.3 Physico-chemical characteristic

4.3.1 Grain length and breadth

The highest grain length and grain breadth raito was obtained from SAU ADL1. The lowest grain length and grain length and grain breadth ratio was recorded SAU ADL 8. Gupta and Agarwal (2000) opined that the morphological traits like grain length, L/B ratio, grain size etc. Appeared to be quite stable and could therefore, be used as primary diagnostic characters for classifying paddy varieties.

4.3.2 Grain size and shape

Grain size and shape were determined on the basis of length (mm) and breadth, length and breadth ratio. Grain length and breadth ratio of the studied materials ranged from 3.14 mm to 2.54 mm (Table 9). The highest ratio was obtained from SAU ADL1 followed by SAU ADL7, SAU ADL8, SAU ADL14 and SAU ADL11. However, the lowest ratio was obtained from Kataribhog. All local genotypes showed length and breadth ratio of more than 2.5 which was considered as widely acceptable shape.

SAU ADL1, SAU ADL3, SAU ADL4, SAU ADL7, SAU ADL13 and SAU ADL14 genotypes were of long slender type. SAU ADL11, SAU ADL8 were medium slender type. SAU ADL2, SAU ADL10 and SAU ADL12 were of medium type. Check variety Kataribhog was of short medium. In general, long grains are preferred in the Indian subcontinent, but in Southeast Asia the demand is for medium to medium long rice. In temperate areas, short grain varieties are prevalent. There is a strong demand for long grain rice on the international market (Cruz and Khush, 2000).

Table 9. Grain length (mm), Grain size, Grain breadth (mm), L/B ratio , grain size and grain shape of Aman rice genotypes and Katarihbog

Treatments	Grain length (mm)	Grain size	Grain breadth (mm)	L/B ratio	Grain shape
SAU ADL1	7.35	long	2.04	3.14	slender
SAU ADL2	6.29	medium	2.39	2.63	medium
SAU ADL3	7.09	long	2.35	3.02	slender
SAU ADL4	7.00	long	2.49	2.81	medium
SAU ADL5	6.81	long	2.30	2.96	medium
SAU ADL6	6.89	long	2.43	2.84	medium
SAU ADL7	6.85	long	1.89	3.08	slender
SAU ADL8	6.57	medium	2.15	3.06	slender
SAU ADL9	7.19	long	2.50	2.88	medium
SAU ADL10	6.02	medium	2.01	2.99	medium
SAU ADL11	6.56	medium	2.15	3.05	slender
SAU ADL12	6.59	medium	2.33	2.83	slender
SAU ADL13	6.72	long	2.23	3.01	slender
SAU ADL14	7.19	long	2.34	3.07	slender
SAU ADL15	7.13	long	2.51	3.84	slender
Kataribhog	4.91	short	1.90	2.58	medium

4.3.3 Grain weight and husk weight

Variety had significant effect on qualitative characters like grain weight of aman rice genotypes and Kataribhog ranged from 0.013 mg to 0.024mg (Figure 3). The highest grain weight (0.024mg) was obtained from SAU ADL1 followed by SAU ADL15. The lowest grain weight (0.012mg) was obtained from Kataribhog. Husk weight ranged among the aman rice genotypes 0.02mg to .0.008mg (Figure 3).

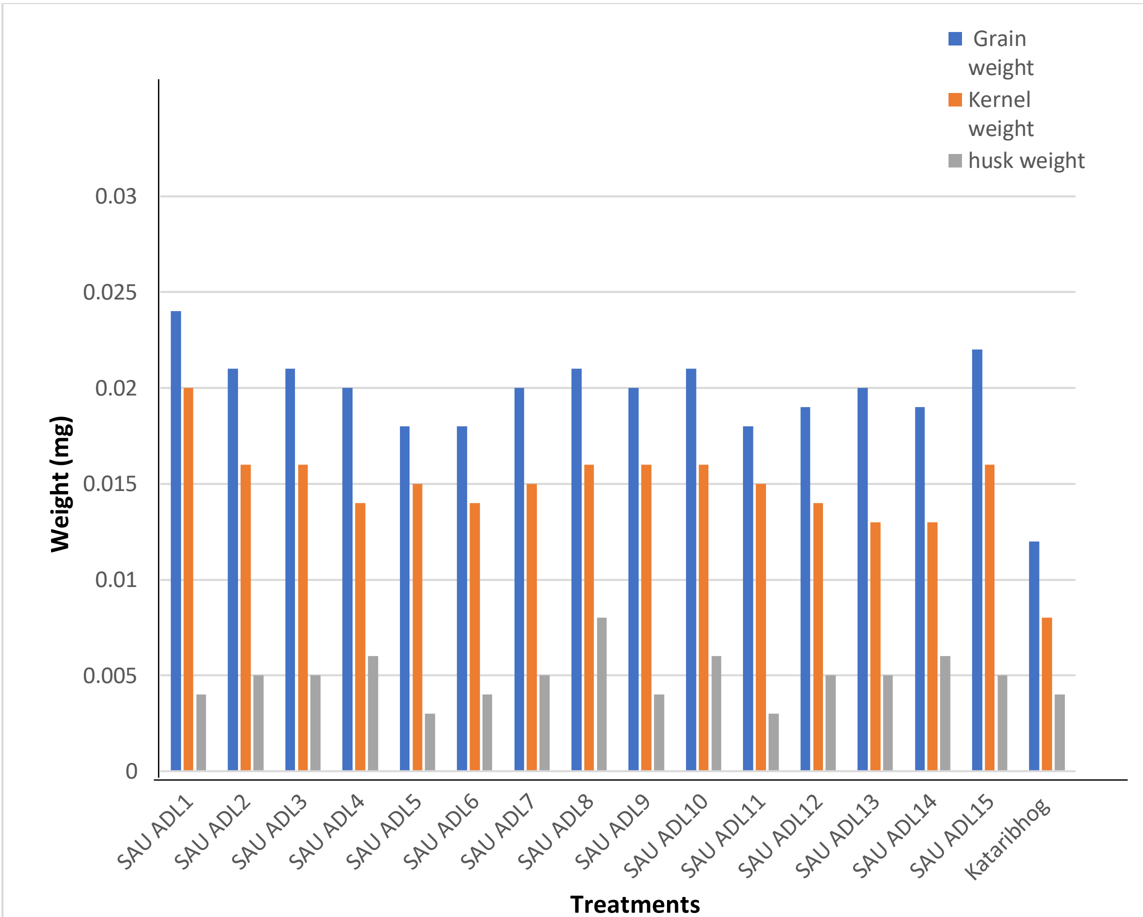

Figure 3. Grain weight (mg), kernel weight and husk weight of Aman rice genotypes and Kataribhog

4.4 Organoleptic characteristic

4.4.1 Aroma

The 2-acetyl-l-pyrroline was an important compound contributing to the aromatic odor and it was a major contributor to the popcorn-like aroma in several of the Asian aromatic rice varieties. (Buttery *et al.*, 1982).

Aroma varied among the varieties (Table 9). Aroma development is influenced by both genetic and environmental factors. Hot weather during flowering and grain development, nitrogenous fertilizers particularly urea can affect aroma. In addition to field factors, there are other factors like storage conditions, milling and processing methods, cooking methods, parboiling etc. which might influence the aroma. These factors must be standardized to harness maximum aroma from rice (Singh *et al*., 1997b). Presence of aroma was recorded in SAU ADL3, SAU ADL5, SAU ADL7, SAU ADL9, SAU ADL10, SAU ADL11, SAU ADL11, SAU ADL14, SAU ADL15 and Kataribhog.

Table 11. Aroma of Aman rice genotypes and Kataribhog

Treatments	Aroma
SAU ADL1	non-aromatic
SAU ADL2	non-aromatic
SAU ADL3	moderately aromatic
SAU ADL4	non-aromatic
SAU ADL5	moderately aromatic
SAU ADL6	non-aromatic
SAU ADL7	moderately aromatic
SAU ADL8	non-aromatic
SAU ADL9	moderately aromatic
SAU ADL10	moderately aromatic
SAU ADL11	moderately aromatic
SAU ADL12	Slightly aromatic
SAU ADL13	non-aromatic
SAU ADL14	moderately aromatic
SAU ADL15	moderately aromatic
Kataribhohg	strongly aromatic

CHAPTER 5

SUMMARY AND CONCLUSION

The field experiment was conducted at the experimental farm of Sher-e-Bangla Agricultural University (SAU), Dhaka, during the period from July 2017 to December 2017 to study the performance of different rice genotypes in Aman season under the Modhupur Tract (AEZ-28). The experiment consisted of 15 rice genotypes viz. (i) SAU ADL1, (ii) SAU ADL2, (iii) SAU ADL3, (iv) SAU ADL4, (v) SAU ADL5, (vi) SAU ADL6, (vii) SAU ADL7, (viii) SAU ADL8, (ix) SAU ADL9, (x) SAU ADL10, (xi) SAU ADL11, (xii) SAU ADL12, (xiii) SAU ADL13, (xiv) SAU ADL14(xv) SAU ADL15 along with a local check variety (xvi) Kataribhog,. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications of each treatment.

The data on crop growth parameters like plant height, number of tillers hill^{-1}, dry matter at different growth stages, SPAD reading and time of first flowering and 50% flowering were recorded. Yield parameters like number of effective and ineffective tillers hill^{-1}, panicle length, filled and unfilled grains panicle^{-1}, 1000-grains weight, grain and straw yield, biological yield and harvest index were recorded after harvest. Data were analyzed using CROPSTAT package. The mean differences among the treatments were compared by least significant difference test (LSD) at 5% level of significance.

Significant variation was recorded for all data (crop growth parameters, yield and yield contributing parameters). Rice genotypes also differed widely for qualitative parameters. The plant height was observed at harvest where SAU ADL14 produced the tallest plant (196.59 cm) and SAU ADL8 gave the shortest plant height (95.10 cm) . The second shortest plant was produced by SAU ADL2 (194.78 cm) which was statistically similar with SAU ADL15 (188.99 cm) and SAU ADL 1 (186.30 cm). The highest number of tillers hill^{-1} (18.75) was obtained from SAU ADL10 and the lowest (6.53) was from SAU ADL12. The highest plant dry matter hill^{-1} (67.72 g) at harvest was found in SAU ADL15 and the lowest was found in SAU ADL 13. At harvest, the maximum tiller hill^{-1} was observed in the SAU ADL5 (9.80). The second maximum tillers hill^{-1} was in Kataribhog (9.13). The minimum tiller numbers hill^{-1} was obtained from SAU ADL14. At 90 DAT, maximum SPAD value was recorded for SAU ADL11 (46.03) which was statistically similar with SAU ADL3, SAU ADL12, SAU ADL6, SAU ADL15, SAU ADL13, SAU ADL2 and the minimum SPAD value was also recorded for SAU ADL8 (35.13) which was statistically similar with SAU ADL1, SAU ADL10, SAU ADL9, SAU ADL14 and SAU ADL3. The genotypes SAU ADL10, SAU ADL14, SAU ADL15, SAU ADL1, SAU ADL2, SAU ADL3, SAU ADL4 , SAU ADL5 and SAU ADL8 needed longest time for flowering (80 days). On the contrary, the genotype SAU ADL 9 needed shortest time (70 days) for flowering.

The highest effective tiller hill^{-1} (9.27) were recorded for the genotype SAU ADL9. SAU ADL 15 also produced second highest tillers hill^{-1} which was statistically similar with Kataribhog , SAU ADL4. On the other contrary, minimum effective tillers hill^{-1} were recorded in SAU ADL12 (5.88) which was statistically similar with SAU ADL5, SAU ADL14, SAU ADL2, SAU ADL8, SAU ADL1, SAU ADL13 and SAU ADL6. The longest panicle length (31.61 cm) was recorded for the genotype SAU ADL12 which was statistically similar with SAU ADL11 , SAU ADL13, SAU ADL7, SAU ADL2,SAU ADL15 and SAU ADL9. On the other contrary, the shortest panicle length was recorded in SAU ADL8 (22.94 cm) which was statistically similar with SAU ADL3, SAU ADL6, SAU ADL11, Kataribhog, SAU ADL11, SAU ADL4 and SAU ADL5.

The highest number of filled grains panicle^{-1} was obtained from SAU ADL9 (138.78) which was statistically similar with SAU ADL1, SAU ADL3 and SAU ADL12. The lowest number of filled grains panicle^{-1} was found in the SAU ADL10 (34.12) which was statistically similar with SAU ADL6 and SAU ADL8.

The maximum 1000 grains weight (41.99 g) was counted in the SAU ADL4 and the minimum number of grains weight was counted in kataribhog (11.45 g). The highest grain yield (2.88 t ha^{-1}) was recorded in SAU ADL1. The lowest grain yield (0.43 t ha^{-1}) was obtained from SAU ADL8 which was statistically similar to SAU ADL10 (0.62) and SAU ADL4 (0.89). The higest straw yield (10.24 t ha^{-1}) was recorded in SAU ADL1. The minimum straw yield (1.67 t ha^{-1}) was obtained from SAU ADL 8. The highest and lowest biological yield were recorded for SAU ADL1 and SAU ADL8 respectively. The highest harvest index was obtained from the genotype SAU ADL 9 (35.67%) and the lowest harvest index (11.47%) was found from SAU ADL10.

Based on the results of the present study, the following conclusions may be drawn-

- Genotypic variations observed among the studied materials.
- Grain yield of SAU ADL1 and SAU ADL14 were superior and almost 37% higher yielder than Kataribhog (local check). They provided long and slender grain. SAU ADL1 is non-aromatic but SAU ADL14 is moderately aromatic in nature.
- The SAU ADL 8 is a short stature and non-aromatic genotype that can escape lodging. It has medium slender type grain with lower yield.
- It needs further research to find out the other qualitative characters of these two potential genotypes before final recommendation.

However, to reach a specific conclusion and recommendation the same experiment needs to be repeated and more research work should be done over different Agro-ecological zones.

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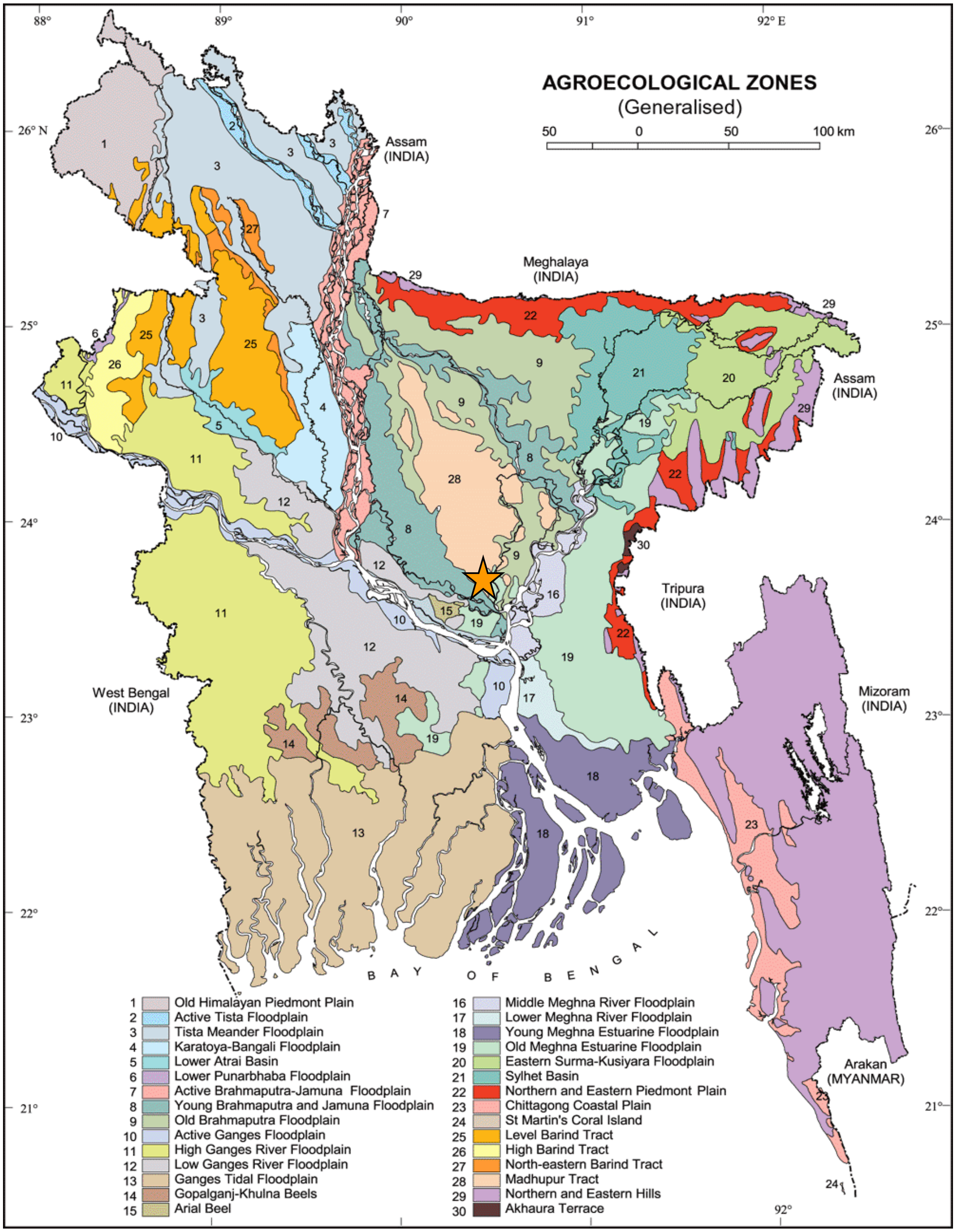
APPENDICES

Appendix I. Map showing the experimental sites under study



 The experimental site under study

Appendix II. Physical characteristics of field soil analyzed in Soil Resources Development Institute (SRDI) laboratory, Khamarbari, Farmgate, Dhaka

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Agronomy field, SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained

B. Physical and chemical properties of the initial soil

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

Source: Soil Resources Development Institute (SRDI)

Appendix III. Field layout of the Experiment in Randomized Complete Block Design

Appendix IV. Summary of analysis of variance for plant height of Aman rice genotypes at different days after transplanting

Sources of variation	Degrees of freedom	Mean square values at different days after transplanting				
		20	40	60	80	At harvest
Replication	2	1.72	4.34	39.14	24.46	9.41
Treatment	15	131.80*	489.12*	1725.00*	2599.32*	3414.19*
Error	30	11.074	40.82	53.41	139.07	51.00

* Significant at 5% level

Appendix V. Summary of analysis of variance for tiller numbers hill^{-1} of Aman rice genotypes at different days after transplanting

Sources of variation	Degrees of freedom	Mean square values at different days after transplanting			
		20 DAT	40 DAT	60DAT	At harvest
Replication	2	2.78	60.86	2.20	0.86
Treatment	15	5.57*	6.09*	7.39*	4.37*
Error	30	2.09	4.62	1.54	0.53

* Significant at 5% level

Appendix VI. Summary of analysis of variance for plant dry matter of Aman rice genotypes at different days after transplanting

Sources of variation	Degrees of freedom	Mean square values at different days after transplanting		
		50 DAT	70 DAT	90 DAT
Replication	2	19.24	6.07	16.51
Treatment	15	69.99*	428.61*	335.60*
Error	30	8.44	57.069	30.27

* Significant at 5% level

Appendix VII. Summary of analysis of variance for duration of 50% flowering, SPAD value, number of effective tillers hill^{-1}, number of ineffective tillers hill^{-1} and panicle length of Aman rice genotypes

Sources of variation	Degrees of freedom	Mean square values						
		Duration of flowering		SPAD value		Effective tillers hill^{-1}	Ineffective tillers hill^{-1}	Panicle length
		first	50%	50	90			
Replication	2	3.67	0.068	16.44	57.02	2.28	0.038	1.62
Treatment	15	25.20*	21.08*	10.02*	35.08*	96.50*	1.31*	21.56*
Error	30	1.99	1.031	6.78	11.97	1.08	0.032	2.68

* Significant at 5% level

Appendix VIII. Summary of analysis of variance for number of filled grains panicle^{-1}, number of unfilled grains panicle^{-1}, 1000-grain weight of Aman rice genotypes

Sources of variation	Degrees of freedom	Mean square values		
		Filled grains Panicle^{-1}	Unfilled grains Panicle^{-1}	1000-grain weight
Replication	2	11.74	12.14	2.69
Treatment	15	3335.51*	839.63*	142.044*
Error	30	129.43	115.68	2.36

* Significant at 5% level

Appendix IX. Summary of analysis of variance for yield characters of aromatic Aman rice genotypes

Sources of variation	Degrees of freedom	Mean square values			
		Grain yield	Straw yield	Biological yield	Harvest index
Replication	2	0.02225	0.029	0.26	2.33
Treatment	15	1.51*	9.63*	17.26*	100.28*
Error	30	0.104	0.33	0.72	1.86

* Significant at 5% level