EVALUATION OF MORPHO-PHYSIOLOGICAL ATTRIBUTES AND YIELD OF TRADITIONAL AROMATIC RICE CULTIVARS IN *AMAN* SEASON

A THESIS

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CERTIFICATE

This is to certify that the thesis entitled, **"EVALUATION OF MORPHO-PHYSIOLOGICAL ATTRIBUTES AND YIELD OF TRADITIONAL AROMATIC RICE CULTIVARS IN *AMAN* SEASON"** submitted to the Department of Agricultural Botany, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE in AGRICULTURAL BOTANY ,** embodies the results of a piece of bonafide research work carried out by **S. M. ANAMUL HASSAN** Registration No. **10-03997** under my supervision and my 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: December, 2017
Place: Dhaka, Bangladesh

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Dedicated To:

My Beloved Parents

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EVALUATION OF MORPHO-PHYSIOLOGICAL ATTRIBUTES AND YIELD OF TRADITIONAL AROMATIC RICE CULTIVARS IN *AMAN* SEASON

ABSTRACT

The experiment was conducted at the Agronomy field of Sher-e-Bangla Agricultural University, Dhaka during July to December, 2017 in *Aman* season to investigate the morpho-physiological attributes and yield performance of nine traditional aromatic rice cultivars. The experiment comprised of one factor viz. Kalizira, Begun Bichi, Chinigura, Chiniatop-1, Sada Sonne, Khoi Sonne, Kataribhog, Badshabhog and Dulabhog (BR 5). The experiment was laid out in Randomized Complete Block Design (RCBD) with four replications. Significant variation was found on morphological, physiological, yield and yield contributing parameters in the traditional aromatic rice cultivars. The lowest grain yield (1.29 t ha^{-1}) was obtained from Chiniatop-1. The highest leaves $hill^{-1}$ (56.23) was recorded from Khoi Sonne. The lowest leaves $hill^{-1}$ (38.3) was obtained from Kataribhog. Maximum leaf area index of 6.03 was recorded in cultivar Chinigura followed by, Badshabhog (5.33) and Sada Sonne (5.01) and minimum of 3.64 was recorded with Kalizira at 60 DAT. At 45 DAT maximum LAR (116.75 cm^2 g^{-1}) was recorded in Begun Bichi and minimum LAR (72.35 cm^2 g^{-1}) in Chiniatop-1. Highest CGR of 28.23 g m^{-2} day^{-1} was recorded by Dulabhog and minimum CGR was recorded in the variety Kalizira (21.02 g m^{-2} day^{-1}). Badshabhog produced the second highest grain $panicle^{-1}$ (156.30). Sada Sonne produced the lowest number of grains $panicle^{-1}$ (53.63). Significant influence of different varieties was observed on 1000-grain weight. The highest 1000 grain weight (17.66 g) was recorded in Khoi Sonne. The lowest 1000 seed weight (9.23 g) was observed in Kalizira. Among the tested nine varieties Chinigura showed the highest grain yield (2.80 t ha^{-1}) and the second highest grain yield in Begun Bichi (2.43 t ha^{-1}). While the lowest grain yield (1.29 tha^{-1}) was obtained from Chiniatop-1. The Kataribhog showed the highest harvest index (41.49%). On the other hand, the lowest harvest index (28.94%) was obtained from Khoi Sonne.

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LIST OF ABBREVIATION AND ACRONYMS

%	=	Percent
^{0}C	=	Degree Celsius
AEZ	=	Agro-Ecological Zone
BBS	=	Bangladesh Bureau of Statistics
BRRI	=	Bangladesh Rice Research Institute
CGR	=	Crop Growth Rate
Chl	=	Chlorophyll
CV%	=	Percentage of Coefficient of Variance
DAT	=	Days after Transplanting
et al.	=	And others
FAO	=	Food and Agricultural Organization
ha^{-1}	=	Per hectare
HD	=	Heading
LAI	=	Leaf Area Index
LAR	=	Leaf Area Ratio
LSD	=	Least Significant Difference
MOP	=	Muriate of Potash
MT	=	Mid Tillering
NS	=	Not significant
PI	=	Panicle Initiation
RCBD	=	Randomized Complete Block Design
SAU	=	Sher-e-Bangla Agricultural University
SPAD	=	Soil-Plant Analyses Development
SRDI	=	Soil Resources and Development Institute
TDM	=	Total Dry Matter
TSP	=	Triple Super Phosphate
Viz	=	Namely
wt	=	Weight

CHAPTER I

INTRODUCTION

Rice is the second most important food crop of the world. More than half of the world's population depends on rice for food calories and protein, especially in developing countries (Haque, 2014). Rice is grown in more than a hundred countries, with a total harvested area of approximately 158 million hectares, producing more than 700 million tons annually (470 million tons of milled rice). Nearly 640 million tons of rice is grown in Asia, representing 90% of global production. Sub-Saharan Africa produces about 19 million tons and Latin America some 25 million tons. In Asia and sub-Saharan Africa, almost all rice is grown (IRRI, 2018). Rice grows in a very wide range of ecological conditions all over the world and encompasses an extremely wide diversity. Since the beginning of civilization, thousands of rice cultivars have been selected for increasing productivity (Singh *et al*., 2000). Manipulation of genetic resources has contributed much towards meeting rising demands of food for ever escalating world population (Cassman *et al*., 2003)

Ninety percent global rice production occurs in tropical and sub tropical Asian countries (Mejia, 2006).Worldwide, rice provides 27% of dietary energy supply and 20% dietary protein (Kueneman, 2006). It constitutes 95% of the cereal consumed and supplies more than 80% of the calories and about 50% of the protein in the diet of the general people of Bangladesh (Yusuf, 1997). Being the 4^{th} largest rice producer of the world, Bangladesh comprises an area of

about 11.10 million hectares for rice production (FAO, 2003) of which around 27 % is occupied by fine rice varieties (BBS, 2003).

Among the various rice types cultivated in our country aromatic rice occupies a unique place because of their characteristic fragrance (aroma) when cooked. This constitutes a small but special group of rice, which is considered best in quality. Aromatic varieties fetch higher price in rice market than the non-aromatic ones. Cultivation of fine as well as aromatic rice has been gaining popularity in Bangladesh over the recent years, because of its huge demand both for internal consumption and export (Das and Baqui, 2000). Despite the favorable agro-climatic conditions, area of aromatic rice is less than 2% in Bangladesh. More than four thousand landraces of rice are adopted in different parts of Bangladesh. Only some of these are unique for quality traits including fineness, aroma, taste and protein contents (Kaul *et al*., 1982). Most of the high quality rice cultivars are low yielding (Shakeel *et al*., 2005). Locally adapted varieties are Chiniatop, Kalizira and Kataribhog. BR34 and BR38 are another two high valued rice varieties released by Bangladesh Rice Research Institute (BRRI), having small grain and pleasant aroma. These varieties could be exported after meeting local demand. Aromatic rice varieties have occupied about 12.5% of the total transplant *Aman* rice cultivation (BBS, 2005). Ashrafuzzaman *et al*. (2009) found variation in morphological and yield components in different varieties of aromatic rice. Yield of rice can be enhanced by improving fertilization, irrigation management and good pest and disease control.

Production of aromatic rice in Bangladesh is becoming popular due to its high prices and export potentiality (Dutta *et al*., 2002). It is also preferred by some consumers despite their price and yield. Farmers' net income was increased by 23% with the adoption of modern varieties (Shrestha *et al*., 2002).

Morpho-physiological characters play a vital role in rice breeding. It is essential to know the physiological behavior and genetic expression of the selective aromatic and modern rice cultivars for definite breeding objectives to improve those cultivars. Identification promising morpho-physiological traits associated with grain quality and yield plays a vital role in varietal development of aromatic rice. Development of rice cultivars with a high yielding ability is one of the most fundamental approaches for dealing with the expected increase in the world demand (IRRI, 1993). However, for developing new high yielding aromatic rice varieties it is essential to have thorough knowledge on physiological parameters therefore, the present experiment was under taken with the following objectives-

1. To study the physiological parameters viz., leaf area index, crop growth rate, leaf area ratio, chlorophyll content and their influence on dry matter production of some aromatic fine rice varieties in *Aman* season;
2. To compare the yield and yield attributes of the test aromatic rice cultivars;
3. To find out suitable varieties/ cultivars aromatic rice varieties for *Aman* season.

CHAPTER II

REVIEW OF LITERATURE

The growth and development of rice may be affected due to varietal performance of different rice cultivars. It may also be affected depending on aromatic rice varieties. Relevant reviews on the above aspects have been presented and discussed in this chapter.

2.1 Effect of rice variety

The successful production of any crop depends on manipulation of basic ingredients of crop culture. The crop variety is one of the important basic ingredients. Some of the works related to different rice varieties are cited below.

Mousomi *et al.* (2017) conducted an experiment with five aromatic rice varieties (Kalizira, Muktasail, Nagrasail, Maloti and Chinigura) and four levels of fertilizer, With few exceptions, all of the growth characters of the aromatic rice varieties were significantly affected due to the application of different fertilizer doses. The longest plant (124.5 cm) at harvest was found in Muktasail with recommended dose of fertilizers whereas the shortest plant (91.40 cm) was noted in Kalizira variety in control treatment. Similarly, recommended dose of fertilizers gave the highest tillers number hill^{-1} (25.00) in Kalizira and the lowest number of tillers hill^{-1} (8.67) was noticed in Chinigura variety at control treatment. The highest grain yield was recorded in Nagrasail variety

(65.33 g pot^{-1}) followed by Kalizira (65.26 g pot^{-1}) with recommended dose of fertilizers while the lowest yield (24.31 g pot^{-1}) was observed in Maloti in control treatment. The overall results indicated that recommended dose of fertilizers influenced the growth characters of aromatic rice varieties.

Aziz and Kashem (2016) conducted a field trial at the farmers' fields of two villages during November 2015 to May 2016 to find out the effect of variety and fertilizer on the growth, yield and yield contributing characters of local fine *Boro* rice. The lowest grain yield of 2.81 t ha^{-1} was recorded from the variety Atobshail. The highest straw yield of 4.90 t ha^{-1} was recorded at Begun bichi. The highest grain yield of 2.91 t ha^{-1} was produced due to interaction of Tapiboro and application of soil test based fertilizer dose.

To evaluate the extent of variability among the small grain aromatic (SGA) rice *(Oryza sativa* L.) genotypes for yield and yield components were evaluated by Saha *et al.* (2015). Twenty four popular SGA rice genotypes including BRRIdhan34 as check were used . Highest grain yield per plant was observed in Chinikanai-1, which was followed by Kalijira PL-9, Kalijira PL- 3 and Badshabhog. Chinikanai-1 had the highest number of grains per panicle. Correlation analysis revealed that the number of panicles per plant (r = 0.646) and number of grains per panicle (r = 0.525) had the positive contribution to grain yield. Based on sensory test, it was found that 18 genotypes were scented and six were lightly scented. After evaluation of yield components, four genotypes namely Chinikanai-1, Kalijira PL-9, Kalijira PL-3 and Badshabhog

were selected as outstanding genotypes, which can be used as potential breeding materials for sub-tropical environment of Bangladesh.

Yuni *et al.* (2015) tested twenty-four experimental hybrid rice varieties which have been developed were tested in lowland rice fields in Sukamandi (West Java) and Batang (Central Java) during the dry season and the rainy season of 2012. The results showed that grains yields were affected by locations, seasons, and genotypes. The genotypes x locations x seasons interaction effect was significant; therefore, the best hybrid was different for each location and season. A7/PK36 hybrid has the best performance in Batang during the dry season, while A7/PK40 and A7/PK32 are the best hybrids in the rainy season. In Sukamandi, nine hybrids were identified as better yielder than that of the check cultivar in the dry season, but not so in the rainy season. Using the correlation and path analysis, we found that the number of panicles per hill and the number of filled grains per panicle could be used as selection criteria for yield in hybrid rice.

Sarkar *et al*. (2014) carried out an experiment to study the effect of variety and nutrient management on the yield and quality of aromatic fine rice. The tallest plant (142.7 cm), the highest number of effective tillers hill(10.02), number of grains panicle (152.3), panicle length (22.71cm), 1000-grain weight (15.55g) and grain yield (3.71 t ha^{-1}) were recorded in BRRI dhan34. The highest grain protein content (8.17%) was found in BRRI dhan34 whereas the highest aroma was found in BRRI dhan37 and BRRI dhan38. The highest grain yield (4.18 t ha^{-1}) was found in BRRI dhan34 combined with 75% recommended dose of

inorganic fertilizers + 50% cow-dung, which was statistically identical to BRRI dhan34 combined with 75% of recommended dose of inorganic fertilizers + 50% poultry manure and the lowest grain yield (2.7 t ha^{-1}) was found in BRRI dhan37 in control (no manures and fertilizers). The highest grain protein content (10.9 %) was obtained in the interaction of BRRI dhan34 with recommended dose of inorganic fertilizers which was as good as that of BRRI dhan38 and 75% of recommended dose of inorganic fertilizers + 50% poultry manure. The highest aroma was found in BRRI dhan38 combined with 75% recommended dose of inorganic fertilizers + 50% cow-dung.

Crop genotypes play a dominant role in crop production systems. They affect crop productivity by their higher yield potentials, resistance against insect pest and diseases under different climatic conditions. To evaluate different varieties of rice for their growth and yield characteristics, an experiment was conducted by Hussain, *et al*. (2014) during 2012. Four varieties including IR- 28, NERICA-4, Koshihikari and Nipponbare were evaluated in a randomized complete block design (RCBD) with three replications. Data on various growth and yield parameters revealed that Koshihikari was the tallest (117 cm) and Nipponbare the shortest one (102 cm). Japonica varieties produced higher number of tillers m^{-2}, dry weight (t ha^{-1}), LAI, number of panicles m^{-2}, ripening ratios and lower nitrogen contents in panicle, stem and leaves. NERICA-4 gave higher values of SPAD, number of spikelets $panicle^{-1}$ (106) and harvest index (0.47). The highest straw weight (11.53 t ha^{-1}) and paddy yields (6.79 t ha^{-1}) were obtained from IR-28. The lowest values of harvest index (0.37) were also

recorded from IR-28. Japonica and IR-28 produced higher paddy yields than NERICA-4 (5.77 t ha^{-1}) so they can be cultivated successfully under temperate climatic conditions.

Islam *et al*. (2013) conducted to evaluate the performance of local aromatic rice cultivars viz. Kalijira, Khaskani, Kachra, Raniselute, Morichsail and Badshabhog. The rice cultivars varied considerably in terms of crop growth characteristics as well as yield and yield contributing characters. The highest plant height (116.00 cm) was found in the variety Morichsail and the lowest in the variety Khaskani. Number of filled grains panicle-1 was found highest (100) with the variety Khaskani and the lowest was recorded in the variety Raniselute. Raniselute produced the highest 1000-grain weight (32.09 g) and the lowest (13.32 g) was recorded from the variety Kalijira. The variety Morichsail produced the highest grain yield (2.53 t ha^{-1}) followed by Kachra (2.41 t ha^{-1}), Raniselute (2.13 t ha^{-1}) and Badshabhog (2.09 t ha^{-1}) and the lowest grain yield (1.80 t ha^{-1}) was obtained from Kalijira. The results of various characters studied in the experiments suggested that some good characters exist in local aromatic rice cultivars which can be exploited through breeding.

Bikash *et al.* (2013) conducted an experiment to study morphological, yield and yield contributing characters of four *Boro* rice varieties of which three were local viz., Bashful, Poshursail and Gosi; while another one was a high yielding variety (HYV) BRRI dhan 28. The BRRI dhan 28 was significantly superior among the cultivars studied. The BRRI dhan 28 was shorter in plant

height, having more tillering capacity, higher leaf number which in turn showed superior growth character and yielded more than those of the local cultivars. The HYV BRRIdhan 28 produced higher number of grains panicle^{-1} and bolder grains resulted in higher grain yield over the local cultivars. Further, BRRI dhan 28 had erect leaves and more total dry mass than those of local varieties. The BRRI dhan 28 produced higher grain yield (7.41 t ha^{-1}) and Bashful, Poshurshail and Gosi yielded ha^{-1}, respectively. Among the local rice cultivars, Gosi showed the higher yielding ability than Bashful and Poshursail.

Haque *et al.* (2014) conducted an experiment in 2009 and 2010 to evaluate some physiological traits and yield of three hybrid rice varieties (BRRI hybrid dhan2, Heera2, and Tia) in comparison to BRRI dhan48 in *Aus* season. However, hybrid varieties demonstrated smaller remobilization of shoot reserve to grain and photosynthetic rate of its flag leaf at 9 and 16 DAF than BRRI dhan48. Heera2 and BRRI hybrid dhan2 maintained significantly higher chlorophyll a:b ratio over Tia and BRRI dhan48 at 2, 9, 16 and 23 DAF in their flag leaf. Shoot reserve remobilization to grain exhibited higher degree of sensitivity to rising of minimum temperature in the studied hybrids compared to the inbred. Inefficient photosynthetic activities of flag leaf and poor shoot reserve translocation to grain resulted poor grain filling percentage in the test hybrids. Consequently the studied hybrids showed significantly lower grain yield (*ca*. 36.7%) as compared to inbred BRRI dhan48, irrespective of planting date in *Aus* season.

Ashrafuzzaman, *et al*. (2009) had undertaken an experiment to evaluate the growth performance and grain quality of six aromatic rice varieties BR34, BR38, Kalizira, Chiniatop, Kataribhog and Basmati grown under rain-fed conditions. The rice varieties differed significantly ($P<0.05$) with respect to leaf chlorophyll content, plant height, internode length, thousand grain weight and grain and straw yields. Varieties differed in morphological and yield and yield contributing traits. Thousand grain weight and grain yield both was highest in BR38. Basmati required shorter days to maturity and Kalizira longest days to maturity.

Abou-Khalif (2009) conducted an experiment in 2008 for physiological evaluation of some hybrid rice varieties in different sowing dates. All agricultural practices recommended for each cultivar were applied. Nitrogen fertilizer was used as urea (46.5% N) in two splits; that is, 2/3 were added and mixed in dry soil before flooding of irrigation water and the other 1/3 was added at panicle initiation stage. Experimental design was spilt plot design, with sowing dates as main and varieties as sub plot treatments. Results indicated that early date of sowing (April 20^{th}) was superior to other dates of sowing for MT, PI, HD, number of tillers m^{-2}, (plant height and root length) at PI and HD stage, chlorophyll content, number of days up to PI and HD, leaf area index, sink capacity , spikelets-leaf area ratio, number of grains $panicle^{-1}$, panicle length (cm), 1000-grain weight (g), number of panicles m^{-2}, panicle weight (g) and grain yield (t ha^{-1}). Sterility percentage was the lowest in sowing 20th April. 1st of June, sowing gave the lowest with all traits under study. H1

hybrid rice variety surpassed other varieties for all characters studied except for number of days to PI and HD.

Islam *et al*. (2009) reported that BRRI dhan3l had about 10-15% higher plant height and 15-25% higher leaf area at all days after transplanting (DAT) compared to Sonarbangla-1. Sonarbangla-1 had about 40% higher dry matter production at 25 DAT but had very similar dry matter production at 50 and 75 DAT, 4-11% higher rooting depth at all DATs, about 22% higher root dry weight at 25 DAT, but 5-10% lower root dry weight at 50 and 75 DAT compared to BRRI dhan31. The photosynthetic rate was higher (20 μ mol m^{-2} sec^{-1}) in BRRI dhan3l at 35 DAT (maximum tillering stage) but at 65 DAT, Sonarbangla-l had higher photosynthetic rate of 19.5 μ mol m^{-2} sec^{-1}. BRRI dhan3l had higher panicles $plant^{-1}$ than Sonarbangla-1, but Sonarbangla-1 had higher number of grains $panicle^{-1}$, 1000-grain weight and grain yield than BRRI dhan31. In 2002, BRRI dhan31 had the highest plant height at 25 DAT, but at 75 DAT, BRRI hybrid dhanl had the highest plant height. Sonarbangla-1 had the largest leaf area at 25 and 50 DAT followed by BRRI dhan31, but at 75 DAT, BRRI dhan31 had the largest leaf area. The highest shoot dry matter was observed in BRRI dhan31 followed by Sonarbangla-1 at all DATs. Sonarbangla-1 had the highest rooting depth and root dry weight at all DATs. BRRI dhan31 gave the highest number of panicles $plant^{-1}$ followed by Sonarbangla-1, BRRI hybrid dhanl had the highest grains $panicle^{-1}$ followed by BRRI dhan31 and Sonarbangla-1 had the highest 1000-grain weight followed

by BRRI dhan31. The highest amount of grains plant^{-1} (34.6 g) was obtained from BRRI dhan31.

Obaidullah *et al.* (2009) studied the growth and yield of inbred and hybrid rice with clonal tillers different of age. They found highest grain yield (5.10 t ha^{-1}) from the clonal tiller of 25 days old and the lowest grain yield (4.31 t ha^{-1}) from 40 days old clonal tillers. Irrespective of variety 25 to 35 days old clonal tiller showed superior performance. Hybrid variety transplanted with 25 days old clonal tiller gave significantly higher grain yield.

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

Nitrogen fertilizer was used as Urea form (46.5% N) in two splits; 2/3 were added and mixed in dry soil before flooding irrigation water and the other 1/3 was added at panicle initiation. Three hybrid rice H1 (SK-2034H), H4

(IR96258/Giza181) and H5 (IR70368A/Giza178) were used. Three irrigation intervals every 4, 7 and 10 days. Three sowing dates 1st May, 15th May and 30th May with seedling age transplanted at 26 days by 20X20 cm planting spacing. All agricultural practices were applied as recommended for each cultivar. As split, split plot design with four replications was used, three sowing dates were allocated in the main plots, three irrigation intervals were allocated in sub-plots and three rice cultivars were allocated in the sub-sub plots. Main results indicated that maximum tillering, panicle initiation, heading dates, crop growth rates (CGR), Leaf area index, straw yield, harvest index and grain yield were decreased by increased irrigation intervals up to 10 days. While roots length was increased by increase irrigation intervals up to 10 days. Also sowing dates at 1st May gave the highest value to all studied characters. While 30th May date of sowing gave the lowest value with all traits under study. Also H1 hybrid rice variety surpassed other varieties for studied characters. The interaction between H1 hybrid rice varieties with 4 days irrigation interval gave the highest value for leaf area index, Leaf area- ratio and the interaction among May 1st with irrigation interval every 10 days gave the highest value of roots length (Abou-Khalif, 2007).

Ahmed *et al.* (2007) conducted a field experiment at Agronomy field, Sher-e-Bangla Agricultural University, Dhaka during December 2005 to May 2006 to study the influence of cultivation methods on inbred and hybrid rice in *Boro* season. Interaction of variety and cultivation method revealed that nursery seedlings of the inbred variety produced the highest grain yield (8.88 t ha^{-1}) and

sprouted seeds broadcast of the inbred variety gave the lowest grain yield (6.35 t ha^{-1}).

Main *et al.* (2007) stated that in south and Southeast Asia, floodwater may remain for more than a month during the period of *Aman* rice grown with maximum submergence reaching to about 50-400 cm in depth. This type of damage would be rather serious for dwarf and semi dwarf varieties, which cause total crop losses. Horizontal expansion of *Aman* rice area is not possible due to high human population pressure on land. Therefore, it is an urgent need of the time to increase rice production through increasing the yield of *Aman* rice at farmers level using inbreed and hybrid varieties. There are different methods of planting such as direct seedlings (haphazard and line sowing), transplanting of seedlings (haphazard and line sowing), transplanting of clonal tillers. The vegetative propagation of using clonal tillers separated from previously established transplanted crop was beneficial for restoration of a damaged crop of *Aman* rice where maximum number of filled grain per panicle (173.67), the highest grain yield (4.96 t ha^{-1}) was obtained with the clonal tillers followed by nursery seedlings the highest harvest index (49.04%) was found from the clonal tillers those were statistically similar with nursery seedlings.

Xia *et al.* (2007) in experiment found that Shanyou63 variety gave the higher yield (12 t ha^{-1}) compared to Xieyou46 variety (10 t ha^{-1}).

AEF (2006) stated that planting 2 clonal tillers / hill showed significantly higher grain yield (4.24 t ha^{-1}) compared two other plant density along with nursery seedlings. The higher yield in clonal tillers compared to nursery seedlings might be due to the higher filled grains per panicle. Clonal tillers gave significantly higher number of filled grains per panicle than nursery seedlings irrespective of variety.

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

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

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

Swain *et al.* (2006) evaluated in a field experiment the performance of rice hybrids NRH1, NRH3, NRH4, NRH5, PA6111, PA6201, DRRH1, IR64, CR749-20-2 and Lalat conducted in Orissa, India during 1999-2000. Among the hybrids tested, PA 6201 recorded the highest leaf area index.

Chowdhury *et al*. (2005) conducted an experiment with 2, 4 and 6 seedlings hill^{-1} to study their effect on the yield and yield components of rice cv. BR23 and Pajam during the amen season. They reported that the cv. BR23 showed superior performance over Pajam in respect of yield and yield contributing characters i.e. number of productive tillers hill^{-1}, length of panicle, l000-grain weight, grain yield and straw yield. On the other hand, the cultivar Pajam produced significantly the tallest plant, total number of grains panicle^{-1}, number of filled grains panicle^{-1} and number of unfilled grains panicle^{-1}.

Myung (2005) worked with four different panicle types of rice varieties and observed that the primary rachis branches (PRBs) panicle^{-1} and grains were more on Sindongjinbyeo and Iksan467 varieties, but secondary rachis branches (SRBs) were fewer than in Dongjin1 and Saegyehwa varieties.

Akbar (2004) reported that variety, seedling age and their interaction exerted significant influence on almost all the crop characters. Among the varieties, BRRI dhan41 performed the best in respect of number of bearing tillers hill^{-1}, panicle length, total spikelets panicle^{-1} and number of grains panicle^{-1}. BRRI dhan41 also produced the maximum grain and straw yields. Sonarbangla-1 ranked first in respect of total tillers hill^{-1} and 1000-grain weight but produced

highest number of non-bearing tillers hill^{-1} and sterile spikelets panicle^{-1}. Grain, straw and biological yields were found highest in the combination of BRRI dhan 41 with 15 day-old seedlings. Therefore, BRRI dhan 4l may be cultivated using 15 day-old seedlings in *Aman* season following the SRI technique to have better grain and straw yields.

Murthy *et al.* (2004) conducted an experiment with six varieties of rice genotypes Mangala, Madhu, J-13, Sattari, CR 666-16 and Mukti and observed that Mukti (5268 kg ha^{-1}) out yielded the other genotypes and recorded the maximum number of filled grains and had lower spikelet sterility (25.85%) compared to the others.

Anwar and Begum (2004) reported that time of tiller separation of rice significantly influenced plant height, total number of tiller hill^{-1}, number of bearing tillers and panicle length but grain and straw yields were unaffected. Therefore, Sonarbangla-1 appeared to be tolerant to tiller separation and separation should be done between 20 to 40 DAT without hampering grain yield.

Sumit *et al.* (2004) worked with newly released four commercial rice hybrids (DRRH 1, PHB 71, Pro-Agro 6201, KHR 2, ADTHR 1, UPHR 1010 and Pant Sankar Dhan 1) and two high yielding cultivars (HYV) as controls (Pant Dhan 4 and Pant Dhan 12) and reported that KHR 2 gave the best yield (7.0 t ha^{-1}) among them.

Bokyeong *et al.* (2003) reported that applied with same nitrogen dose Sindongjinbyeo and Iksan467 gave high primary rachis branches than Sindongjinbyeo and Dongjin No. 1 varieties.

Dongarwar *et al.* (2003) comprised an experiment to investigate the response of hybrid rice KJTRH-1 in comparison with 2 traditional cultivars, Jaya and Swarna, to 4 fertilizer rates, i.e. 100:50:50, 75:37.5:37.5, 125:62.5:62.5 and 150:75:75 kg NPK ha^{-1} and reported that KJTRH-1 produced significantly higher yield (49.24 q ha^{-1}) than Jaya (39.64 q ha^{-1}) and Swarna (46.06 q ha^{-1}).

Siddiquee *et al.* (2002) conducted a study to evaluate the difference between hybrid and inbred rice in respect of their growth duration, yield and quality in Boro season, 1999. Among the varieties, Aalok 6201 had the highest grain yield followed by BRRI dhan29 and IR68877H but statistically they were similar. BRRI dhan28 had the lowest grain yield, which was statistically similar to Loknath503. BRRI dhan28 and the tested hybrid rice had lower growth duration than BRRI dhan29. Milling out turn varied from 67 to 70% among the tested varieties. Loknath 503 had the lowest milling out turn (70%) and, BRRI dhan28 and BRRI dhan29 had the highest milling out turn (70%) for unparboiled but parboiled rice the highest milling out turn(73%) were found in BRRI dhan28 and IR68877H . All tested hybrid rice were medium bold, whereas BRRI dhan29 and BRRI dhan28 were medium slender and long slender, respectively in both parboiled and unparboiled condition. Among the varieties, amylose content (%) was higher in BRRI dhan29 and protein content (%) was higher in IR68877H for both under parboiled and unparboiled

condition. Alkali spreading value was higher in BRRI dhan28. Cooking quality of all the varieties was more or less similar.

Rahman *et al.* (2002) carried out an experiment with 4 varieties of transplant *Aman* rice viz., BR1l, BR22, BR23 and Tuishimala and 6 structural arrangement of rows viz., 25 cm + 25 cm, 30 cm + 20 cm, 35 cm + 1 5 cm, 40 cm + 10 cm) 45 cm + 05 cm and haphazard planting at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh. Thousand grains weight and grain yield were highest in BR23 and these were lowest in Tulshirnaia.

Obulamma *et al.* (2002) performed an experiment with hybrid rice DRRHI and APHR-2 at Andhra Pradesh, India. The treatments were 4 spacing (15 x 10, 20 x 10, 15 x 15 and 20 x 15 cm^2) and 3 seedling densities (1, 2 and 3 seedlings $hill^{-1}$). APHR-2 was found to produce higher yield than DRRH-l.

Biswas and Salokhe (2002) conducted an experiment in a Bangkok clay soil to investigate the influence of N rate, light intensity, tiller separation, and plant density on the yield and yield attributes of parent and clone plants of transplanted rice. Application of 75 kg N and 120 kg N ha^{-1} resulted in similar yields. The 50% reduction of light intensity reduced grain yield to 43.5% compared with normal light intensity. Separation of more than 4 tillers $hill^{-1}$ had an adverse effect on the mother crop. Nitrogen fertilizer had no influence on grain weight, per cent filled grains, and panicle size of the mother crop, but increased N produced a higher number of tillers. Reduction of light intensity

and higher tiller separation adversely affected grain weight and panicle number. Variation of N rate and light intensity of the mother crop had no influence on grain yield, grain weight, and panicle number of clonal tillers transplanted with 75 kg N ha^{-1} and with normal light intensity. The clonal tillers produced higher yields than the nursery seedlings, and transplanting 2 clonal tillers $hill^{-1}$ resulted in almost the same yield as 3 clonal tillers and 4 clonal tillers $hill^{-1}$. A single clonal tiller had the capacity to produce 4.5 t ha^{-1} grain yields. Yield components of clonal tillers, i. e., panicle number and grain weight, had no influence due to variations of N and light intensity of the mother crop, but higher densities of clonal tillers transplanted per hill gave lower panicle number and grain weight.

Xu and Wang (2001) evaluated ten restorer and ten maintainer lines. They observed that the restorer lines showed more spikelet fertility than maintainer lines. They studied growth duration, number of effective tillers, number of spikelets $panicle^{-1}$ and adaptability.

Bhowmick and Nayak (2000) observed that CNHR2 produced more number of productive tillers (413.4 m^{-2}) and filled grains $panicle^{-1}$ (111.0) than other varieties, whereas IR36 gave the highest 1000-grain weight (21.07 g) and number of panicles m^{-2} than other tested varieties. In a trial, varietal differences in harvest index and yield examined using 60 Japanese varieties and 20 high yielding varieties bred in Asian countries. It was reported that harvest index varied form 36.8% to 53.4%. Mean values of harvest index were 43.5% in the Japanese group and 48.8% in high yielding group. Yield ranged

from 22.6 g plant^{-1} to 40.0 g plant^{-1}. The mean value of yield in Japanese group was 22.8 g plant^{-1}, and that in the high yielding group was 34.1 g plant^{-1}. They also reported that a positive correlation was found between harvest index and yield in the high yielding group (Cui *et al.*, 2000).

Patel (2000) studied the varietal performance of Kranti and IR36. He observed that Kranti produced significantly higher grain and straw yield than IR36. The mean yield increased with Kranti over IR36 was 7.1 and 10.0% for grain and straw, respectively. Molla (2001) reported that Pro-Agro6201 (hybrid) had a significant higher yield than IET4786 (HYV), due to more mature panicles m^{-2}, higher number of filled grains panicle^{-1} and greater seed weight.

Chen-Liang *et al*. (2000) showed that the cross between Peiai 64s and the new plant type lines had strong heterosis for filled grains plant^{-1}, number of spikes plant^{-1} and grain weight plant^{-1} but heterosis for spike fertility was low.

Chapter III

MATERIALS AND METHODS

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

3.1 Experimental period

The experiment was conducted during the period from July to December, 2017 in T. *Aman* season.

3.2 Site description

The experiment was conducted in the Sher-e-Bangla Agricultural University farm, Dhaka, under the agro-ecological zone of Modhupur Tract, AEZ-28. For better understanding about the experimental site is shown in the Map of AEZ of Bangladesh in Appendix I.

3.3 Climate

The experimental area under the sub-tropical climate that is characterized by high temperature, high humidity and heavy rainfall with occasional gusty winds in *Kharif* season (April-September) and less rainfall associated with moderately low temperature during the *Rabi* season (October-March). The weather data during the study period at the experimental site are shown in Appendix II.

3.4 Soil

The farm belongs to the General soil type, Shallow Red Brown Terrace Soils under Tejgaon Series. The land was above flood level and sufficient sunshine was available during the experimental period. Soil samples from 0-15 cm depths were collected from experimental field. The analyses were done at Soil Resource and Development Institute (SRDI), Dhaka. The physicochemical properties of the soil are presented in Appendix III.

3.5 Planting material

Nine aromatic rice varieties, Kalizira, Kataribhog, Begun Bichi, Badshabhog, Chinigura, Dulabhog , Chiniatop-1, Sada Sonne, Khoi Sonne were used as the test crop.

3.6 Seed collection and sprouting

Seeds of Dulabhog (BR 5) were collected from BRRI, Joydebpur, Gazipur. Kalizira, Kataribhog, Begun Bichi, Badshabhog, Chinigura, Chiniatop-1, Sada Sonne, Khoi Sonne were collected from Germplasam centre, SAU, Dhaka. Healthy seeds were selected following standard method. Seeds were immersed in water in a bucket for 24 hrs. These were then taken out of water and kept in gunny bags. The seeds started sprouting after 48 hrs which were suitable for sowing in 72 hrs.

3.7 Raising of seedlings

A common procedure was followed in raising of seedlings in the seedbed. The nursery bed was prepared by puddling with repeated ploughing followed by

laddering. The sprouted seeds were sown as uniformly as possible. Irrigation was gently provided to the bed as and when needed. No fertilizer was used in the nursery bed.

3.8 Collection and preparation of initial soil sample

The initial soil samples were collected before land preparation from a 0-15 cm soil depth. The samples were collected by means of an auger from different location covering the whole experimental plot and mixed thoroughly to make a composite sample. After collection of soil samples, the plant roots, leaves etc. were picked up and removed. Then the sample was air-dried and sieved through a 10-mesh sieve and stored in a clean plastic container for physical and chemical analysis.

3.9 Preparation of experimental land

The experimental field was first opened on 11 July, 2017 with the help of a power tiller, later the land was irrigated and prepared by three successive ploughing and cross-ploughing. Each ploughing was followed by laddering to have a good puddled field. All kinds of weeds and residues of previous crop were removed from the field. The field layout was made on 23 July, 2017 according to design immediately after final land preparation. Individual plots were cleaned and finally leveled with the help of wooden plank.

3.10 Fertilizer management

At the time of first ploughing cow-dung at the rate of 10 t ha^{-1} was applied. The experimental plots were fertilized with @ 150, 100, 50, 62.5, 10 kg ha^{-1} in the

form of nitrogen, triple superphosphate (TSP), muriate of potash (MP), gypsum and zinc sulphate, respectively (BARC, 2012) one day before transplanting. The entire amounts of triple superphosphate (TSP), muriate of potash (MP), gypsum and zinc sulphate were applied at final land preparation as basal dose. The whole amount of all the fertilizers except urea were applied at the time of final land preparation and thoroughly incorporated with soil with the help of a spade. Urea was top dressed in three equal splits on 15, 30, and 45 DAT (BRRI, 2000).

3.11 Experimental treatments

The experiment consisted of one factor, included nine local aromatic rice cultivars (treatments).

i) V_1 =Kalizira
ii) V_2 =Begun Bichi
iii) V_3 =Chinigura
iv) V_4 =Chiniatop-1
v) V_5 =Sada Sonne
vi) V_6 =Khoi Sonne
vii) V_7 =Kataribhog
viii) V_8 =Badshabhog
ix) V_9 =Dulabhog

The experiment was laid out in Randomized Complete Block Design (RCBD) with four replications. The whole field was divided into four blocks each containing 11 plots. In total, there were 36 plots. The treatments were randomly

assigned to each unit plot. The size of unit plot was 4.0 m × 2.5 m. The distance between the blocks was 1 m and that between plots was 50 cm.

3.12 Uprooting and transplanting of seedlings

Thirty days old seedlings were uprooted carefully and were kept in soft mud in shade. The seed beds were made wet by application of water in previous day before uprooting the seedlings to minimize mechanical injury of roots. Seedlings were then transplanted maintaining spacing of 25 cm X 15 cm from row to row and hill to hill, respectively.

3.13 Intercultural operations

3.13.1 Gap filling

After one week of transplanting, a minor gap filling was done where it was necessary using the seedling from the same source.

3.13.2 Weeding

During plant growth period two hand weeding were done, first weeding was done at 23 DAT (Days after transplanting) followed by second weeding at 38 DAT.

3.13.3 Application of irrigation water

Irrigation water was added to each plot according to the critical stage. Irrigation was done up to 5 cm.

3.13.4 Method of water application

The experimental plots were irrigated through irrigation channels. Centimeter marked sticks were installed in each plot which were used to measure depth of irrigation water.

3.13.5 Plant protection measures

Plants were infested with rice stem borer and leaf hopper to some extent which was successfully controlled by applying two times of Diazinone 60 EC on 20 August and 5 September, 2017. Crop was protected from birds during the grain filling period.

3.14 General observation of the experimental field

The field was investigated time to time to detect visual difference among the treatment and any kind of infestation by weeds, insects and diseases so that considerable losses by pest could be minimized. The field looked nice with normal green color plants. Incidence of stem borer, green leaf hopper, leaf roller was observed during tillering stage. But any bacterial and fungal disease was not observed. The flowering was not uniform.

3.15 Harvesting and post harvest operation

Maturity of crop was determined when 90% of the grains become golden yellow in color. The harvesting was done on ten pre-selected hills from which data were collected and 6 mid lines from each plot was separately harvested, bundled, properly tagged and then brought to the threshing floor. Threshing was done by pedal thresher. The grains were cleaned and sun dried to moisture content of 12%. Straw was also sun dried properly. Finally grain and straw yields plot^{-1} were recorded and converted to t ha^{-1}.

3.17 Recording of data

A. Morphological characters

Plant height at harvest
Number of leaves plant $^{-1}$
Number of tillers hill^{-1}
Length of panicle

B. Growth characters

Leaf area index (LAI)

Chlorophyll content (SPAD value)

Crop growth rate (CGR)

Leaf area ratio (LAR)

Total dry matter

C. Yield and its attributes:

Panicles hill^{-1}

Number of seed panicle^{-1}

1000-grain weight

Grain yield

Straw yield

Biological yield

Harvest index (%)

3.17 Experimental measurements

Experimental data collection began at harvest. The necessary data on agronomic characters were collected from ten selected hills from each plot in field and at harvest.

Plant height

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

Leaves plant^{-1}

Number of leaves plant^{-1} were counted at harvest from pre selected plant and finally averaged as their number plant^{-1}.

Tillers hill^{-1}

Number of tillers hill^{-1} were counted at harvest from pre selected hills and finally averaged as their number hill^{-1}. Only those tillers having three or more leaves were considered for counting.

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.

Leaf area index (LAI)

Leaf area (blade area) was measured by portable leaf area meter (Model LI3000A) at 15 days interval up to 90 days after transplanting (DAT) starting from 15 DAT. Then LAI was calculated by using the following formula:

$$LAI = \frac{\text{Leaf area of hills}}{\text{Ground area occupied by these hills}}$$

Leaf Area Ratio (LAR)

LAR is calculated using following formula-

$LAR(cm^2\ g^{-1}) = LA / W$

Where LA is the leaf area and W is total plant dry weight.

SPAD value (chlorophyll content)

Measurement of Chlorophyll Content (SCMR Values): The SPAD-502 Minolta Camera Co. Ltd., Japan, (Futuhara *et al.*, 1979) (Soil Plant Analytical Development) meter was used for measuring the relative chlorophyll content of leaves. The chlorophyll content was measured from recent fully expanded

leaves. Mean of five values from five hills was obtained. This meter enables obtaining instant readings without destroying the plant tissue. Ten leaves were randomly taken from each plot to determine chlorophyll content at 15 days interval after transplanting (DAT).

Crop growth rate (CGR)

CGR values for the crop during the sampling intervals have been computed by using the formulae of Brown (1984) and Radford (1967).

$$CGR = \frac{W_2 - W_1}{(t_2 - t_1)} \text{ g m}^{-2} \text{ d}^{-1}$$

Where, W_1 and W_2 are the total dry matter production in grams at the time t_1 and t_2 respectively.

Total dry matter

Dry matter of the plant was recorded at fortnightly interval by destructive sampling of 5 hills in the third row of every plot. After shade drying, the samples were subjected to 60^0C-70^0C temperature in a hot air oven till constant weight was obtained. After complete drying, dry matter was expressed as g m^{-2}.

Panicles hill^{-1}

Number of panicles at harvest was counted in five hills, and then the average number per hill^{-1} was computed.

Grains panicle^{-1}

Number of grains from randomly selected 10 hills were counted and average of which gave the number of grains panicle^{-1}.

1000-grain weight

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 12% moisture and the mean weight were expressed in gram.

Grain yield

Grain yield was determined from the central 5 m length of all 6 inner rows of the plot and expressed as t ha^{-1} on 12% moisture basis. Grain moisture content was measured by using a digital moisture tester.

Straw yield

Straw yield was determined from the central 5 m length of all 6 inner rows of each plot. After threshing, the sub-sample was oven dried to a constant weight and finally converted to t ha^{-1}.

Biological yield

The biological yield was calculated with the following formula-

Biological yield= Grain yield + Straw yield

Harvest index (%)

It denotes the ratio of economic yield to biological yield and was calculated with following formula.

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

3.18 Statistical analysis

The recorded data on various parameters were statistically analyzed. Using MSTAT statistical package programmed. The mean for all the treatments was calculated and analysis of variance for all the characters was performed by F-test. Difference between treatment means were determined by least significant difference (LSD) according to Gomez and Gomes (1984).

CHAPTER IV

RESULTS AND DISCUSSION

The experimental results regarding the morpho-physiological attributes and yield performance of aromatic rice cultivars in *Aman* season have been presented and discussed in this chapter.

4.1 Plant height

Significant influence was remarked in terms of plant height with different varieties of transplanted rice (Figure 1). Results showed that the highest plant height (153.60 cm) was found in variety of $V_{5,}$ (Sada sonne), which was statistically similar with $V_{3,}$ Chinigura (151.25cm). The competition in accordance with plant height among the test varieties, the shortest plant was observed with $V_{7,}$ (Kataribhog) (67.20 cm). The results corroborate with the findings of Islam *et al.* (2009), Bisne *et al.* (2006), Mishra and Pandey (1998) and Hossain *et al.* (1991) who observed various plant height due to different varieties.

4.2 Number of leaves hill^{-1}

Significant variation was marked in terms of number of leaves hill^{-1} of aromatic rice among the test varieties (Table 2). Results showed that the highest number of leaves hill^{-1} (56.23) was produced from V_6, Khoi Sonne treatment which was statistically similar with V_2, Bagun Bichi (56.00). The lowest leaves hill^{-1} (38.3) was obtained from V_7 (Kataribhog).

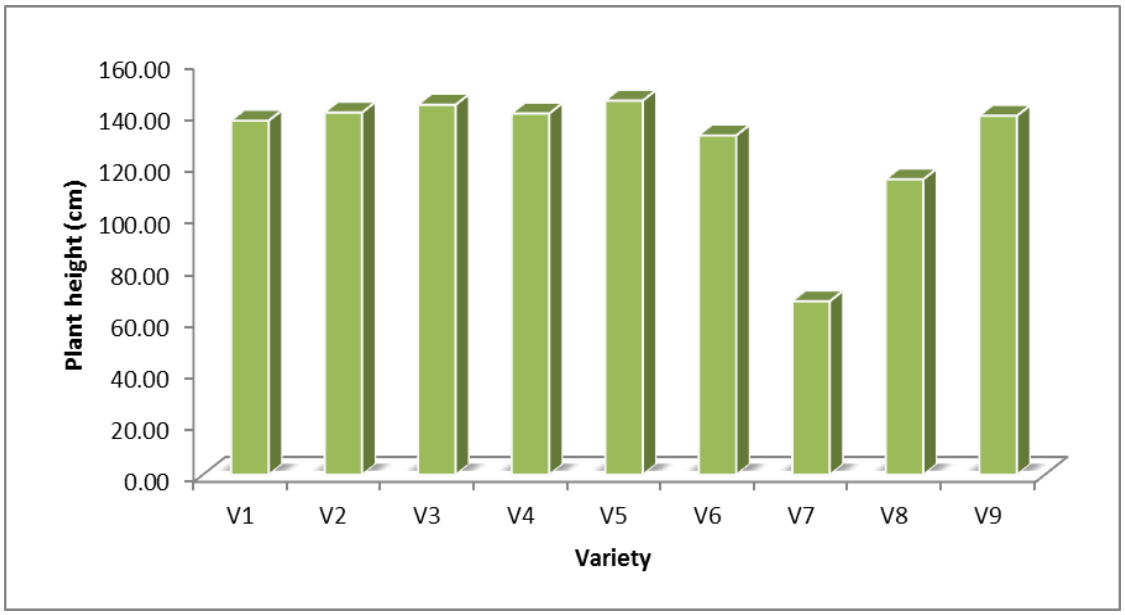

Figure 1. Effect of variety on the plant height of rice

The results substantiate with the findings of Luh (1980) who observed highest tiller and leaf number in rice occurred at 40 to 60 days after transplanting, depending upon the tillering capacity of the variety, the spacing used and the fertility level.

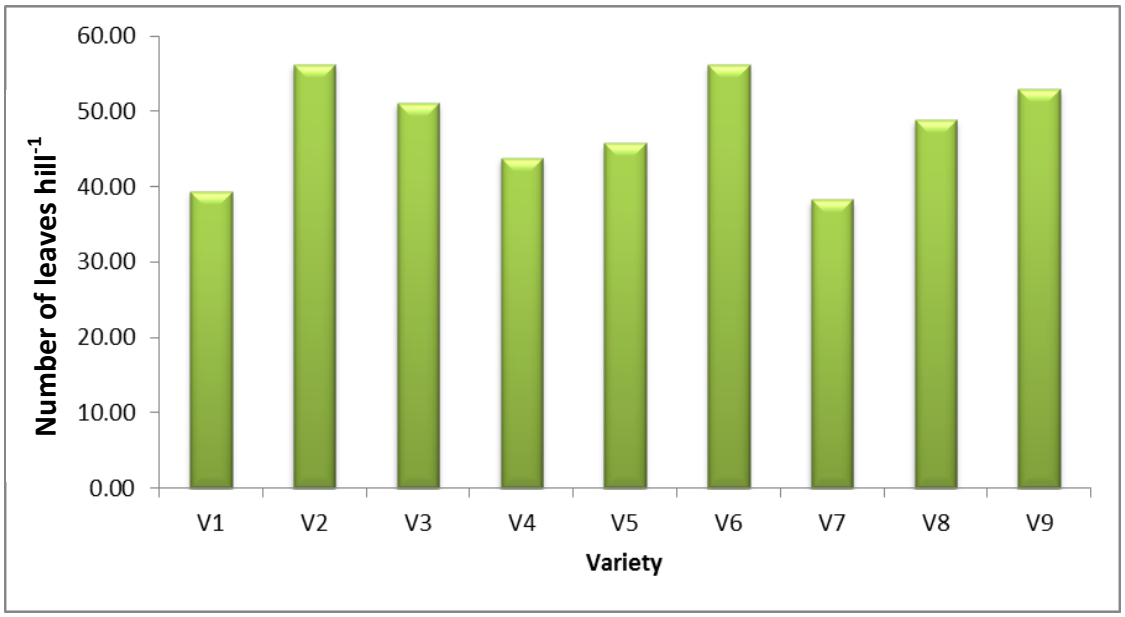

Figure 2. Effect of variety on Number of leaves hill^{-1}

4.3 Leaf area index

Leaf area index (LAI) increased from 15 DAT to 60 DAT beyond which declined sharply, significant variation was observed in LAI among the aromatic rice cultivars studied from 30 DAT to maturity (Table 1). Maximum leaf area index of 6.03 was recorded in cultivar V_3 Chinigura followed by $V_{8,}$ Badshabhog (5.33) and $V_{5,}$ Sada Sonne (5.01) and minimum of 3.64 was recorded with $V_{1,}$ Kalizira closely followed by $V_{4,}$ Chiniatop-1(3.82) at 60 DAT. The decrease in the leaf area index towards maturity may be due to lesser number of leaves as a result of senescence in old leaves.

Table 1: Leaf area index in traditional aromatic rice cultivars during *Aman* season

Variety	Leaf area index					
	15	30	45	60	75	90
Kalizira	0.24b	1.78	3.32fg	3.64f	3.43bc	1.43c-e
Begun Bichi	0.22c	1.64	4.01d	4.33d	3.66a	1.56cd
Chinigura	0.19e	1.77	5.71a	6.03a	3.39b-e	2.08d
Chiniatop-1	0.26a	3.11	3.50efg	3.82ef	2.17g	1.03f
Sada Sonne	0.21cd	2.20	4.70bc	5.01bc	3.50ab	1.70a-c
Khoi Sonne	0.26a	1.61	3.61ef	3.93ef	1.70i	1.11ef
Kataribhog	0.20de	1.72	3.12g	3.91ef	3.40b-c	1.34c-f
Badshabhog	0.22c	1.98	5.01b	5.33b	2.01gh	1.96ab
Dulabhog	0.24b	1.91	3.78de	4.09de	3.09ef	1.22df
$LSD_{(0.05)}$	0.13	NS	0.38	0.38	0.21	0.39
CV(%)	2.75	5.21	8.91	8.23	11.52	10.57

In a column, means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability. NS=Non-significant

4.4 Leaf area ratio

Leafiness in terms of leaf area ratio (LAR) revealed that there was significant difference among the varieties (Table 2). In five genotypes viz., Begun Bichi , Chinigura, Kataribhog , Badshabhog and Dulabhog there was gradual increase in LAR up to 45 DAT and thereafter decreased till maturity while in

four genotypes viz., Kalizira, Chiniatop-1, Sada Sonne and Khoi Sonne LAR gradually decreases after 30DAT. At 45 DAT maximum LAR (116.75 cm^2 g^{-1}) was recorded in Begun Bichi and minimum LAR (72.35 cm^2 g^{-1}) in Chiniatop-1. The decrease in leaf area ratio in later stages was due to decrease in leaf area in later stages because of senescence of older leaves and increase in dry weight. Similar results were also reported by Park *et al.* (1995).

Table 2: Leaf area ratio in aromatic rice cultivars during *Aman* season

Variety	Leaf area ratio (cm^2 g^{-1})					
	15	**30**	**45**	**60**	**75**	**90**
Kalizira	41.25	88.61de	83.89fg	51.04d-f	34.76ab	12.91b-d
Begun Bichi	39.59	69.23h	116.75a	66.08a	27.83c-e	15.22ab
Chinigura	41.71	91.39d	114.37ab	63.94ab	18.37gh	16.39a
Chiniatop-1	40.89	120.39a	72.35h	43.03g	18.40h	7.83g
Sada Sonne	44.26	100.25bc	99.71cd	56.79b-e	28.77c	12.72b-e
Khoi Sonne	35.78	106.7b	101.32c	57.11cd	21.33f	11.21c-f
Kataribhog	39.55	84.01d-g	90.2ef	49.17fg	16.56h	9.89d-g
Badshabhog	45.84	86.82d-f	90.17ef	53.46c-e	28.63cd	10.13c-g
Dulabhog	40.91	75.43h	95.55c-e	59.05bc	35.09a	13.23a-c
$LSD_{(0.05)}$	NS	7.71	8.33	6.39	2.43	3.19
CV (%)	13.64	12.54	24.74	21.10	13.80	11.05

In a column, means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability. NS=Non-significant

4.5 Crop growth rate

Significant difference among the varieties was found for crop growth rate (CGR) (Table 3). The crop growth rate (CGR) increased gradually up to 45-60 days but decreased later on. Highest CGR of 28.23 g m^{-2} day^{-1} was recorded by $V_{9,}$ Dulabhog and minimum CGR was recorded in the variety $V_{1,}$ Kalizira (21.02 g m^{-2} day^{-1}). Similar finding were also reported by Erfani and Nasiri (2000). The increase in CGR is due to increased leaf area index values and

light interception thereby increased photosynthetic rate and dry matter production. After reaching the maximum CGR it decreases till maturity due to ageing of leaves and leaf shedding.

Table 3: Crop growth rate in aromatic rice cultivars during *Aman* season

Variety	Crop growth rate ($g\ m^{-2}\ day^{-1}$)				
	15-30	**30-45**	**45-60**	**60-75**	**75-90**
Kalizira	9.43gf	12.98de	21.02f	18.24b-f	8.04
Begun Bichi	10.98c-e	13.41de	21.16f	19.79a-d	9.81
Chinigura	8.38g	13.93de	26.65b-d	19.36b-e	9.05
Chiniatop-1	12.87ab	15.08bc	26.95a-c	15.26f	6.15
Sada Sonne	11.52c	16.77a	27.36ab	22.31a	8.47
Khoi Sonne	13.81a	15.52b	23.05f	21.09ab	6.84
Kataribhog	9.01fg	13.31e	22.24f	17.57de	7.89
Badshabhog	10.79c-e	14.81c	26.39b-e	17.33de	9.14
Dulabhog	11.11cd	13.30e	28.23a	20.72a-c	8.96
$LSD_{(0.05)}$	0.90	1.11	2.73	2.92	NS
Cv(%)	7.29	11.36	15.90	18.96	15.37

In a column, means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability. NS=Non-significant

4.6 Chlorophyll meter reading (SPAD Value)

Significant differences were observed for SPAD values throughout growth period among the aromatic rice genotype (Table 4). The maximum SPAD values were recorded for cultivar V_9, Dulabhog throughout the crop growth period followed by V_3, Chinigura while the lowest values were found in V_1, Kalizira. These results are in agreement with Swain *et al.* (2006) who found highly significant and positive relation between total chlorophyll content at all the growth stages and grain number per square meter.

Table 4: SPAD reading (values) in aromatic rice cultivars during *Aman* season

Variety	SPAD reading					
	15	30	45	60	75	90
Kalizira	35.56gh	38.41f-h	35.22ef	36.51g	36.59h	29.85i
Begun Bichi	35.21h	40.82c-e	38.17bc	38.29ef	35.83h	32.39gh
Chinigura	38.88c	43.08ab	40.61a	41.70ab	41.85bc	38.19ab
Chiniatop-1	38.40cd	40.63c-e	35.70de	41.34bc	41.52b-d	37.07a-e
Sada Sonne	36.80fg	39.47d-f	36.97cd	38.87e	39.54f	36.66a-f
Khoi Sonne	41.29ab	41.61c	37.47cd	40.71cd	41.17c-e	37.56a-c
Kataribhog	38.29c-e	38.49f-h	36.73c-e	36.96g	42.57ab	37.53a-d
Badshabhog	37.89c-f	39.03fg	35.71d-f	37.34fg	38.57fg	33.38g
Dulabhog	42.03a	43.54a	39.58ab	42.89a	43.63a	38.32a
$LSD_{(0.05)}$	1.58	1.44	1.97	1.17	1.09	1.75
CV(%)	8.52	5.47	13.65	9.38	10.36	13.57

In a column, means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

4.7 Total dry matter

Total dry matter for aromatic rice genotypes has shown significant difference among all the aromatic rice cultivars from 30 DAT to maturity (Table 5). There was a steady increase in total dray weight in all the stages till maturity. The highest dry matter production of 1365.97 g m^{-2} was recorded $V_{2,}$ Begun Bichi followed by $V_{3,}$ Chinigura (1343.75 g m^{-2}) and $V_{9,}$ Dulabhog (1314.98 g m^{-2}) while minimum dry matter production of 1107.33 g m^{-2} was recorded for the genotypes $V_{1,}$ Kalizira closely followed by $V_{4,}$ Chiniatop-1(1122.23 g m^{-2}). The highest dry matter production in variety Begun Bichi than in other cultivars can be attributed to more LAI, LAR and better crop growth rates recorded with this cultivar. Similar results were also reported by Sinha *et al*. (2009).

Table 5: Total dry matter production in aromatic rice cultivars during *Aman* season

Variety	Total dry matter ($g\ m^{-2}$)					
	15	**30**	**45**	**60**	**75**	**90**
Kalizira	59.66	201.09h	395.72g	713.15f	986.68g	1107.33f
Begun Bichi	48.99	256.19ab	489.06a	912.46a	1228.76a	1365.97a
Chinigura	47.44	220.20d	471.73a-c	882.13a-c	1216.76ab	1343.75ab
Chiniatop-1	66.66	192.31h	401.29e-g	801.03d-f	1029.90fg	1122.23e
Sada Sonne	53.77	218.42d-e	419.63d-f	734.92fg	1031.78f	1178.99d
Khoi Sonne	51.00	243.23bc	478.27a-c	809.40de	1124.72d	1132.75ef
Kataribhog	54.77	216.64d-g	438.73d	834.58d	1094.56e	1197.21de
Badshabhog	53.32	219.97de	419.40de	765.03g	1075.89f	1210.32d
Dulabhog	65.33	258.30a	484.58ab	888.80ab	1179.21bc	1314.98a-c
$LSD_{(0.05)}$	NS	14.09	20.01	41.85	42.67	77.05
CV(%)	4.97	4.64	6.59	13.79	14.07	25.40

In a column, means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability. NS=Non-significant

4.8 Panicles $hill^{-1}$

The production of effective tillers $hill^{-1}$ was significantly influenced by the tested different varieties (Table 6). Rice variety of V_3, Chinigura showed the highest tiller number $hill^{-1}$ (14.33). The minimum tillers $hill^{-1}$ was found in V_1, Kalizira (10.67), which was statistically identical with V_5 Sada Sonne (11.34) at 75DAT. Islam *et al*. (2009), Bisne *et al*. (2006), Chowdhury *et al*. (2005), Akbar (2004) and Bhowmick and Nayak (2000) reported similar trend of tillering habits with different varieties of rice.

4.9 Panicle length

The panicle length was varied significantly due to different varieties (Table 1). The highest (30.00 cm) and the lowest (16.57 cm) panicle length were obtained from V_4, Chiniatop-1 and V_7, Kataribhog, respectively. Such findings might be

due to the genetic make-up of the varieties though Babiker (1986) observed that panicle length differed due to the varietal variation.

4.10 Grains panicle^{-1}

Performance of test varieties under the present study showed a significant difference in respect of grains panicle^{-1} (Table 6). The highest number of grains panicle^{-1} (181.30) was observed in variety of Chinigura which was significantly different from all other test varieties. Badshabhog produced the second highest grain panicle^{-1} (156.30). Sada Sonne produced the lowest number of grains panicle^{-1} (53.63). The results obtained by Chowdhury *et al*. (2005), Murthy *et al.* (2004), Bhowmick and Nayak (2000) and Patel (2000) was in agreement with findings of present study. Hossain *et al.* (1991) reported varietal variation in number of grains panicle^{-1} and Anon. (1998) found higher number of grains panicle^{-1} in the hybrid varieties. Rahman (2001) found highest number of grains panicle^{-1} in the mother plants than the clonal tillers. However, Biswas (2001) reported higher grain in the clonal tillers than the mother plants.

Table 6: Effect of variety on the number of tiller hill^{-1}, panicle length and grain panicle^{-1} of rice

Treatment	Panicles hill^{-1}		Panicle length (cm)		Grains panicle^{-1}	
Kalizira	10.67	c	26.92	ab	126.30	e
Begun Bichi	14.15	ab	26.38	ab	142.40	c
Chinigura	14.33	ab	24.88	a-c	181.30	a
Chiniatop-1	13.33	a	30.00	a	116.30	f
Sada Sonne	11.34	c	26.50	ab	53.63	i
Khoi Sonne	13.80	a	24.90	a-c	80.33	h
Kataribhog	12.81	a	16.57	d	113.80	g
Badshabhog	13.00	a	24.94	a-c	156.30	b
Dulabhog	13.17	a	23.01	bc	133.30	d
LSD $_{(0.05)}$	1.75		4.76		0.05	
CV (%)	9.75		8.42		5.45	

In a column, means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

4.11 Weight of 1000 grains

Significant influence of different varieties was observed on 1000-grain weight (Table 7). It is attained that the highest 1000 grain weight (17.66 g) was recorded in $V_{6,}$ Khoi Sonne. The lowest 1000 seed weight (9.23 g) was observed in $V_{1,}$ Kalizira. The results are in agreement with the findings of Chowdhury *et al*. (2005) and Rahman *et al.* (2002) who observed varied 1000 grains weight among different varieties of rice.

4.12 Grain yield

Different varieties significantly produced variable grain yield (Table 7). Among the tested nine varieties $V_{3,}$ Chinigura showed the highest grain yield (2.80 t ha^{-1}) which was statistically differ with that was the second highest grain yield in $V_{2,}$ Begun Bichi (2.43 t ha^{-1}). On the other hand, the lowest grain yield (1.29 t ha^{-1}) was obtained from $V_{4,}$ Chiniatop-1. Number of leaves, number tillers $hill^{-1}$, grains $panicle^{-1}$ which ultimately gave higher grain yield in $V_{3,}$ Chinigura. The results are in agreement with the findings of Islam *et al*. (2009), Bisne *et al.* (2006), Siddiquee *et al*. (2002) and Chowdhury *et al*. (2005) whose stated that grain yield differed significantly among the varieties.

Table 7: Effect of variety on yield and yield contributing character of rice

Treatment	1000-grain weight (g)	Grain yield (t ha^{-1})
Kalizira	9.23 e	1.41 cd
Begun Bichi	14.48 b	2.43 ab
Chinigura	11.53 c	2.80 a
Chiniatop-1	10.83 cd	1.29 d
Sada Sonne	15.51 b	1.53 cd
Khoi Sonne	17.66 a	1.38 cd
Kataribhog	11.61 c	1.78 b-d
Badshabhog	10.13 de	2.12 a-c
Dulabhog	10.63 cd	1.83 b-d
$LSD_{(0.05)}$	1.19	0.69
CV (%)	5.46	10.00

In a column, means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

4.13 Straw yield

Straw yield differed significantly due to varietal differences (Table 8). Chinigura gave the highest straw yield (5.08 t ha^{-1}) which was statistically similar with V_2, Begun Bichi (4.97 t ha^{-1}) and V_7, Kataribhog (5.08 t ha^{-1}). The lowest straw yield was found in V_9 (2.40 t ha^{-1}) which was statistically similar with V_1, V_4, V_5 andV_6 treatment. The differences in straw yield among the varieties may be attributed to the genetic makeup of the varieties. The results uphold with the findings of Chowdhury *et al*. (2005), Akbar (2004), Patel (2000) and Om *et al.* (1999) where they concluded that straw yield differed significantly among the varieties.

4.14 Biological yield

Variety had effect on biological yield (Table 8) though the maximum biological yield (7.88 t ha^{-1}) was found in V_3, Chinigura followed V_2, Begun Bichi (7.40 t ha^{-1}) , V_8, Badshabhog (4.71 t ha^{-1}) and V_7, Kataribhog (6.55 t ha^{-1}). Whereas the lowest biological yield (3.74 t ha^{-1}) was obtained from V_4, Chiniatop-1 which was statistically at par with V_1, Kalizira (3.99 t ha^{-1}), which was statistically similar with Sada Sonne, Khoi Sonne , Dulabhog and Kataribhog . Rahman (2001) reported that Chinigura produced higher biological yield compared to six local aromatic cultivars which was supported by Singh and Gangwer (1989).

4.15 Harvest index

Different varieties significantly produced variable harvest index (Table 8). The Kataribhog showed the highest harvest index (41.49). On the other hand, the

lowest harvest index (28.94) was obtained from $V_{6,}$ Khoi Sonne. Higher grain yield and lower biological yield was the probable reason for the maximum harvest index. Muir (1998) reported that hybrid varieties generally have a higher harvest index than do conventional varieties. Rahman (2001) observed highest harvest index in hybrid than the inbred varieties. Similar result was also reported by Cui *et al.* (2000).

Table 8: Effect of variety on straw yield, biological yield, and harvest index contributing character of rice

Treatment	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
Kalizira	2.58 d	3.99 c	35.27 a-c
Begun Bichi	4.97 ab	7.40 ab	31.85 b-d
Chinigura	5.08 a	7.88 a	39.04 ab
Chiniatop-1	2.45 d	3.74 c	32.21 b-d
Sada Sonne	2.82 d	4.35 c	29.95 cd
Khoi Sonne	2.86 d	4.24 c	28.94 cd
Kataribhog	4.77 a-c	6.55 b	41.49 a
Badshabhog	4.59 bc	6.71 b	34.79 a-d
Dulabhog	2.40 d	4.23 c	28.83 cd
LSD $_{(0.05)}$	0.44	1.04	7.63
CV (%)	7.55	8.78	5.63

In a column, means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted at the Agronomy field of Sher-e-Bangla Agricultural University, Dhaka during the period from July to December, 2017 in T. *Aman* season to investigate morpho-physiological attributes and yield performance of aromatic rice cultivars in *Aman* season. The experiment comprised of nine rice varieties viz. V_1 =Kalizira, V_2 =Begun Bichi, V_3 =Chinigura, V_4 = Chiniatop-1, V_5 =Sada Sonne, V_6 =Khoi Sonne, V_7 =Kataribhog, V_8 =Badshabhog, V_9 =Dulabhog (BRRIdhan5). The experiment was laid out in Randomized Complete Block Design (RCBD) with four replications. There were 36 plots having unit plot size of 4.0 m × 2.5 m. The treatments of the experiment were assigned at random to each unit plot.

Significant variation was recorded for data on growth, yield and yield contributing parameters of experimental materials. Data were collected on plant height, leaves hill^{-1}, tillers hill^{-1}, grains panicle^{-1}, panicle length, 1000-grain weight, grain yield and straw yield, biological yield and harvest index (%).

Significant influence was remarked in terms of plant height with different varieties of transplanted rice. Results showed that the highest plant height (153.60 cm) was found in variety of $V_{5,}$ Sada Sonne. Significant variation was marked in terms of number of leaves hill^{-1} of aromatic rice among the test varieties. Results showed that the highest number of leaves hill^{-1} (56.23) was produced from $V_{6,}$ Khoi Sonne variety. The production of tillers hill^{-1} was

significantly influenced by the tested different varieties. The highest number of leaves hill^{-1} (56.23) was produced from $V_{6,}$ Khoi Sonne variety which was statistically similar with V_2, Bagun Bichi (56.00). The lowest leaves hill^{-1} (38.3) was obtained from $V_{7,}$ Kataribhog.

Maximum leaf area index of 6.03 was recorded in cultivar $V_{3,}$ Chinigura followed by $V_{8,}$ Badshabhog (5.33) and $V_{5,}$ Sada Sonne (5.01) and minimum of 3.64 was recorded with $V_{1,}$ Kalizira closely followed by $V_{4,}$ Chiniatop-1(3.82) at 60 DAT. In five genotypes viz. Begun Bichi, Chinigura, Kataribhog , Badshabhog and Dulabhog there was gradual increase in LAR up to 45 DAT and thereafter decreased till maturity while in four genotypes viz., Kalizira, Chiniatop-1, Sada Sonne and Khoi Sonne LAR gradually decreases after 30DAT. At 45 DAT maximum LAR (116.75 cm^2 g^{-1}) was recorded in $V_{2,}$ Begun Bichi and minimum LAR (72.35 cm^2 g^{-1}) in $V_{4,}$ Chiniatop-1. Highest CGR of 28.23 g m^{-2} day^{-1} was recorded by $V_{9,}$ Dulabhog and minimum CGR was recorded in the variety $V_{1,}$ Kalizira (21.02 g m^{-2} day^{-1}). The maximum SPAD values were recorded for genotypes Dulabhog throughout the crop growth period followed by Chinigura while the lowest values were found in Kalizira. There was a steady increase in total dray weight in all the stages till maturity. The highest dry matter production of 1365.97 g m^{-2} was recorded $V_{2,}$ Begun Bichi followed by $V_{3,}$ Chinigura (1343.75 g m^{-2}) and $V_{9,}$ Dulabhog (1314.98 g m^{-2}) while minimum dry matter production of 1107.33 g m^{-2} was recorded for the genotypes $V_{1,}$ Kalizira closely followed by $V_{4,}$ Chiniatop-1(1122.23 g m^{-2}).

Rice variety of $V_{3,}$ Chinigura showed the highest tiller number hill^{-1} (14.33). The minimum tillers hill^{-1} was found in $V_{1,}$ Kalizira (10.67), which was statistically identical with $V_{5,}$ Sada Sonne (11.34) at 75DAT. The highest (30.00 cm) and the lowest (16.57 cm) panicle length were obtained from $V_{4,}$ Chiniatop-1 and $V_{7,}$ Kataribhog, respectively. The highest number of grains panicle^{-1} (181.30) was observed in variety of $V_{3,}$ Chinigura which was significantly different from all other test varieties. Badshabhog produced the second highest grain panicle^{-1} (156.30). Sada Sonne produced the lowest number of grains panicle^{-1} (53.63). Significant influence of different varieties was observed on 1000-grain weight. It was attained that the highest 1000 grain weight (17.66 g) was recorded in $V_{6,}$ Khoi Sonne. The lowest 1000 seed weight (9.23 g) was observed in $V_{1,}$ Kalizira.. Among the tested nine varieties $V_{3,}$ Chinigura showed the highest grain yield (2.80 t ha^{-1}) which was statistically differ with that was the second highest grain yield in $V_{2,}$ Begun Bichi (2.43 t ha^{-1}). On the other hand, the lowest grain yield (1.29 t ha^{-1}) was obtained from $V_{4,}$ Chiniatop-1. Chinigura gave the highest straw yield (5.08 t ha^{-1}) which was statistically similar with $V_{2,}$ Begun Bichi (4.97 t ha^{-1}) and $V_{7,}$ Kataribhog (5.08 t ha^{-1}). The lowest straw yield was found in $V_{9,}$ Dulabhog (2.40 t ha^{-1}). Variety had effect on biological yield (Table 8) though the maximum biological yield (7.88 t ha^{-1}) was found in Chinigura followed Begun Bichi (7.40 t ha^{-1}) , Badshabhog (4.71 t ha^{-1}) and Kataribhog (6.55 t ha^{-1}). Whereas the lowest biological yield (3.74 t ha^{-1}) was obtained from Chiniatop-1 which was statistically at par with Kalizira (3.99 t ha^{-1}), which was statistically similar

with Sada Sonne, Khoi Sonne, Dulabhog and Kataribhog. Different varieties significantly produced variable harvest index (Table 8). The Kataribhog showed the highest harvest index (41.49). On the other hand, the lowest harvest index (28.94) was obtained from Khoi Sonne.

Conclusion

Among the nine aromatic (fine) rice cultivars,

- ❖ Begun Bichi, Chinigura, Badshabhog and Dulabhog exhibited higher LAI, LAR, CGR, TDM and relative chlorophyll content throughout the growth period compared to the rest five cultivars.
- ❖ Chinigura demonstrated the best performance in respect of grain yield (2.80 t ha^{-1}) closely followed by Begun Bichi (2.43 t ha^{-1}).

Recommendation

- Chinigura, Begun Bichi, Badshabhog and Dulabhog may be cultivated for getting higher grain yield in *Aman* season.
- Further experiment should be done at the different Agro-ecological zone of Bangladesh for the confirmation of the result.

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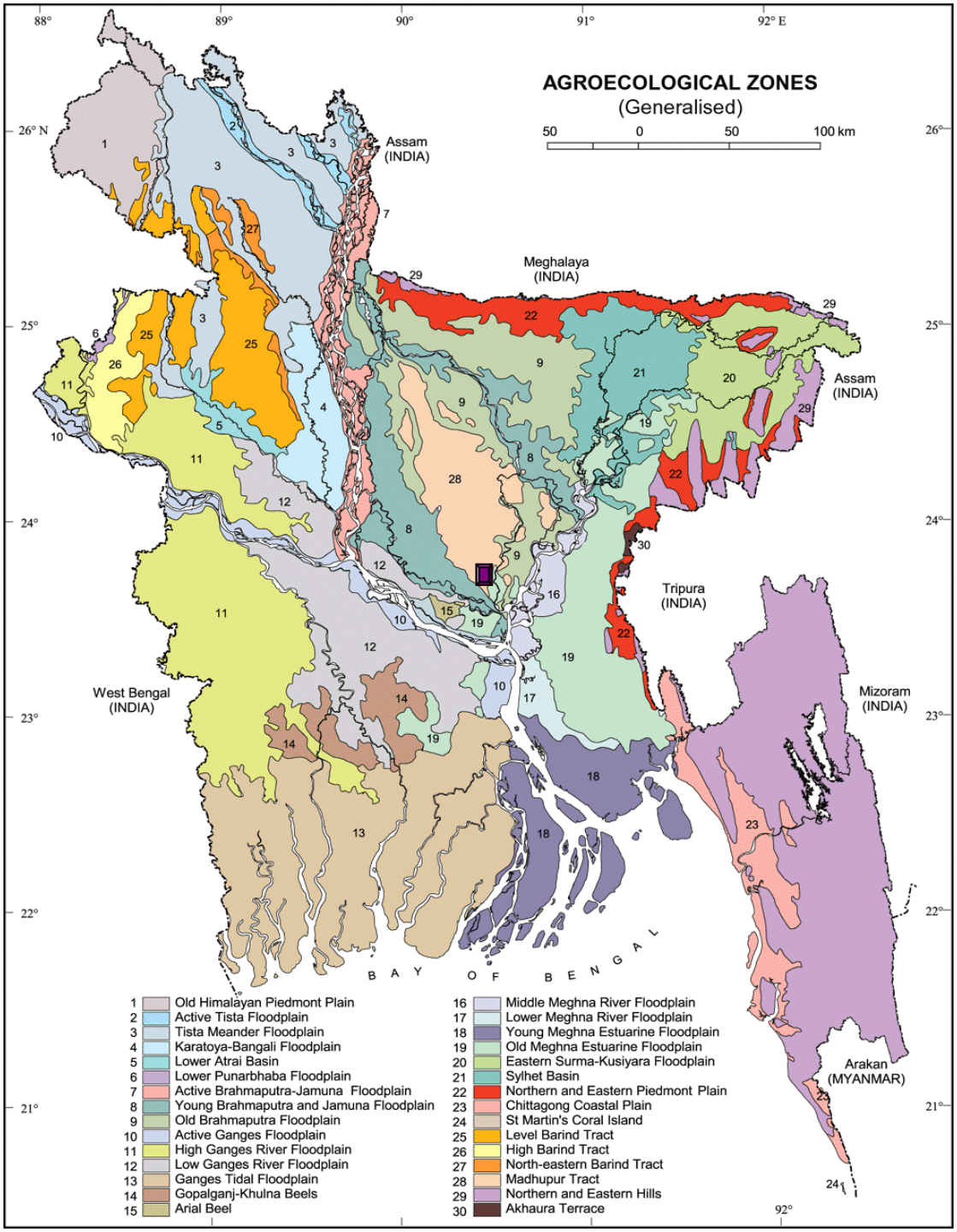
APPENDICES

Appendix I: Map showing the experimental sites under study



The experimental site under study

Appendix II: Characteristics of soil of experimental is analyzed by Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

A. Morphological characteristics of the experimental field

Morphological features	**Characteristics**
Location	Agronomy Field laboratory, SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	Medium hHigh 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. Analysis of variance of the data of leaf area index in traditional aromatic rice cultivars

Source of variation	Degrees of freedom	Mean square of Leaf area index					
		15	30	45	60	75	90
Replication	3	0.019	0.124	1.366	0.728	1.018	1.362
Factor B	8	10.663**	12.884*	18.689*	16.389*	14.597*	22.514*
Error	24	3.157	3.143	2.187	1.122	0.607	1.211

*significant at 5% level of probability

Appendix IV. Analysis of variance of the data of leaf area ratio in traditional aromatic rice cultivars

Source of variation	Degrees of freedom	Mean square of number of Leaf area ratio					
		15	30	45	60	75	90
Replication	3	0.513	0.094	0.495	2.926	3.811	3.988
Factor A	8	1.280**	3.033*	2.151*	4.613*	5.114*	7.898*
Error	24	0.117	0.241	2.267	3.372	1.167	2.781

*significant at 5% level of probability

Appendix V. Analysis of variance of the data of SPAD reading in traditional aromatic rice cultivars

Source of variation	Degrees of freedom	Mean square of SPAD reading					
		15	30	45	60	75	90
Replication	2	2.099	0.122	1.087	0.342	0.893	2.837
Factor A	1	18.777*	26.283*	32.624*	28.347*	26.386*	45.839**
Error	30	0.116	1.126	2.544	2.835	3.314	2.788

*significant at 5% level of probability

Appendix VI. Analysis of variance of the data of crop growth rate ratio in traditional aromatic rice cultivars

Source of variation	Degrees of freedom	Mean square of number of crop growth rate					
		15	30	45	60	75	90
Replication	3	0.120	0.591	1.051	1.022	0.464	1.402
Factor A	8	7.770*	9.40**	8.300*	10.684*	3.808**	9.098**
Error	24	2.266	10.012	13.107	2.871	4.372	4.139

*significant at 5% level of probability

Appendix VII: Analysis of variance of the data on plant height and Number of leaves per hill, Number of tillers hill^{-1}, Panicle length, Grains panicle^{-1}, of rice as influenced by cultivation system and different variety

Sources of Variation	Degrees of freedom	Mean Square				
		Plant height (cm)	Number of leaves hill^{-1}	Number of tillers hill^{-1}	Panicle length (cm)	Grain panicle^{-1}
Replication	3	1455.82	85.41	8.44	12.59	5833.67
Factor A	8	1922.08*	121.37*	3.77*	39.02*	4513.89*
Error	24	542.51	73.57	7.05	7.81	1.29

*significant at 5% level of probability

Appendix VIII: Analysis of variance of the data on yield and yield contributing character of rice as influenced by different variety

Sources of Variation	Degrees of freedom	Mean Square				
		1000-grains weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
Replication	3	452.76	15.14	14.02	58.28	661.07
Factor A	8	27.64*	1.66*	4.17*	9.88*	63.29*
Error	24	0.49	0.17	0.27	0.37	20.04

*significant at 5% level of probability