ADAPTABILITY ASSESSMENT OF TRADITIONAL AROMATIC RICE CULTIVARS IN *BORO* SEASON BASED ON GROWTH VARIABLES, AROMA QUALITY AND YIELD

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CERTIFICATE

This is to certify that the thesis entitled *"ADAPTABILITY ASSESSMENT OF TRADITIONAL AROMATIC RICE CULTIVARS IN BORO SEASON BASED ON GROWTH VARIABLES, AROMA QUALITY AND YIELD"* 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 *MASTERS OF SCIENCE (M.S.)* in Agricultural Botany, embodies the result of a piece of bonafide research work carried out by ***Satu Biswas***, Registration *No.**13-05325*** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

June, 2020

Dhaka, Bangladesh

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Dedicated to
My
Beloved Parents

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ADAPTABILITY ASSESSMENT OF TRADITIONAL AROMATIC RICE CULTIVARS IN *BORO* SEASON BASED ON GROWTH VARIABLES, AROMA QUALITY AND YIELD

Satu Biswas

ABSTRACT

The experiment was conducted at the experiment field of Sher-e-Bangla Agricultural University (SAU), Dhaka during the period from December 2018 to May 2019 to study the adaptability assessment of traditional aromatic rice cultivars in *Boro* season based on growth variables, aroma quality and yield. The experiment comprised of single factor (variety). Twelve aromatic rice varieties *viz*., Kalizira, BRRI dhan 50, Dulabhog, Shakkhorkhora, Madhumala, Badsabhog, Kataribhog-2, Chiniatap-2, Kataribhog-1, Zirabhog, BRRI dhan 34 and Chiniatap-1 were considered for the present study. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Data on different growth, yield contributing parameters, yield parameters and quality parameters were recorded and analyzed statistically. The highest number of effective tillers hill^{-1} (26.00), length of panicle (31.00 cm), number of total grains panicle^{-1} (221.00), number of filled grains panicle^{-1} (179.30), grain yield (3.52 t ha^{-1}), straw yield (5.28 t ha^{-1}), biological yield (8.80 tha^{-1}) and harvest index (40.00%) were found from BRRI dhan 50 whereas the lowest grain yield (1.68 t ha^{-1}), straw yield (4.28 t ha^{-1}), biological yield (5.96 t ha^{-1}) and harvest index (28.1900%) were recorded from Madhumala. In case of aroma quality, variety Zirabhog showed strong aroma whereas the mild aroma was found from BRRI dhan50. So, considering overall performance, BRRI dhan50 gave best performance, and this variety may be considered as best among the varieties under the present study.

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ABBREVIATIONS AND ACRONYMS

AEZ	=	Agro-Ecological Zone
BBS	=	Bangladesh Bureau of Statistics
BCSRI	=	Bangladesh Council of Scientific Research Institute
cm	=	Centimeter
CV	=	Coefficient of Variation
DAS	=	Days After Sowing
DMRT	=	Duncan's Multiple Range Test
et al.,	=	And others
e.g.	=	exempli gratia (L), for example
etc.	=	Etcetera
FAO	=	Food and Agricultural Organization
g	=	Gram (s)
i.e.	=	id est (L), that is
Kg	=	Kilogram (s)
LSD	=	Least Significant Difference
m^2	=	Meter squares
ml	=	Mililitre
M.S.	=	Master of Science
No.	=	Number
SAU	=	Sher-e-Bangla Agricultural University
var.	=	Variety
^oC	=	Degree Celsius
%	=	Percentage
NaOH	=	Sodium hydroxide
GM	=	Geometric mean
mg	=	Milligram
P	=	Phosphorus
K	=	Potassium
Ca	=	Calcium
L	=	Litre
µg	=	Microgram
USA	=	United States of America
WHO	=	World Health Organization

CHAPTER I

INTRODUCTION

Rice *(Oryza sativa* L.) is the most important food crop in Bangladesh and also it is the staple food of more than half of the world's population. Among the leading rice growing countries of the world, Bangladesh is ranked 3rd in both rice area and production (BRRI, 2019). Rice is the major staple food crop in Bangladesh, covering about 75% of the total cropped area. Ninety percent global rice production occurs in tropical and sub-tropical Asian countries (Ashraf *et al*., 2017). Worldwide, rice provides 27% of dietary energy supply and 20% dietary protein (Sangeetha *et al*., 2013). 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 (Sumon *et al*., 2018). Being the 3th largest rice producer of the world, Bangladesh comprises an area of about 10.27 million hectares for rice production (FAO, 2016). Total rice production in Bangladesh was about 10.59 million tons in the year 1971 when the country's population was only about 70.88 million. However, the country is now producing about 35.5 million m tons to feed her 157 million people (BBS, 2016). Thus, Bangladesh will require about 27.26 million tons of rice for the year 2020.Aromatic rice is known for its characteristic fragrance when cooked. It fetches higher rice in market than non-aromatic ones. In fact aromatic rice is very popular in the national and in the international markets (Yoshihashi, 2005). Cultivation of aromatic rice has been gaining popularity in Bangladesh on the recent years, because of its huge demand both for internal consumption and export (Das and Baqui, 2000). However, the choice of grain quality depends of the consumers' income. The demand for scented fine grain rice has been increased due to economic development of the people of Bangladesh (Ali *et al*., 2016). Most of the well-off people preferred long, slender scented fine grain rice (Mannan *et al*., 2012, Sarkar *et al*., 2014). Despite the generally favorable agro-climatic conditions, area of

aromatic rice cultivation is less than 2% of the national rice acreage of Bangladesh (Singh *et al*., 2004, Ashrafuzzaman *et al*., 2009).

The traditional fine-grained aromatic rice genotypes are comparatively taller than modern ones and more suitable for low-lying areas. But most of the traditional fine-grained rice genotypes are photoperiod-sensitive, well adopted to the local environment and suitable for in growing in the *Boro* season (Hossain, 2008). However, aromatic rice varieties have occupied about 12.5% of the total transplant *Boro* rice cultivation (Roy *et al*., 2018). Most of the high quality rice cultivars are low yielding. Due to low yield, farmers have little interest to growing these aromatic rice cultivars.

Being the 3th largest rice producer of the world, Bangladesh comprises an area of about 11.10 million hectares for rice production (FAO, 2015) of which around 27% is occupied by fine rice varieties (BBS, 2016). Most of the consumers prefer fine rice varieties with good cooking quality that have aroma. Due to special flavor and taste, aromatic rice is highly favored. This quality of rice receives a premium price in the market and has export potential (Arumugachamy *et al*., 2002). Bangladesh produces several fine aromatic rice varieties with excellent eating quality for regular consumption as steamed rice as well as for polao, biriani, jarda, firni type preparations which are served on special occasions. Yield and quality of rice depends on the genetic potential of cultivars, it surrounding environment and management practices. Selection of right type of variety is most important factors for maximizing rice production. Yield of rice changes due to growing environment, such as different locations, seasonal fluctuations, different dates of planting etc. (Sarker *et al*., 2014).

The cultivated area of rice decreased for last decade due to increase of cultivation of more profitable contemporary crops. However, the demand of rice has been increasing day by day due to upliftment of economic condition of the south Asian people. To fulfill the aromatic rice requirement, it is important

to increase the rice yield. Under present circumstance it should be possible to overcome by increasing high yielding rice production. The objective of this experiment is to determine the best performance of growth and yield under irrigated system.

Based on the above proposition, the present research programme has been undertaken to investigate the variations in morpho-physiological characters in aromatic rice cultivars and their relation with grain yield of the same.

OBJECTIVES :

The specific objectives of this study are

1. To observe the growth and yield performance of selected local aromatic rice cultivars in *Boro* season;
2. To evaluate the variation in aroma quality (retention) of different aromatic rice cultivars in *Boro* season;

CHAPTER II

REVIEW OF LITERATURE

Variety plays an important role in the yield formation of crops. So, variety is the most important factor needed to be considered in rice cultivation. Some of the important and informative works and research findings related to the variety done at home and abroad have been reviewed under the following headings:

Khatun (2020) conducted a field experiment with six rice varieties to determine their growth and yield performance. The experiment was laid out in a randomized complete block design (RCBD) with four replications. All the growth and yield contributing attributes varied significantly among the six rice varieties. The results revealed that in all rice varieties maximum growth performance observed at 58-68 Days after transplanting and maximum dry matter production was observed at 68 days after transplanting. Maximum number of filled spikelet observed in Binadhan-17 (164.89/ penical) and that was significantly different from other varieties. Percent of sterile spikelet was highest in BRRI dhan39 (12.9%) and that was statistically similar with Binadhan-16 (11.96%) and BRRI dhan33 (12.36%). Maximum 1000-seed weight was observed in Binadhan-17 (27.25 g). Highest grain yield was obtained from Binadhan-17 (6.13 t/h) that was significantly different from other varieties. Lowest grain yield observed in BRRI dhan39 (4.49 t/h) that was statistically similar to BRRI dhan33 (4.57 t/h) and Binadhan-7 (4.86 t/h).

Salam *et al*. (2019) carried out an experiment in Boro season during November 2018 to April 2019 at two farmer's fields of Batiaghata and Dumuria sub-district under Khulna district of Bangladesh with the objective of testing agronomic status and adaptability of four modern rice varieties in comparison with the popular mega variety BRRI dhan28. The varieties were BRRI dhan67,

BRRI dhan81, BRRI dhan84 and BRRI dhan86. BRRI dhan28 was chosen as a control due to its wide acceptability among the farmers. The soil of the studied area was moderately alkaline and medium to moderately saline. In Batiaghata and Dumuria field, initial soil EC was 3.19 and 3.29 dS/m, respectively and it was 4.7 and 4.8 dS/m, accordingly at maturity stage. It was observed that germination rate, plant height, effective tiller number were significantly higher in BRRI dhan67 than the other varieties but insignificant with BRRI dhan28 ($p \leq 0.05$) for both fields. All the yield components spikelets per panicle, filled grain and 1000-grain weight were also significantly higher in BRRI dhan67 in compared to the other varieties but insignificant with BRRI dhan28 ($p \leq 0.05$) for both fields as well. The highest grain yield was observed in BRRI dhan67 in both plots (7.89 and 7.29 t/ha) and showed significant differences among all other varieties ($p \leq 0.05$). Harvest Index of BRRI dhan67 (51.02±4.2, 57.84±8.6) % indicated that this variety is the best yielder among the varieties. Considering overall performances and facts, BRRI dhan67 showed better agronomic performance and adaptation than the other modern varieties in compare with popular mega BRRI dhan28.

Sumon *et al*. (2018) conducted a study to evaluate the growth, yield and proximate composition of aromatic rice varieties in *Aman* season at the research farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh subplots. From the findings they sated that 'Raniselute' variety produced the highest plant height and sated that 'BRRI dhan34' gave the highest panicle length (27.93 cm), number of filled grains panicle^{-1} (192.5), 1,000-grain weight (17.22 g), grain yield (2.26 t ha^{-1}). 'Raniselute' variety produced the highest straw yield (7.81 t ha^{-1}), biological yield (9.05 t ha^{-1}) and 'BRRI dhan34' gave the maximum grain yield (2.26 t ha^{-1}).

Mahmood (2017) conducted an experiment to evaluate the Performance of *Boro* rice (genotypes) in coastal area of Bangladesh. The experiment consisted of five rice varieties as treatment such as Arize Tej, Tea Sakti, Shathi and

BRRI Dhan 28. The collected data were analyzed statistically and means were adjudged by DMRT at 5% level of probability. Among the five varieties the Arize Tej gave the highest performance. From the above investigated results, it was observed that the Arize Tej was the most efficient for better growth and higher yield of hybrid boro rice genotypes grown in coastal area of Bangladesh.

Rashid *et al*. (2017) conducted an experiment to evaluate the yield performance of seven aromatic rice varieties of Bangladesh *viz*. Jirakatari, Chiniatab, Chinigura, Kataribhog, Kalizara, Badshabhog and BRRI dhan34. The entire yield contributing attributes and quality parameters varied significantly among the aromatic rice varieties. The highest plant height (167.0 cm) was found in the variety Chinigura and the lowest (120.1 cm) in the variety Chiniatab. In the variety Kataribhog number of filled grains panicle^{-1} was found highest (255.6) and the lowest (130.7) was recorded in the variety Badshabhog. Badshabhog produced the highest 1000-grain weight (18.3 g) and the lowest (11.4 g) was recorded from the variety Kataribhog. The highest grain yield (2.54 t ha^{-1}) was obtained from Kataribhog and the lowest grain yield (1.83 t ha^{-1}) was obtained from Kalizara. Among the seven aromatic rice varieties under North-west condition Kataribhog and BRRI dhan34 are suitable in respect of yield.

Chowdhury *et al*. (2016) conducted an experiment was at Bangladesh Agricultural University, Mymensingh with a view to finding out the effect of variety and level of nitrogen on the yield performance of fine aromatic rice. The experiment consisted of three varieties viz. Kalizira, Binadhan-13 and BRRI dhan34, and six levels of nitrogen. The highest grain yield (3.33 t ha^{-1}) was obtained from Binadhan-13 followed by BRRI dhan34 (3.16 t ha^{-1}) and the lowest grain yield was found in Kalizira (2.11 t ha^{-1}).

A study was conducted by Mandira *et al*. (2016) in South Tripura district of Tripura for three consecutive kharif seasons to evaluate the performance of rice variety gomati at farmer's field under rainfed conditions. The gomati variety of

rice was found superior over local varieties. Rice variety gomati increased mean grain yield by 41.62%.

Haque *et al.* (2015) evaluated the two popular indica hybrids (BRRI hybrid dhan2 and Heera2) and one elite inbred (BRRI dhan45) rice varieties. Both hybrid varieties out yielded the inbred. However, the hybrids and inbred varieties exhibited statistically identical yield in late planting. Filled grain (%) declined significantly at delayed planting in the hybrids compared to elite inbred due to increased temperature impaired- inefficient transport of assimilates. Results suggest that greater remobilization of shoot reserves to the grain rendered higher yield of hybrid rice varieties.

Chamely *et al*. (2015) conducted an experiment with three varieties *viz*., BRRI dhan28 (V_1), BRRI dhan29 (V_2) and BRRI dhan45 (V_3); and five rates of nitrogen *viz*., control (N_0), 50 kg (N_1), 100 kg (N_2), 150 kg (N_3) and 200 kg (N_4) N ha^{-1} to study the effect of variety and rate of nitrogen on the performance of Boro rice. The growth analysis results indicate that the tallest plant (80.88 cm) and the highest number of total tillers $hill^{-1}$ (13.80) were observed in BRRI dhan29 at 70 DATs and the highest total dry matter (66.41 g m^{-2}) was observed in BRRI dhan45. The shortest plant (78.15 cm) and the lowest number of tillers $hill^{-1}$ (12.41) were recorded from BRRI dhan45 and the lowest dry matter (61.24 g) was observed in BRRI dhan29. The harvest data reveal that variety had significant effect on total tillers $hill^{-1}$, effective tillers $hill^{-1}$, non-effective tillers $hill^{-1}$, panicle length, grain yield, straw yield and harvest index. The highest grain yield (4.84 t ha^{-1}) was recorded from BRRI dhan29.

Hossain *et al.* (2014a) evaluated the five rice cultivars (one hybrid: WR96, three modern: BR16, BR26, and BRRI Dhan27 and one local: Pari). Most of the yield- contributing characters examined and showed wide variations among the cultivars whereas modern cultivar BR16 produced the highest panicle length, number of grain $panicle^{-1}$ and grain yield ha^{-1}. At the same time as local

cultivar Pari generated the lowest number of tiller plant^{-1}, panicle length, grain number panicle^{-1} and grain yield ha^{-1}. Moreover, hybrid cultivar WR96 produced the highest percentage of spotted grain panicle^{-1}.

Jisan *et al*. (2014) carried out an experiment at Bangladesh Agricultural University, Mymensingh with a view to examine the yield performance of some transplant *Aman* rice varieties as influenced by different levels of nitrogen. The experiment consisted of four varieties viz. BRRI dhan49, BRRI dhan52, BRRI dhan56, BRRI dhan57. Data revealed that among the varieties, BRRI dhan52 produced the tallest plant (117.20 cm), whereas the lowest by BRRI dhan57. Data revealed that variety exerted significant influence on yield contributing characters. Among the varieties, BRRI dhan52 produced the grains panicle^{-1}(121.5) and 1000-grain weight (23.65 g), whereas the lowest values of these parameters was produced by BRRI dhan57.

Roy (2014) conducted a field experiment to evaluate the growth and yield performance of local boro rice varieties. Twelve local boro rice varieties were included in this study namely Nayon moni, Tere bale, Bere ratna, Ashan boro, Kajol lata, Koijore, Kali boro, Bapoy, Latai balam, Choite boro, GS one and Sylhety boro. Growth parameters viz. plant height and number of tillers hill-1 (at different days after transplanting); yield contributing characters such as effective tillers hill-1 , panicle length, number of grains panicle-1 , filled grains panicle-1 , thousand grain weight, grain yield, straw yield, biological yield and harvest index were recorded. The result revealed that the plant height and number of tillers hill-1 at different days after transplanting varied significantly among the varieties. The plant height for all the varieties and number of tillers hill-1 for most of the varieties increased up to harvest. At harvest, the tallest plant (123.80 cm) was recorded in Bapoy and the shortest (81.13 cm) was found in GS one. The maximum number of tillers hill-1 (46.00) was observed in Sylhety boro and the minimum (19.80) in Bere ratna. All of the parameters of yield and yield contributing characters differed significantly at 1% level

except grain yield, biological yield and harvest index. The maximum number of effective tillers hill^{-1} (43.87) was recorded in the variety Sylhety boro and the minimum (17.73) was found in Bere ratna. The highest (110.57) and the lowest (42.13) number of filled grains panicle-1 was observed in the variety Koijore and Sylhety boro, respectively. Thousand grain weight was the highest (26.35g) in Kali boro and the lowest (17.83g) in GS one. Grain yield was not differed significantly among the varieties but numerically the highest grain yield (5.01 t ha-1) was found in the variety Koijore and the lowest in GS one(3.17 t ha-1). Considering all parameters the varieties Koijore (5.01tha-1), Choite boro, Sylhety boro, Ashan boro, Bere ratna performed better for the southwest region of Bangladesh Considering all parameters the varieties Koijore (5.01tha-1), Choite boro, Sylhety boro, Ashan boro, Bere ratna performed better for the southwest region of Bangladesh.

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

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

Sarkar *et al*. (2014) conducted an experiment at Bangladesh Agricultural University, Mymensingh, to study the yield and quality of aromatic fine rice as

affected by variety and nutrient management. The experiment comprised three aromatic fine rice varieties viz. BRRI dhan34, BRRI dhan37 and BRRI dhan38 and eight nutrient managements. Results revealed that the highest grain yield (3.71 t ha^{-1}) was recorded in BRRI dhan34.

Sarker *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 were 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 BRRI dhan 28 produced higher number of grains $panicle^{-1}$ and bolder grains resulted in higher grain yield over the local cultivars. Further, BRRI dhan28 had more total dry mass than those of local varieties. The BRRI dhan28 produced higher grain yield (7.41 t ha^{-1}) than Bashful, Poshurshail and Gosi, respectively. Among the local rice cultivars, Gosi showed the higher yielding ability than Bashful and Poshursail.

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

Islam *et al*. (2013) conducted an experiment to study the yield and quality of aromatic fine rice as affected by variety and nutrient management. The experiment comprised three aromatic fine rice varieties viz. BRRI dhan34, BRRI dhan37 and BRRI dhan38. The tallest plant (142.7 cm), the highest number of effective tillers hill-1 (10.02), number of grains $panicle^{-1}$ (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.

Haque *et al.* (2013) conducted an experiment to evaluate some physiological traits and yield of three rice varieties (BRRI hybrid dhan 2, Heera 2, and Tia) in comparison to BRRI dhan48 in *Aus* season. Compared to BRRI dhan 48, hybrid varieties accumulated greater shoot dry matter at anthesis, higher flag leaf chlorophyll at 2, 9, 16 and 23 days after flowering (DAF), flag leaf photosynthetic rate at 2 DAF and longer panicles. Heera 2 and BRRI hybrid dhan 2 maintained significantly higher chlorophyll a, b ratio over Tia and BRRI dhan 48 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 (36.7%) as compared to inbred BRRI dhan48, irrespective of planting date in *Aus* season.

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

Sritharan and Vijayalakshmi (2012) evaluated the physiological traits and yield potential of six rice cultivars *viz.,* PMK 3, ASD 16, MDU 3, MDU 5, CO 47 and RM 96019. The plant height, total dry matter production and the growth attributes like leaf area index, crop growth rate and R:S ratio were found to be higher in the rice cultivar PMK 3 that showed significant correlation with yield. Yield and yield components like number of productive tillers, fertility

co-efficient, panicle harvest index, grain weight and harvest index were found to be higher in PMK 3.

Panwar *et al.* (2012) studied to evaluate the performance of rice varieties. Growth parameters *viz.* plant height (cm), No. of tillers m , leaf area index and dry matter accumulation (g) was highest in JGL-3844 over rest of varieties. The effective tillers m^{-2} (331.6), panicle length (25.63), grains $panicle^{-1}$ (68.23), sterility percent (12.1%), grain yield (60.9 q ha^{-1}) and straw yield (92.58 q ha^{-1}) yield were also highest in variety JGL-3844.

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

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

Kataribhog which may be attributed to the lower number of panicles and grain panicle^{-1}.

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

Samonte *et al*. (2011) reported that the two elite lines recommended for release are high yielding in Texas. RU0703190 is also very early maturing conventional long grain rice. The high yield potential of these new releases will impact grain production of rice farmers and their income.

Abou-Khalif (2009) conducted an experiment for physiological evaluation of some rice varieties in different sowing dates. Four hybrid rice H_1, H_2, GZ 6522 and GZ 6903 were used. Results indicated that H1 hybrid rice variety surpassed other varieties for number of tillers m^{-2}, chlorophyll content, leaf area index, sink capacity, number of grains panicle^{-1}, panicle length (cm), 1000-grain weight (g), number of panicles m^{-1}, panicle weight (g) and grain yield (ton ha^{1}).

Obaidullah *et al*. (2009) conducted a field experiment to study 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.

Razzaque *et al.* (2009) studied on salt tolerant genotypes PVSB9, PVSB19, PNR381, PNR519, Iratom24 and salt sensitive genotype NS15 along with one standard check salt tolerant rice cultivar Pokkali. The different morphological characters studied include plant height, total number of tillers, Root Dry Weight (RDW), Shoot Dry Weight (SDW) and Total Dry Matter (TDM) content of the selected rice genotypes in view to evaluate their response at different salinity levels. The genotypes Pokkali, PVSB9, PVSB19 showed significantly higher values and the lowest value of all these characters were recorded in NS15.

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

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

Masum *et al.* (2008) reported that that Nizershail produced the taller plant height than BRRI dhan44 at different DAT. Total tillers $hill^{-1}$ was significantly

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

Hossain *et al.* (2008) reported that all the yield contributing characters differed significantly due to cultivar. The tallest plant was observed in Chinigura (162.8 cm) which statistically similar to Kataribhog. Kalizira produced the maximum number of grains $panicle^{-1}$ (135.90). Among the cultivars, BRRI dhan 38 gave the maximum grain yield (4.00 t ha^{-1}). Five varieties were evaluated by Ndaeyo *et al.* (2008). Among the varieties, the variety WAB224-8-HB produced the highest grain yield (4.73 and 4.40 t ha^{-1}) followed by WAB189-B-B-B-8-HB (4.37 and 4.20 t ha^{-1}) for both years.

Hossain *et al*. (2008) conducted the study to observe the yield and quality of ten popular aromatic rice varieties of Bangladesh. The varieties were Kataribhog (Philippines), Kataribhog (Deshi), Badshabhog, Chinigura, Radhunipagal, Kalizera, Zirabhog, Madhumala, Chiniatab and Shakhorkora. All the yield contributing attributes and quality parameters varied significantly among the aromatic rice varieties. The highest grain yield was obtained from Kataribhog (Philippines) which identically followed by Badshabhog. In respect of quality, Zirabhog gave the highest head rice outturn that was statistically similar to Badshabhog and Chiniatab. All the tested varieties had bold type shape. Grain protein content ranged from 6.6-7.0 % in brown rice. The cooking time of tested varieties varied from 12 to 16 minutes. Aroma intensity differed due to variety. Kalizera, Badshabhog, Chiniatab contained high level of aroma while, rests of the varieties had moderate type aroma.

Kamal (2007) conducted an experiment at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during January-May 2006 to determine the effect of variety and planting method on the yield of boro rice. Four varieties viz., Binajdhan5, Binadhan6, BRRI dhan28 and BRRI dhan29, and three planting methods viz., transplanting method, drum seeding and line sowing were included as experimental treatments. The experiment was laid out in a randomized complete block design with three replications Binadhan5 produced the highest grain yield (4.61 t ha^{-1}) which was the consequence of highest number of effective tillers $hill^{-1}$ and highest number of grains $panicle^{-1}$. Among the planning methods, transplanting method produced the maximum grain yield (4.59 t ha^{-1}) because of highest number of grains $panicle^{-1}$. In case of effect of interaction of Binadhan5 and transplanting method produced the highest grain (5.20 t ha^{-1}) yield. It may be concluded that the variety Binadhan5 may be grown following transplanting method for higher grain yield in boro season.

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

Khan *et al*. (2006) reported that the variety Rachna showed the highest yield of 4009.590 kg ha^{-1} followed by Basmati-385, Shaheen and Super with the production of 3678.983, 2939.257 and 2175.303 kg ha^{-1}, respectively. However, the plant height (cm) of Rachna was at 2nd position (125.400 cm) after Basmati-385 at 129.767 cm. The maximum tiller $plant^{-1}$ (18) was obtained by variety Rachna, which significantly differ from variety Super that produced 10 tillers $plant^{-1}$. The maximum spike $plant^{-1}$ 18 were shown by

variety Rachna and the number of tiller plant^{-1} produced by Rice variety Basmati-385 i.e., 17. The highest yield of Rachna variety was due to the best performance in terms of tillers plant^{-1}, spike plant^{-1} and weight of 1000 grains.

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

Wang *et al.* (2006) studied the effects of plant density 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%.

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

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.

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 dhan1) 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) among them.Pant dhan 12) and reported that KHR 2 gave the best yield (7.0 t/ha) among them.

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}).

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 (15x10, 2U x10, 15x15 and 20cm x15 cm) 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.

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

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted at the experimental field of Sher-e-Bangla Agricultural University, Dhaka during the period December 2018 to May 2019 with a view to adaptability assessment of traditional aromatic rice cultivars in *Boro* season based on growth variables, aroma quality and yield. Details of different materials used and methodologies followed to conduct the studies are presented in this chapter.

3.1 Site description

The experiment was conducted at the Sher-e-Bangla Agricultural University research field, Dhaka, under the Agro-ecological zone of Modhupur Tract, AEZ-28. The land area is situated at 23°41' N latitude and 90°22' E longitude at an altitude of 8.6 meter above sea level. The experimental site is shown in the AEZ Map of Bangladesh in Appendix I.

3.2 Climate

The experimental area is 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 of the experimental site is shown in Appendix II.

3.3 Soil

The farm 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 20 medium distinct dark yellowish brown mottles. The experimental area was flat having available irrigation and drainage system. 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 by Soil Resources and Development Institute (SRDI), Dhaka. The physicochemical properties of the soil are presented in Appendix III.

3.4 Treatments

Single factor experiment was conducted and 12 traditional aromatic rice varieties were considered as the treatment for the present study which is as follows:

1. V_1 = Kalizira
2. V_2 = BRRI dhan50
3. V_3 = Dulabhog
4. V_4 = Shakkhorkhora
5. V_5 = Madhumala
6. V_6 = Badsabhog
7. V_7 = Kataribhog-2
8. V_8 = Chiniatap-2
9. V_9 = Kataribhog-1
10. V_{10} = Zirabhog
11. V_{11} = BRRI dhan34
12. V_{12} = Chiniatap-1

3.5 Plant materials and collection of seeds

Twelve traditional aromatic rice varieties were used as plant materials for the present study. The seeds of traditional varieties were collected from BRRI, Joydebpur, Gazipur, Bangladesh and personal collection.

3.6 Seed sprouting

Healthy seeds were kept in water bucket for 24 hours and then it was kept tightly in gunny bags. The seeds started sprouting after 48 hours and were sown after 72 hours.

3.7 Preparation of nursery bed and seed sowing

As per BRRI recommendation, seedbed was prepared with 1m wide adding nutrients as per the requirements of soil. Seeds were sown in the seed bed on December, 2018 in order to transplant the seedlings in the main field.

3.8 Preparation of experimental land

The plot selected for the experiment was opened in the first week of December 2018 with a power tiller, and was exposed to the sun for a week, after which the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain a good tilth. Weeds and stubble were removed, and finally obtained a desirable field for transplanting of the seedlings.

3.9 Fertilizer application

The following doses of fertilizer were applied for cultivation of crop as recommended by BRRI, 2016.

Fertilizer	Recommended doses (kg ha^{-1})
Urea	150
TSP	100
MP	100
Zinc sulphate	10
Gypsum	60

The fertilizers N, P, K, S and Zn in the form of urea, TSP, MP, gypsum and zinc sulphate, respectively were applied. The entire amount of TSP, MP, gypsum and zinc sulphate were applied during the final preparation of land. Mixture of cowdung and compost was applied at the rate of 10 ton ha^{-1} during 15 days before transplanting. Urea was applied in three equal installments at seedling establishment, tillering and before panicle initiation.

3.10 Experimental design and layout

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications (block). Each block was first divided into 12 sub plots

where varieties of rice were assigned. Thus the total number of unit plots was 12×3=36. The size of the unit plot was 3m × 2m. The distance maintained between the block was 0.75m and between rows was 0.50m. The treatments (varieties) were randomly assigned to the plots within each block.

3.11 Uprooting of seedlings

The nursery bed was made wet by application of water one day before uprooting the seedlings. The seedlings were uprooted on 20 December, 2018 without causing much mechanical injury to the roots.

3.12 Transplanting of seedlings in the field

The seedlings were transplanted in the main field on December 21, 2018 with a spacing 15 cm from hill to hill and 20 cm from row to row.

3.13 Intercultural operations

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

3.13.1 Irrigation and drainage

Flood irrigation was given to maintain a constant level of standing water upto 3 cm at the early stages to enhance tillering and 4-5 cm in the later stage to discourage late tillering. The field was finally dried out at 15 days before harvesting.

3.13.2 Gap filling

Gap filling was done for all of the plots at 10 days after transplanting (DAT) by planting same aged seedlings.

3.13.3 Weeding

The crop was infested with some common weeds, which were controlled by uprooting and remove them three times from the field during the period of experiment. Weeding was done after 16, 34 and 54 days of transplanting.

3.13.4 Plant protection

There were some incidence of insects specially stem borer which was controlled by Furadan 5G @ 10 kg ha^{-1} at 30 days after transplanting. Brown spot of rice was controlled by spraying tilth.

3.14 Harvesting, threshing and cleaning

The rice plant was harvested depending upon the maturity of the plant and harvesting was done manually from each plot. The harvested crop of each plot was bundled separately, properly tagged and brought to threshing floor. Enough care was taken for harvesting, threshing and also cleaning of rice seed. Fresh weight of grain and straw were recorded plot wise. The grains were cleaned and finally the weight was adjusted to a moisture content of 12%. The straw was sun dried and the yields of grain and straw plot-1 were recorded and converted to ton ha^{-1}.

3.15 General observation of the experimental field

The field was observed time to time to detect visual difference among the treatments and any kind of infestation by weeds, insects and diseases so that considerable losses by pest was minimized.

3.16 Recording of data

The following data were recorded during the study period:

3.16.1 Growth parameters

1. Plant height
2. Number of leaves $hill^{-1}$
3. Number of tillers $hill^{-1}$

3.16.2 Yield contributing parameters

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

4. Panicle length
5. Number of total grains panicle^{-1}
6. Number of filled grains panicle^{-1}
7. Number of unfilled grains panicle^{-1}

3.16.3 Yield parameters

1. 1000 grain weight
2. Grain yield
3. Straw yield
4. Biological yield Harvest index (%)

3.16.4 Quality parameters

1. Aroma

3.17 Procedures of recording data

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

3.17.1 Plant height

The height of plant was recorded in centimeter (cm) at the time of 30, 60, 90 DAT and at harvest. Data were recorded as the average of same 4 plants pre-selected at random from the inner rows of each plot. The height was measured from the ground level to the tip of the tallest leaf of the plant.

3.17.2 Number of leaves hill^{-1}

Number of leaves plant-1 was counted from the average of same 4 plants pre-selected at random from the inner rows of each plot.

3.17.3 Number of total tillers hill^{-1}

Total tillers which had at least one leaf visible were counted. It includes both productive and unproductive tillers. It was counted from the average of same 12 plants pre-selected at random from the inner rows of each plot.

3.17.4 Flag leaf length

Flag leaf length was measured with a meter scale from 12 pre-selected plants from the inner rows of each plot.

3.17.5 Flag leaf breadth

Flag leaf breadth was measured with a meter scale from 12 pre-selected plants from the inner rows of each plot.

3.17.6 Number of effective tillers hill^{-1}

The total number of effective tillers hill^{-1} was counted from 12 selected hills at harvest and average value was recorded.

3.17.7 Number of non-effective tillers hill^{-1}

The total number of effective tillers hill^{-1} was counted from 12 selected hills at harvest and average value was recorded.

3.17.8 Panicle length

The length of the panicle was measured with a meter scale from 10 selected panicles and the average value was recorded.

3.17.9 Number of total grains panicle^{-1}

The total number of filled and unfilled grains were counted together randomly from selected 4 plants of a plot and then average number of total grains panicle^{1} was recorded.

3.17.10 Number of filled grains panicle^{-1}

The total number of filled grains was collected randomly from selected 12 plants of a plot and then average number of filled grains panicle-1 was recorded.

3.17.11 Number of unfilled grains panicle^{-1}

The total number of unfilled grains was collected randomly from selected 12 plants of a plot and then average number of unfilled grains panicle^{-1} was recorded.

3.17.12 Weight of 1000 grain

One thousand cleaned dried grains were counted randomly from each plot and weighed by using a digital electric balance when the grains retained 12%

moisture and the mean weight was expressed in gram.

3.17.13 Grain yield

Grain from each plot area was thoroughly sun dried till constant weight was attained. Then yield per hectare was determined based on net plot area.

3.17.14 Straw yield

After separation of grains from plants of each plot the straw was sun dried till a constant weight is obtained and expressed as t ha^{-1}.

3.17.15 Biological yield

Biological yield was determined using the following formula

Biological yield = Grain yield + Straw yield

3.17.16 Harvest index (%)

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

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

3.17.17 Aroma quality

Forty grains of each cultivar were soaked in 10ml 1.7% KOH solution at room temperature in a covered glass petri-plate for about 1 hour. The sample was scored on 1-4 scale with 1, 2, 3 and 4 corresponding to absence of aroma, slight to moderate aroma, and strong aroma, respectively. The five panels of students and staffs were invited to score the aroma in each cultivar.

Aroma of rice was detected by olfactory test following the method developed by Nagaraju *et al*. (1991). In this method, a panel of five judges estimated the intensity of aroma of the chemical treated rice samples by olfaction and gave a score individually for each sample according to the following Table.

Degree of Aroma	Score	Type of quality
-	1	-
+	2	Good
++	3	Better
+++	4	Best

Their scores were averaged to obtain the numerical value of aroma for each treatment.

3.18 Statistical analysis

The data were analyzed in Randomized Complete Block Design for ANOVA and the means were separated by LSD at 5% level of significance using the statistical computer package program MSTAT-C (Russell, 1986).

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to study the adaptability assessment of traditional aromatic rice cultivars in *Boro* season based on growth variables, aroma quality and yield. The results obtained from the study have been presented and discussed in this chapter through different tables, figures and appendices. The results have been presented and discussed and possible interpretation has been given under the following headings.

4.1 Growth parameters

4.1.1 Plant height

Plant height of different aromatic rice varieties at different days after transplanting showed statistically significant variation (Fig. 1 and Appendix 5). It was observed that the highest plant height (54.67, 63.22, 81.84 and 113.50 cm at 30, 60, 90 DAT and at harvest, respectively) was found from the variety Shakkhorkhora. At 30 DAT, Shakkhorkhora was significantly different from other varieties but at 90 DAT it was statistically similar with Kalizira and Chiniatap-1 while at the time of harvest it was significantly different from other varieties followed by Madhumala. The lowest plant height (39.67, 46.65, 60.08 and 75.54 cm at 30, 60, 90 DAT and at harvest, respectively) was found from the variety BRRI dhan 50 which was significantly different from all other varieties at all growth stages. Similar result was also observed by Rashid *et al*. (2017) and Sarker *et al.* (2013) who found that variety had significant influence on plant height of rice.

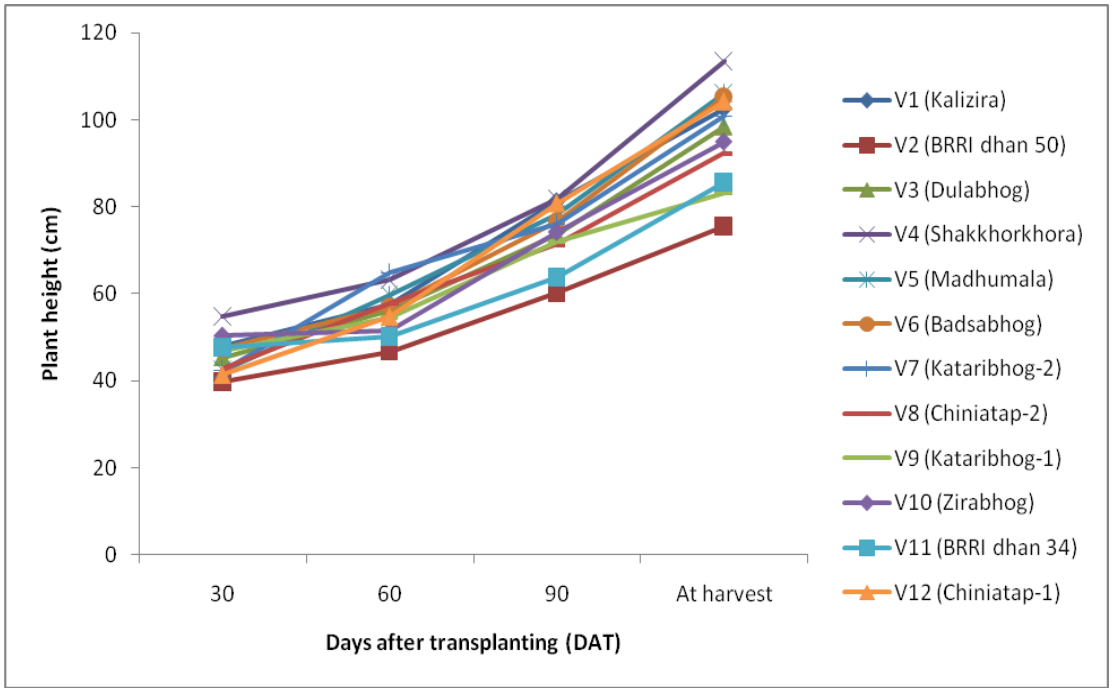

Fig.1. Plant height of aromatic rice at different days after transplanting as influenced by different cultivars

4.1.2 Number of leaves hill^{-1}

Significant variation was recorded on number of leaves hill^{-1} of rice varieties at different growth stages (Table 1 and Appendix 6). It was evident that the highest number of leaves hill^{-1} (25.00, 43.67, 68.67 and 64.00 at 30, 60, 90 DAT and at harvest, respectively) was found from the variety BRRI dhan 50. At 30 DAT, BRRI dhan50 was statistically same with the variety Chiniatap-2 while it was significantly different from other varieties at 60, 90 DAT and at harvest regarding number of leaves hill^{-1}. The lowest number of leaves hill^{-1} (15.67, 34.33, 46.33 and 64.00 at 30, 60, 90 DAT and at harvest, respectively) was found from the variety Kalizira which was statistically identical with Zirabhog at the time of harvest. At 30 DAT, it was significantly same with BRRI dhan34 whereas at 90 DAT, it was significantly same with Chiniatap-1. The result obtained from the present study was similar with the findings of Sarker *et al.* (2013).

Table 1. Number of leaves hill^{-1} of aromatic rice at different days after transplanting as influenced by different cultivars

Treatments	Number of leaves hill^{-1}			
	30 DAT	60 DAT	90 DAT	At harvest
Kalizira	15.67 f	34.33 g	46.33 g	64.00 i
BRRI dhan 50	25.00 a	43.67 a	68.67 a	100.3 a
Dulabhog	20.67 cd	40.00 d	57.67 d	97.33 b
Shakkhorkhora	18.33 e	37.67 e	57.67 d	81.33 g
Madhumala	22.67 b	41.33 c	57.67 d	86.67 d
Badsabhog	19.33 de	39.00 d	51.33 e	70.33 h
Kataribhog-2	20.67 cd	36.00 f	48.67 f	91.00 c
Chiniatap-2	25.67 a	38.00 e	56.67 d	84.33 ef
(Kataribhog-1	16.33 f	41.00 c	63.00 b	85.67 de
Zirabhog	21.33 bc	42.33 b	61.00 c	63.67 i
BRRI dhan 34	16.67 f	36.00 f	61.67 c	83.33 f
Chiniatap-1	21.00 c	39.67 d	47.33 g	80.33 g
$LSD_{0.05}$	1.45	0.98	1.32	1.89
CV(%)	5.45	8.57	7.63	8.39

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

4.1.3 Number of tillers hill^{-1}

Recorded data on number of tillers hill^{-1} of rice varieties at different growth stages showed significant variation (Table 2 and Appendix 7). Results revealed that the highest number of tillers hill^{-1} (10.17, 14.67, 25.00 and 28.33 at 30, 60, 90 DAT and at harvest, respectively) was found from the variety BRRI dhan 50. At 30 DAT, the highest number of tillers hill^{-1} achieved from BRRI dhan 50 showed significant difference from all other varieties and similarly it also showed significant difference from other varieties at all growth stages (at 60, 90 DAT and at harvest). The lowest number of tillers hill^{-1} (10.17, 14.67, 25.00 and 28.33 at 30, 60, 90 DAT and at harvest, respectively) was found from the variety Madhumala which was statistically similar with Shakkhorkhora, Kataribhog-2 and Kataribhog-1 at 90 DAT but at the time of harvest it

showed significantly same result with Kataribhog-2. Supported result was also observed by the findings of Rashid *et al*. (2017) and Haque *et al.* (2013).

Table 2. Number of tillers hill^{-1} of rice at different days after transplanting as influenced by different cultivars

Treatments	Number of tillers hill^{-1}			
	30 DAT	60 DAT	90 DAT	At harvest
Kalizira	6.33 e	9.000 e	20.67 c	24.67 c
BRRI dhan 50	10.17 a	14.67 a	25.00 a	28.33 a
Dulabhog	6.50 e	12.00 b	15.33 f	18.00 f
Shakkhorkhora	8.50 b	10.67 cd	14.67 fg	17.33 f
Madhumala	5.50 f	8.670 e	14.00 g	15.33 g
Badsabhog	6.50 e	10.33 cd	18.67 d	23.67 c
Kataribhog-2	7.93 c	12.33 b	14.33 fg	15.67 g
Chiniatap-2	7.17 d	12.33 b	17.00 e	19.67 e
Kataribhog-1	7.17 d	10.00 d	14.67 fg	17.00 f
Zirabhog	7.33 d	9.00 e	19.33 d	21.67 d
BRRI dhan 34	7.83 c	10.67 cd	22.67 b	26.00 b
Chiniatap-1	7.17 d	11.33 bc	19.00 d	21.33 d
$LSD_{0.05}$	0.38	0.96	0.98	1.36
CV(%)	4.25	6.73	8.44	6.91

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

4.1.4 Length of flag leaf

Length of flag leaf of different aromatic rice varieties showed statistically significant variation (Table 3 and Appendix 8). It was observed that the highest length of flag leaf (40.95 cm) was found from the variety V_8 (Chiniatap-2) which was significantly different from other varieties followed by Badsabhog, Kataribhog-2, BRRI dhan34 and Chiniatap-1. The lowest length of flag leaf (24.30 cm) was found from the variety BRRI dhan50 which was statistically similar with Madhumala and Kataribhog-1. Similar result was also observed by Haque *et al.* (2013).

4.1.5 Breadth of flag leaf

Non-significant variation was recorded on breadth of flag leaf of rice affected by varietal difference (Table 3 and Appendix 8). However, the highest breadth of flag leaf (1.40 cm) was found from the variety Madhumala whereas the lowest breadth of flag leaf (1.03 cm) was found from the variety Chiniatap-2. Similar result was also observed by Haque *et al.* (2013).

Table 3. Length and breadth of flag leaf of rice as influenced by different cultivars

Treatments	Length of flag leaf	Breadth of flag leaf
Kalizira	26.24 de	1.11
BRRI dhan 50	24.30 g	1.20
Dulabhog	25.45 ef	1.20
Shakkhorkhora	26.61 d	1.20
Madhumala	24.82 fg	1.40
Badsabhog	32.38 b	1.20
Kataribhog-2	32.20 b	1.15
Chiniatap-2	40.95 a	1.03
Kataribhog-1	25.19 fg	1.07
Zirabhog	30.38 c	1.15
BRRI dhan 34	32.78 b	1.16
Chiniatap-1	32.34 b	1.09
$LSD_{0.05}$	0.9594	NS
CV(%)	7.24	4.38

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

4.2 Yield contributing parameters

4.2.1 Number of non-effective tillers hill^{-1}

Recorded data on number of non-effective tillers hill^{-1} of rice showed significant difference due to varietal difference (Table 4 and Appendix 9). Results revealed that the highest number of non-effective tillers hill^{-1} (5.34) was found from the variety Madhumala which was statistically identical with Kataribhog-2 whereas the lowest number of non-effective tillers hill^{-1} (1.34)

was found from the variety Kalizira which was significantly different from other varieties. Similar result was also observed by the findings of Chamely *et al*. (2015) and Sarker *et al.* (2013).

4.2.2 Number of effective tillers hill^{-1}

Number of effective tillers hill^{-1} of different aromatic rice varieties showed statistically significant variation (Table 4 and Appendix 9). It was observed that the highest number of effective tillers hill^{-1} (26) was found from the variety BRRI dhan50 which was significantly different from other varieties followed by Kalizira and BRRI dhan34. The lowest number of effective tillers hill^{-1} (10) was found from the variety Madhumala which was statistically identical with Kataribhog-2. Similiar result was also observed by the findings of Chamely *et al*. (2015), Sarker *et al.* (2013) and Abou-Khalif (2009).

Table 4. Effective and non-effective tillers hill^{-1} of aromatic rice as influenced by different cultivars

Treatment	**Yield contributing parameters**	
	Number of non-effective tillers hill^{-1}	Number of effective tillers hill^{-1}
Kalizira	1.34 f	23.33 b
BRRI dhan 50	2.33 e	26.00 a
Dulabhog	2.33 de	15.67 e
Shakkhorkhora	3.66 c	13.67 f
Madhumala	5.34 a	10.00 g
Badsabhog	3.67 c	20.00 c
Kataribhog-2	5.33 a	10.33 g
Chiniatap-2	3.34 c	16.33 de
Kataribhog-1	3.67 c	13.33 f
Zirabhog	2.34 e	19.33 c
BRRI dhan 34	2.67 d	23.33 b
Chiniatap-1	4.33 b	17.00 d
$LSD_{0.05}$	0.32	0.9638
CV(%)	5.21	7.79

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

4.2.3 Length of panicle

Significant variation was recorded on length of panicle of of the tested aromatic varieties (Fig. 2 and Appendix 10). The maximum length of panicle (31.00 cm) was found from the variety BRRI dhan 50 which was statistically similar with BRRI dhan 34 whereas the lowest length of panicle (21.67 cm) was found from the variety Dulabhog which was significantly different from other varieties. Chamely *et al*. (2015) and Islam *et al*. (2013) found similar result which supported the present study.

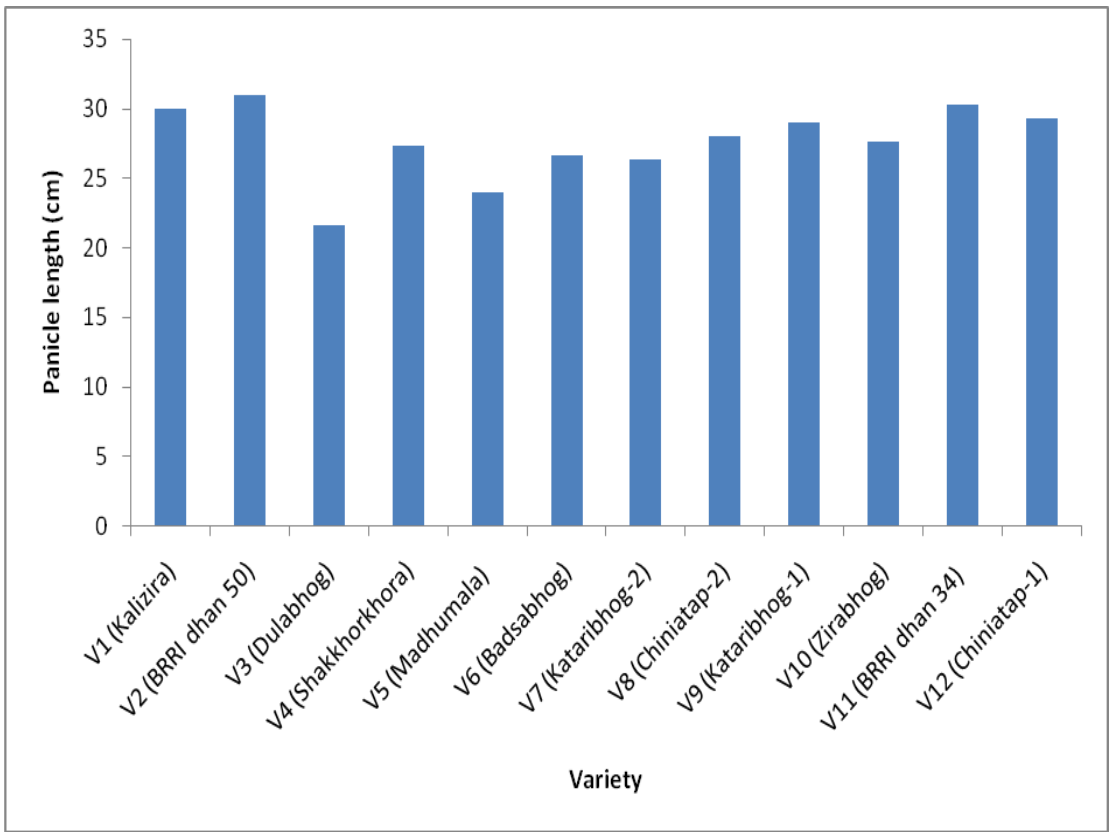

Fig. 2. Panicle length of aromatic rice as influenced by different cultivars

4.2.4 Number of total spikelets panicle^{-1}

Recorded data on number of total spikelets panicle^{-1} of rice showed significant difference due to varietal difference (Table 5 and Appendix 10). Results

revealed that the highest number of total spikelets panicle^{-1} (221) was found from the variety BRRI dhan50 which was significantly different from other varieties followed by Zirabhog. The lowest number of total spikelets panicle^{-1} (148.00) was found from the variety Kalizira which was statistically identical with Kataribhog-2, Kataribhog-1 and Chiniatap-1. The result obtained from the present study was similar with the findings of Rashid *et al*. (2017), Chamely *et al*. (2015) and Sarker *et al.* (2013).

4.2.5 Number of filled grains panicle^{-1}

Number of filled grains panicle^{-1} of different aromatic rice varieties showed statistically significant variation (Table 5 and Appendix 10). It was observed that the highest number of filled grains panicle^{-1} (179.30) was found from the variety BRRI dhan50 which was significantly different from other varieties followed by Dulabhog, Zirabhog and BRRI dhan34 whereas the lowest number of filled grains panicle^{-1} (95.33) was found from the variety Madhumala which was significantly different from other varieties. The result obtained from the present study was similar with the findings of Rashid *et al*. (2017) and Sarker *et al.* (2013).

4.2.6 Number of unfilled grains panicle^{-1}

Significant variation was recorded on number of unfilled grains panicle^{-1} of aromatic rice due to varietal difference (Table 5 and Appendix 10). It was evident that the highest number of unfilled grains panicle^{-1} (41.67) was found from the variety BRRI dhan50 followed by Kataribhog-2 whereas the lowest number of unfilled grains panicle^{-1} (11.33) was found from the variety Kalizira which was statistically identical with Madhumala. Abou-Khalif (2009) also found similar result with the present study.

Table 5. Yield contributing parameters of aromatic rice as influenced by different cultivars

Treatment	Yield contributing parameters		
	Number of total spikelets panicle^{-1}	Number of filled grains panicle^{-1}	Number of unfilled grains panicle^{-1}
Kalizira	148.0 e	136.7 d	11.33 g
BRRI dhan50	221.0 a	179.3 a	41.67 a
Dulabhog	184.3 c	158.3 b	26.00 d
Shakkhorkhora	173.0 d	150.7 c	22.33 e
Madhumala	109.7 f	95.33 g	14.33 g
Badsabhog	171.0 d	145.3 c	25.67 d
Kataribhog-2	149.0 e	115.3 f	33.67 b
Chiniatap-2	169.0 d	148.7 c	20.33 ef
Kataribhog-1	152.0 e	121.7 e	30.33 c
Zirabhog	191.7 b	161.7 b	30.00 c
BRRI dhan34	183.0 c	164.3 b	18.67 f
Chiniatap-1	149.0 e	127.3 e	21.67 ef
$LSD_{0.05}$	6.021	5.869	3.101
CV(%)	10.34	9.87	6.22

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

4.3 Yield parameters and aroma quality

4.3.1 Weight of 1000 grains

Recorded data on 1000 grain weight of aromatic rice varities showed significant difference due to varietal difference (Table 6 and Appendix 11). Results revealed that the highest 1000 grain weight (22.67 g) was found from the variety Madhumala which was significantly different from other varieties followed by BRRI dhan50. The lowest 1000 grain weight (10.52 g) was found from the variety BRRI dhan34 which was statistically similar with Dulabhog, Badsabhog and Zirabhog. Similar result was also observed by the findings of Rashid *et al*. (2017).

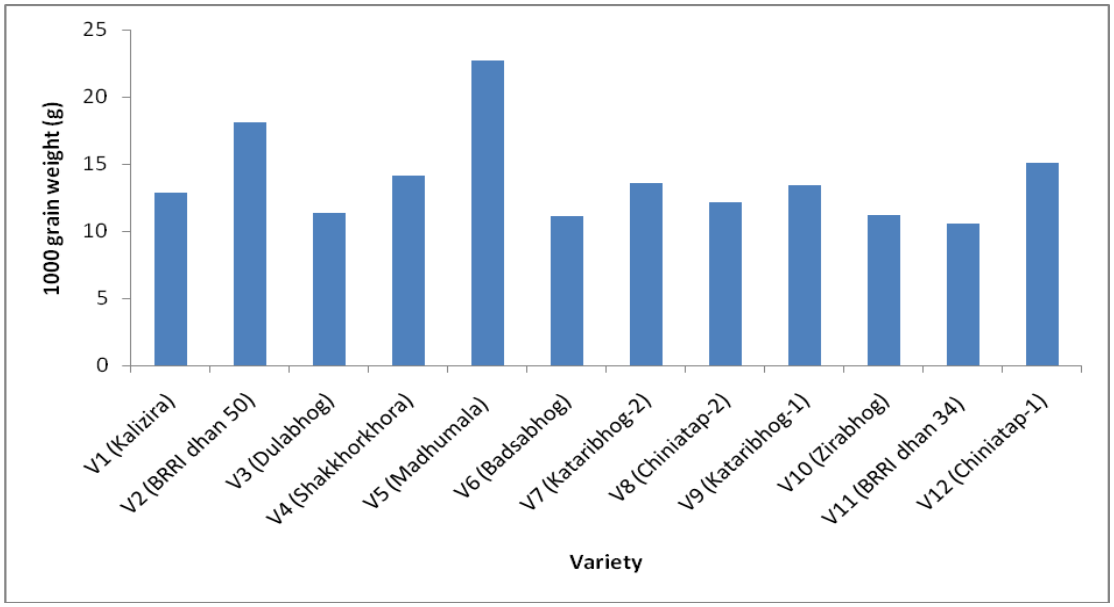

Fig. 3. Thousand seed weight of rice as influenced by different cultivars

4.3.2 Grain yield

Significant variation was recorded on grain yield of aromatic rice varieties due to varietal difference (Table 6 and Appendix 11). It was evident that the highest grain yield (3.52 t ha^{-1}) was found from the variety BRRI dhan50 which was significantly different from other varieties while the second highest grain yield (3.26 t ha^{-1}) was found from BRRI dhan34. The lowest grain yield (1.68 t ha^{-1}) was found from the variety Madhumala which was statistically identical with Kataribhog-2. The result obtained from the present study was similar with the studies of Rashid *et al*. (2017), Chamely *et al*. (2015) Sarker *et al.* (2013) and Islam *et al*. (2013).

4.3.3 Straw yield

Straw yield of different aromatic rice cultivars showed statistically significant variation (Table 6 and Appendix 11). It was observed that the highest straw yield (5.28 t ha^{-1}) was found from the variety BRRI dhan50 which was statistically identical with Kalizira, Badsabhog and BRRI dhan34 whereas the lowest straw yield (4.28 t ha^{-1}) was found from the variety Madhumala Kataribhog-2. Similar result was also observed by Chamely *et al*. (2015).

4.3.4 Biological yield

Significant variation was recorded on biological yield of aromatics rice varieties affected by varietal difference (Table 6 and Appendix 11). It was evident that the highest biological yield (8.80 t ha^{-1}) was found from the variety BRRI dhan50 which was significantly different from other varieties followed by BRRI dhan34. The lowest biological yield (5.96 t ha^{-1}) was found from the variety Madhumala which was statistically identical with Kataribhog-2.

4.3.5 Harvest index

Recorded data on harvest index of rice showed significant difference due to varietal difference (Fig. 4 and Appendix 11). Results revealed that the highest harvest index (40.00%) was found from the variety BRRI dhan 50 which was significantly different from other varieties followed by BRRI dhan 34 whereas the lowest harvest index (28.1900%) was found from the variety Madhumala which was statistically identical with Kataribhog-2 and Kataribhog-1. Chamely *et al*. (2015) and Abou-Khalif (2009) also found similar result which supported the present study.

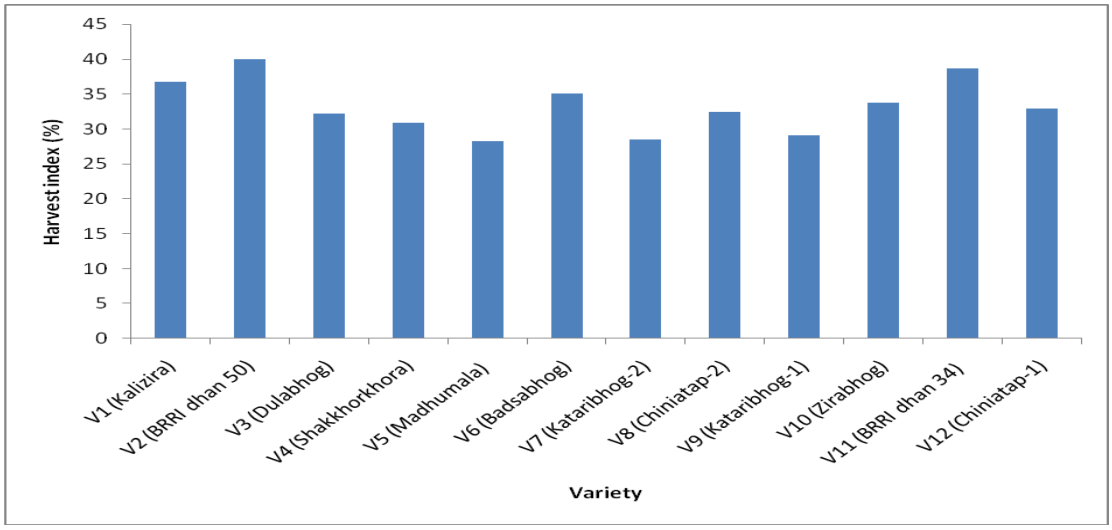

Fig. 4. Harvest index of aromatic rice varieties are tasted in this study.

4.3.6 Aroma quality

Significant variation was recorded on aroma quality of rice influenced by varietal difference (Table 6 and Appendix 11). Results indicated that the variety Zirabhog showed strong aroma quality (numerical) (2.46) which was significantly different from other varieties whereas the mild aroma quality (numerical) (0.92) was found from BRRI dhan 50 which was statistically similiar with Kalizira, Badsabhog and BRRI dhan 34.

Table 6. Yield parameters and aroma quality of rice as influenced by different cultivars

Treatment	Yield parameters and aroma quality			
	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Aroma (Numerical)
Kalizira	3.04 c	5.22 a	8.26 bc	1.00 h
BRRI dhan 50	3.52 a	5.28 a	8.80 a	0.92 h
Dulabhog	2.28 fg	4.80 c	7.08 ef	2.21 c
Shakkhorkhora	2.12 gh	4.75 c	6.87 fg	2.23 c
Madhumala	1.68 i	4.28 d	5.96 h	1.65 e
Badsabhog	2.84 d	5.25 a	8.09 c	1.05 h
Kataribhog-2	1.74 i	4.36 d	6.10 h	1.40 f
Chiniatap-2	2.33 f	4.85 c	7.18 ef	1.93 d
Kataribhog-1	1.94 h	4.72 c	6.66 g	1.33 g
Zirabhog	2.61 e	5.12 ab	7.73 d	2.46 a
BRRI dhan 34	3.26 b	5.17 a	8.43 b	1.03 h
Chiniatap-1	2.40 f	4.88 bc	7.28 e	2.36 b
$LSD_{0.05}$	0.1855	0.245	0.3213	0.08
CV(%)	5.27	6.59	8.33	3.24

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

CHAPTER V

SUMMARY AND CONCLUSION

The field experiment was conducted at the experiment field of Sher-e-Bangla Agricultural University (SAU), Dhaka during the period from December 2018 to May 2019 to study the adaptability assessment of traditional aromatic rice cultivars in boro season based on growth variables, aroma quality and yield. The experiment comprised of single factor (variety). Twelve aromatic rice varieties *viz*., Kalizira, BRRI dhan50, Dulabhog, Shakkhorkhora, Madhumala, Badsabhog, Kataribhog-2, Chiniatap-2, Kataribhog-1, Zirabhog, BRRI dhan34 and Chiniatap-1 were considered for the present study. The experiment was laid out in a Randomized complete Block Design (RCBD) with three replications. Data on different growth, yield contributing parameters, yield parameters and quality parameters were recorded. The collected data were statistically analyzed for evaluation of the treatment effect. Significant variation among the varieties was observed regarding different parameters.

Different growth parameters were significantly influenced by different varieties of aromatic rice. Results showed that the highest plant height (54.67, 63.22, 81.84 and 113.50 cm at 30, 60, 90 DAT and at harvest, respectively) was found from Shakkhorkhora whereas the highest number of leaves hill^{-1} (25.00, 43.67, 68.67 and 64.00 at 30, 60, 90 DAT and at harvest, respectively) and number of tillers hill^{-1} (10.17, 14.67, 25.00 and 28.33 at 30, 60, 90 DAT and at harvest, respectively) were found from BRRI dhan 50 while the highest length of flag leaf (40.95 cm) was found from Chiniatap-2 and the highest breadth of flag leaf (1.40 cm) was found from Madhumala. On the other hand, the lowest plant height (39.67, 46.65, 60.08 and 75.54 cm at 30, 60, 90 DAT and at harvest, respectively) was found from the variety BRRI dhan 50 whereas the lowest number of leaves hill^{-1} (15.67, 34.33, 46.33 and 64.00 at 30, 60, 90 DAT and at harvest, respectively) was found from the variety Kalizira. Again, the lowest number of tillers hill^{-1} (10.17, 14.67, 25.00 and 28.33 at 30, 60, 90 DAT and at

harvest, respectively) was found from Madhumala but the lowest length of flag leaf (24.30 cm) and breadth of flag leaf (1.03 cm) were found from BRRI dhan 50 and Chiniatap-2, respectively.

Different yield contributing parameters were also significantly influenced by different varieties of aromatic rice. Result revealed that the highest number of effective tillers hill^{-1} (26), length of panicle (31.00 cm), number of total grains panicle^{-1} (221) and number of filled grains panicle^{-1} (179.30) were found from BRRI dhan 50 but the highest 1000 grain weight (22.67 g) was found from Madhumala. On the other hand, the lowest number of effective tillers hill^{-1} (10) was found from the variety Madhumala but the lowest length of panicle (21.67 cm) and 1000 grain weight (10.52 g) were found from Dulabhog and BRRI dhan 34, respectively. Again, the lowest number of total grains panicle^{-1} (148) and number of filled grains panicle^{-1} (136.70) were found from the variety Kalizira. Similarly, the lowest number of non-effective tillers hill^{-1} (1.34) and number of unfilled grains panicle^{-1} (11.33) were found from Kalizira whereas the highest number of non-effective tillers hill^{-1} (5.34) and number of unfilled grains panicle^{-1} (41.67) were found from Madhumala and BRRI dhan 50, respectively.

Different varieties of aromatic rice also showed significant influence on different yield parameters and aroma quality. Results showed that the highest grain yield (3.52 t ha^{-1}), straw yield (5.28 t ha^{-1}), biological yield (8.80 t ha^{-1}) and harvest index (40.00%) were found from BRRI dhan50 whereas the lowest grain yield (1.68 t ha^{-1}), straw yield (4.28 t ha^{-1}), biological yield (5.96 t ha^{-1}) and harvest index (28.1900%) were recorded from Madhumala. Similarly, the variety Zirabhog showed highest aroma quality (numerical) (2.46) whereas the lowest aroma quality (numerical) (0.92) was found from BRRI dhan50.

From the above results, it may be concluded that the variety BRRI dhan50 gave best result in terms of growth and yield performance due to higher number of effective tillers hill^{-1}, length of panicle, number of total grains panicle^{-1} and

number of filled grains panicle^{-1}, and this variety showed highest grain yield (3.52 t ha^{-1}). So, considering overall performance, variety BRRI dhan50 may be considered as best among the varieties under the present study.

Recommendation:

- Modern aromatic rice variety, BRRI dhan50 should be cultivated for getting higher grain yield.
- Such type of study is needed in different agro-ecological zones (AEZ) of Bangladesh for testing the regional compliance and other quality attributes.

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REFERENCES

Abou-Khalif, A.A.B. (2009). Evaluation of some hybrid rice varieties in under different sowing times. *Afr. J. Plant Sci.* **3**(4): pp. 53-58

Akram, M., Rehman, A., Ahmad, M. and Cheema, A.A. (2007). Evaluation of rice hybrids for yield and yield components in three different environments. *J. Animal and Plant Sci.* **17**(3-4): 70-75

Alam, M.S. (2012). A research publication on "tech. and productivity in rice sector". Published in the Daily Star on February 9 (Thursday), 2012 (online available at: http://archive.thedailystar.net/newDesign/news-details.php?nid =221607)

Ali, H., Sawar, N., Hasnain, Z., Ahmad, N. and Hussain, A. (2016). Zinc fertilization under optimum soil moisture condition improved the aromatic rice productivity. *Philippine J. Crop Sci*. **41**(2):71-78

Amin, M.R., Hamid, A., Choudhury, R.U., Raquibullah, S.M. and Asaduzzaman M. (2006). Nitrogen fertilizer effect on tillering, dry matter production and yield of traditional varieties of rice. *Int. J. Sustain. Crop Production.* **1**(1): 17-20

Arumugachamy, S., Vairavan, S., Vivekanandan, P. and Palanisamy, S. (2002). Aromatic and quality rice improvement in Tamil Nadu. *Intl. Rice Res. Newsl*. **17**(6): 11-12

Ashraf, U., Kanu, A.S., Deng, Q., Mo, Z., Pan, S., Tian, H. and Tang, X. (2017). Lead (Pb) toxicity; physio-biochemical mechanisms, grain yield, quality and Pb distribution proportions in scented rice. *Frontiers in Plant Sci*., **8**: 1-17

Ashrafuzzaman, M., M.R. Islam, M.R. Ismail, S.M. Shahidullah and M.M. Hanafi. (2009). Evaluation of six aromatic rice varieties for yield and yield contributing characters. *Int. J. Agric. Biol.* **11**: 61672-78-620

BBS (Bangladesh Bureau of Statistics).(2016).Statistical pocket book of Bangladesh. Mins. Planning. Govt. Peoples Repub. Bangladesh. 72-78

Biswas, P. K.and Salokhe, V. M. (2002). Effects of N rate, shading, tiller separation, and plant density on the yield of transplant rice. *Top Agric.* (Trinidad). **79**(3): 279-287

BRRI. (2019). Annual Report for 1919. Bangladesh Rice Res. Inst., Joydebpur, Gazipur, Bangladesh. Pub. No. 207. pp. 11, 278-289

Chamely, S.G., Islam, N., Hoshain, S., Rabbani, M.G., Kader, M.A. and Salam, M.A. (2015). Effect of variety and nitrogen rate on the yield performance of boro rice. *Progressive Agric*. **26** (1): 6-14

Chowdhury, S.A., Paul, S.K. and Sarkar, M.A.R. (2016). Yield performance of fine aromatic rice in response to variety and level of nitrogen. *J. Environ. Sci. & Natural Resources*, **9**(1): 41-45

Das, T. and Baqui, M.A. (2000). Aromatic rice of Bangladesh. In: Aromatic rice, Oxford and IBM publishing Co. Pvt. Ltd., New Delhi.;184-187

Dongarwar, U.R., Patankar, M.N and Pawar, W. S. (2003). Response of hybrid rice to different fertility levels. *J. Soils and Crops.* **13**(1): 120-122.

FAO (Food and Agriculture Organization). (2015). Production year book, Food and Agricultural Organization of the United Nations, Rome, Italy. 57

FAO (Food and Agriculture Organization). (2016). Production year book, Food and Agricultural Organization of the United Nations, Rome, Italy. No. 57

Garba, A.A., Mahmoud, B.A., Adamu, Y. and Ibrahim, U. (2013). Effect of variety, seed rate and row spacing on the growth and yield of rice in Bauchi, Nigeria. *African J. Food, Agric. Nutri. Dev.* **13**(4): 8155

George, S.P., Bastian, D., Radhakrishan, N.V. and Aipe, K.C. (2005). Evaluation of aromatic rice varieties in Wayanad, Kerala. *J. Tropic. Agric.* **43**(1-2): 67-69

Haque, M. M., Pramanik, H. R. and Biswas, J. K. (2013). Physiological behavior and yield performances of hybrid rice at different planting dates in *Aus* Season. *Bangladesh Rice J.* **17**(1&2): 7-14

Hossain, M.B., Islam, M.O. and Hasanuzzaman, M. (2008). Influence of different nitrogen levels on the performance of four aromatic rice cultivars. *Int. J. Agric. Biol.* **10(2)**: 693-696

Hossain, M.F., Islam, M.S., Rahman, M.M., Faruk, M.O. and Ershad, M.G. (2008). Yield and quality performance of some aromatic rice varieties of Bangladesh. *J. Agrofor. Environ*. **2**(2): 155-158

Hossain, M.M., Sultana, F. and Rahman, A.H.M.A. (2014a). A comparative screening of hybrid, modern varieties and local rice cultivar for brown leaf spot disease susceptibility and yield performance. *Archives Phytopath. Plant Protect.,* **47**(7): 795-802

Islam, M.S., Sarkar, M.A.R., Ullah, M.A. and Khanam, S. (2015). Effect of transplanting date on the growth and yield of aromatic rice in irrigated ecosystem. *IOSR J. Agric. Vet. Sci*. **8**(1):59-65

Islam, N., Kabir, M.Y., Adhikary, S. K. and Jahan, M.S. (2013). Yield Performance of Six Local Aromatic Rice Cultivars. *IOSR J. Agric. Vet. Sci. (IOSR-JAVS)*. **6**(3): 58-62

Jeng, T.L., Tseng, T.H., Wang, C.S., Chen, C.L. and Sung, J.M. (2009). Yield and grain uniformity in contrasting rice genotypes suitable for different growth environments. *Field Crops Res.* **99**: 59-66

Kamal, M.M. (2007). Performance of modern boro rice varieties under different planting methods. *J. Bangladesh Agril. Univ*. **5**(1): 43-47, 2007

Khan, T.N., Razzaq, A., Shahbaz, M., Ajmal, S., Ali, G.M. and Joyia, M.F. (2006). Performance of four varieties of fine rice for best yield and yield components under climatic conditions of Bahawalpur (Pakistan). *J. Agric. Social Sci.,* **2**(3): 187-188

Khatun, S. (2020). Growth and yield performance of six aman rice varieties of Bangladesh. *Asian Res. J. Agric*. **12**(2): 1-7

Mahmood, R. (2017). Performance of hybrid *Boro* rice in coastal area of Bangladesh. *Progressive Agric*. **30**(2): 186-193, 2019

Mandira, B., Kumar, S., Chakraborty, D., Kapil, A.C. and Nath, D.J. (2016). Performance of rice variety gomati in front line demonstration under rainfed condition of south Tripura district. *Intl. J. Agric. Sci*., **8**(63): 3555-3556

Mannan, M.A., Bhuiya, M.S.U., Akand, M.M. and Rana, M.M. (2012). Influence of date of planting on the growth and yield of locally popular traditional aromatic rice varieties in *Boro* season. *J. Sci. Foundation*. **10**(1): 20-28

Masum, S.M., Ali, M.H. and Ullah, M.J. (2008). Growth and yield of two aman rice varieties as affected by seedling number hill^{-1} and urea super granules. *J. Agric. Edu. Technol.,* **11** (& 2): 51-58

Myung, K. (2005). Yearly variation of genetic parameters for panicle characters of Japonica rice *(Oryza sativa* L.). *Japanese J. Crop Sci.* **69**(3): 357-358

Obaidullah, M., Biswas, P. K. and Ruhul Amin, A. K. M. (2009). Influence of clonal tiller age on growth and yield of *Aman* rice varieties. *J. Sher-e-Bangla Agric. Univ.* **3**(1): 35-39

Obulamma, U., Reddeppa, R. and Reddy, R. (2002). Effect of spacing and seedling number on growth and yield of hybrid rice. *J. Res. Angrau.* **30**(1): 76-78

Oka, A.O., Ubi, B.E. and Efisue, A.A. (2012). A Comparative Study on Local and Newly Introduced Rice Varieties in Ebonyi State of Nigeria based on Selected Agronomic Characteristics. *Int. J. Agric. Forestry.* **2**(1): 11-17 (doi: 10.5923/j.ijaf.20120201.03.)

Panwar, C.S., Vishwakarma, S.K. and Verma, N. (2012). Comparative performance of different rice varieties in relation to growth and yield. *Bioinfolet.* **9**(4a): 631-632

Patel, J.R. (2000). Effect of water regime, variety and blue green algae on rice (*Oryza sativa). Indian J. Agron*., **45**(1): 103-106

Rahman, M.A., Hossain, S.M.A., Sarkar, N.A.R., Hossain, M.S. and Islam, M.S. (2002). Effect of variety and structural arrangement of rows on the yield and yield components of transplant *Aman* rice. *Bangladesh .J. Agril. Sci.,* **29**(2): 303-307

Rashid, M.M., Ghosh, A.K., Roni, M.N., Islam, M.R and Alam, M.M. (2017). Yield performance of seven aromatic rice varieties of Bangladesh. *Int. J. Agric. Environ. Res.* **3**(2): 2637

Razzaque, M.A., Talukder, N.M., Islam, M.S., Bhadra, A.K. and Dutta, R.K. (2009). The effect of salinity on morphological characteristics of seven rice (Oryza sativa) genotypes differing in salt tolerance. *Pak. J. Biol. Sci*. **12**(5): 406-412

Roy, A., Sarkar, M.A.R. and Paul, S.K. (2018). Effect of age of seedlings at staggered transplanting and nutrient management on yield performance of aromatic fine rice (cv. BRRI dhan38). *SAARC J., Agric.,* **16**(1): 49- 59

Roy, S. K. (2014). Evaluation of growth and yield potentialities of local boro rice varieties in south-west region of Bangladesh. *Life Sci. J.* **11**(10):277-281] (ISSN: 1097-8135)

Salam, T. B., Karmakar, B., Hossain, S. M. T., Robin, M. H., Mariam, M. Z. and Hossain, M. (2019). Agronomic Performance of Modern Rice Varieties in South-west Bangladesh. *Plant Sci. Today*. **6**(4):528-532

Samonte, S.O.P.B., Tabien, R.E. and Wilson, L.T. (2011). Variation in yield related traits within variety in large rice yield trials. *Texas Rice*.**11**(5): 9-11

Sangeetha, S. P., Balakrishnan, A. and Devasenapathy, P. (2013). Influence of Organic Manures on Yield and Quality of Rice (*Oryza sativa* L.) and Blackgram (*Vignamungo* L.) in Rice-Blackgram Cropping Sequence. *American J. Plant Sci.,* **4**: 1151-1157

Sarkar, S. K., Sarkar, M. A. R., Islam, N. and Paul, S. K. (2014). Yield and quality of aromatic fine rice as affected by variety and nutrient management. *J. Bangladesh Agril. Univ*. **12**(2): 279–284

Sarkar, S.K., Sarkar, M.A.R., Islam, N. and Paul, S.K. (2014). Yield and quality of aromatic fine rice as affected by variety and nutrient management. *J. Bangladesh Agril. Univ*. **12**(2): 279-284

Shiyam, J.O., Binang, W.B. and Ittah, M.A. (2014). Evaluation of growth and yield attributes of some lowland chinese hybrid rice *(Oryza sativa* L.) varieties in the Coastal Humid Forest Zone of Nigeria. *J. Agric. Veterinary Sci.,* **7**(2): 70-73

Singh, T.,Sikka, R. and Sidhue, M.M. (2004). Performance of transplanted Basmati rice in cropping systems as affected by N application. *Int. Rice Res. Notes*., **29**(1):63-65

Sokoto, M.B. and Muhammad, A. (2014). Response of rice varieties to water stress in Sokoto, Sudan Savannah, Nigeria. *J. Biosci. Medicines*. **2**: 68-74

Sritharan, N. and Vijayalakshmi, C. (2012). Physiological basis of rice genotypes under aerobic condition. *Plant Archives.* **12**(1): 209-214.

Sumit, C., Pyare, L., Singh, A.P. and Tripathi, M.K. (2004). Agronomic and morpho-physiological analysis of growth and productivity in hybrid rice *(Oryza sativa* L.). *Ann. Biol.* **20** (2): 233-238

Sumon, M.J.I., Roy, T.S., Haque, M.N., Ahmed, S. and Mondal, K. (2018). Growth, yield and proximate composition of aromatic rice as influenced by inorganic and organic fertilizer management, *Not. Sci. Biol.*, **10**(2): 211-219

Wang, L.J., Xu, J.Z. and Yi, Z.X. (2006). Effects of seedling quantity and row spacing on the yields and yield components of hybrid and conventional rice in northern China. *Chinese J. Rice Sci.* **20**(6): 631-637

Yao, F., Huang, I., Cui, K., Nie, L., Xiang, I, Liu, X., Wu, W., Chen, M. and Peng, S. (2011). Agronomic performance of high-yielding rice variety grown under alternate wetting and drying irrigation. *Field Crops Res.* **126**: 16-22

Yoshihashi, T. (2005). Does drought condition induce the aroma quality of aromatic rice? Japan Intl. Res. Center Agril. Sci. (JIRCAS). Food Sci. Divn. News Letter for *Intl. Collaboration. Japan*. **45**: 4

APPENDICES

Appendix I. Agro-Ecological Zone of Bangladesh showing the experimental location

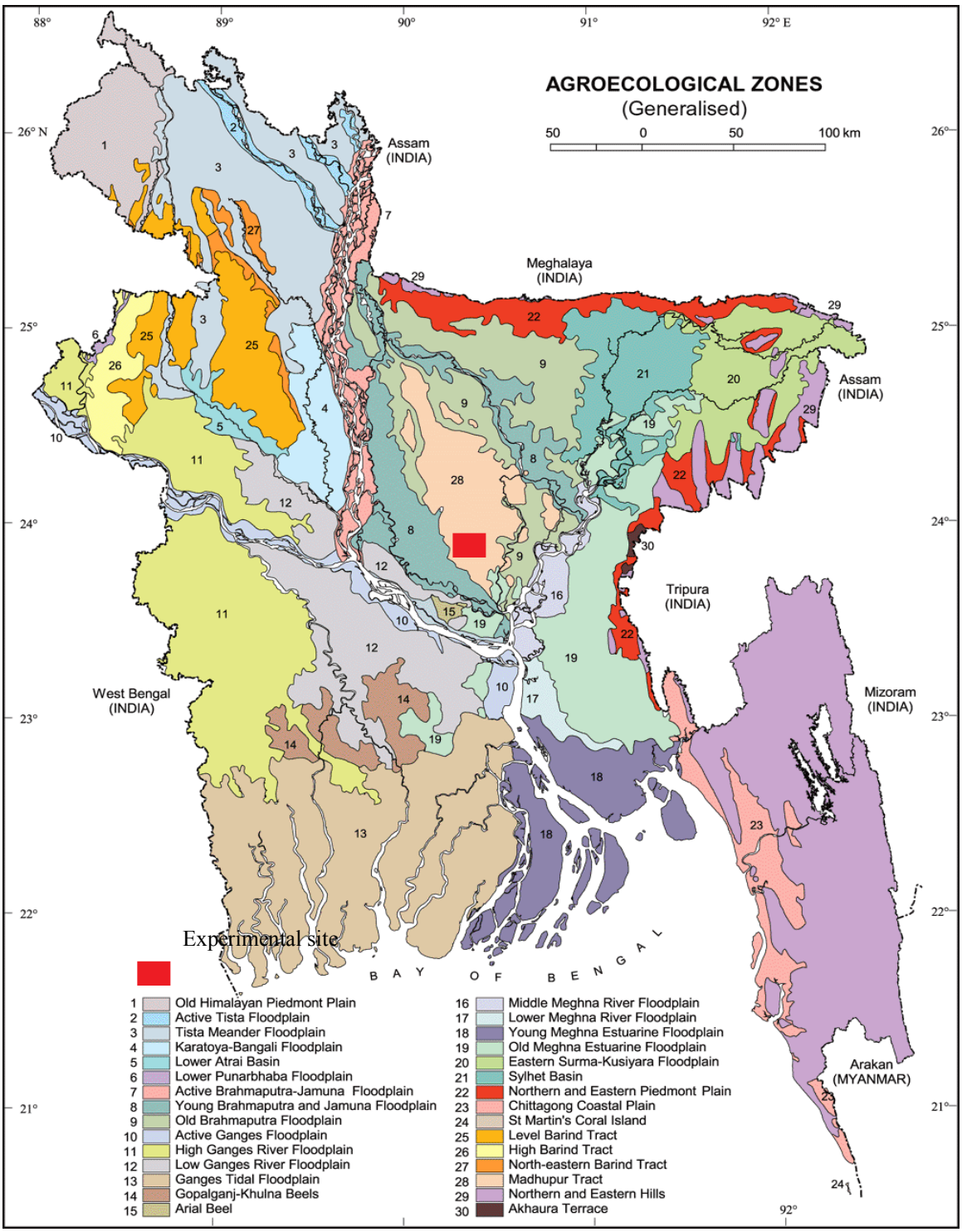

Fig. 5. Experimental site

Appendix II. Monthly records of air temperature, relative humidity and rainfall during the period from December 2018 to May 2019

Year	Month	Air temperature (°C)			Relative humidity (%)	Rainfall (mm)
		Max	*Min*	*Mean*		
2018	December	25.50	6.70	16.10	54.80	0.0
2019	January	23.80	11.70	17.75	46.20	0.0
2019	February	22.75	14.26	18.51	37.90	0.0
2019	March	35.20	21.00	28.10	52.44	20.4
2019	April	34.70	24.60	29.65	65.40	165.0
2019	May	32.64	23.85	28.25	68.30	182.2

Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka-1212.

Appendix III. Characteristics of experimental soil analyzed at Soil Resources Development Institute (SRDI), Farmgate, Dhaka.

A. Morphological characteristics of the experimental field

Morphological features	**Characteristics**
Location	Agronomy Farm, SAU, Dhaka
AEZ	Modhupur 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
Cropping pattern	Not Applicable

Source: Soil Resource Development Institute (SRDI)

B. Physical and chemical properties of the initial soil

Characteristics	**Value**
Partical size analysis % Sand	27
%Silt	43
% Clay	30
Textural class	Silty Clay Loam (ISSS)
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20
Exchangeable K (me/100 g soil)	0.1
Available S (ppm)	45

Source: Soil Resource Development Institute (SRDI)

Appendix IV. Layout of the experiment field

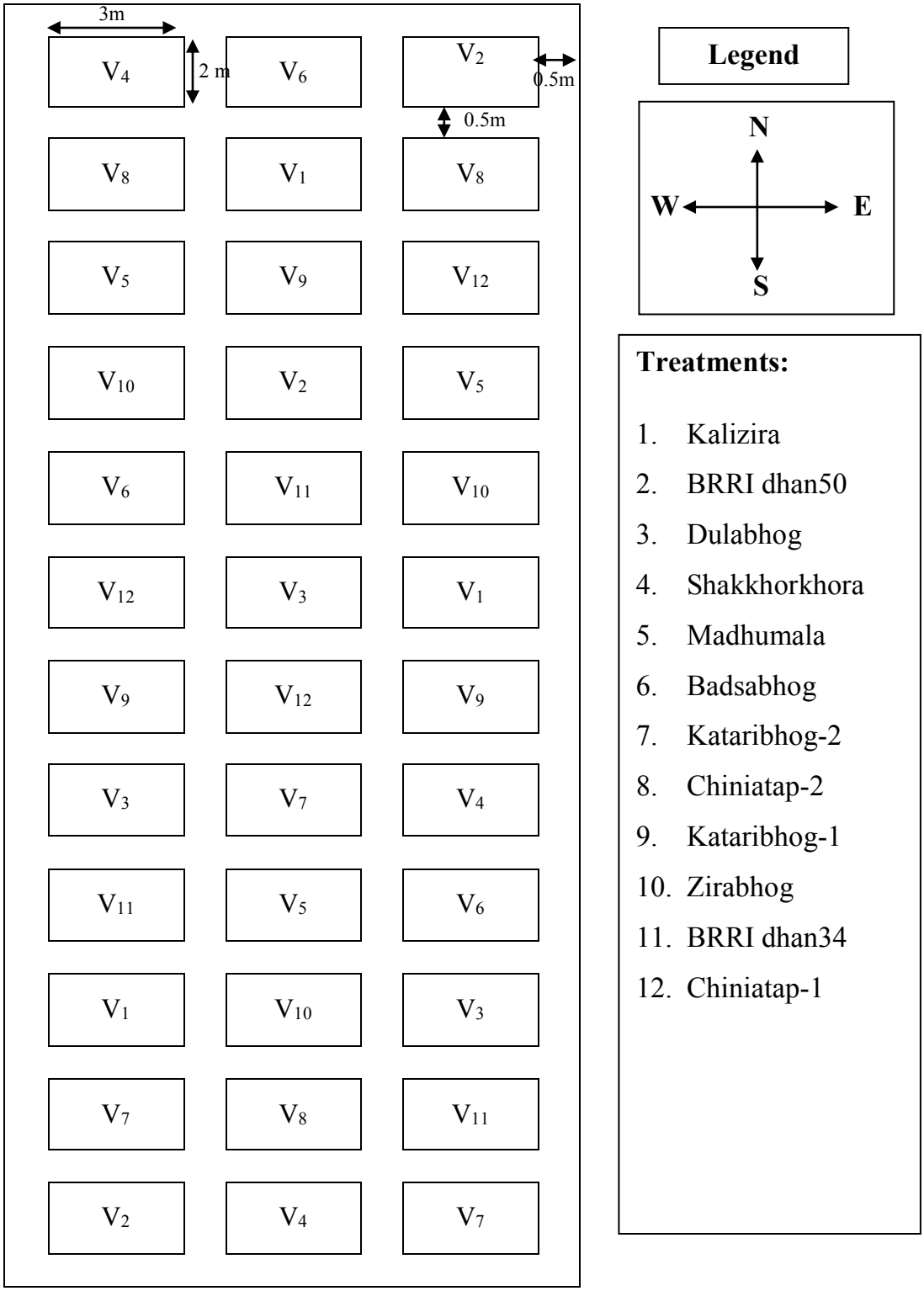

Fig. 6. Layout of the experimental plot

Appendix V. Plant height of rice at different days after transplanting as influenced by different cultivars

Sources of variation	Degrees of freedom	Plant height (cm)			
		30 DAT	60 DAT	90 DAT	At harvest
Replication	2	1.036	2.544	4.361	3.289
Variety	11	67.244**	112.67*	107.29*	205.47*
Error	22	1.351	2.455	3.376	4.289

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix VI. Number of leaves hill^{-1} of rice at different days after transplanting as influenced by different cultivars

Sources of variation	Degrees of freedom	Number of leaves hill^{-1}			
		30 DAT	60 DAT	90 DAT	At harvest
Replication	2	1.075	0.879	1.314	2.056
Variety	11	76.24**	103.25**	67.24*	83.75*
Error	22	2.045	3.114	4.075	3.217

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix VII. Number of tillers hill^{-1} of rice at different days after transplanting as influenced by different cultivars

Sources of variation	Degrees of freedom	Number of tillers hill^{-1}			
		30 DAT	60 DAT	90 DAT	At harvest
Replication	2	0.275	0.366	1.244	0.871
Variety	11	18.712**	33.249*	12.593**	42.156*
Error	22	0.714	1.036	1.057	2.139

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix VIII. Length and breadth of flag leaf of rice as influenced by different cultivars

Sources of variation	Degrees of freedom	Length of flag leaf	Breadth of flag leaf
Replication	2	0.759	0.001
Variety	11	18.04**	NS
Error	22	0.637	0.003

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix IX. Effective and non-effective tillers hill^{-1} of rice as influenced by different cultivars

Sources of variation	Degrees of freedom	Yield contributing parameters		
		Total number of tillers hill^{-1}	Number of non-effective tillers hill^{-1}	Number of effective tillers hill^{-1}
Replication	2	2.035	0.013	1.086
Variety	11	48.712*	3.218**	103.56*
Error	22	1.514	0.103	2.114

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix X. Yield contributing parameters of rice as influenced by different cultivars

Sources of variation	Degrees of freedom	Yield contributing parameters			
		Panicle length (cm)	Number of total grains panicle^{-1}	Number of filled grains panicle^{-1}	Number of unfilled grains panicle^{-1}
Replication	2	0.325	6.374	5.87	0.452
Variety	11	44.71**	1207.84*	876.24*	104.26*
Error	22	2.077	12.59	9.371	2.537

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix XI. Yield parameters of rice as influenced by different cultivars

Sources of variation	Degrees of freedom	Yield parameters					
		1000 grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)	Aroma (Numerical)
Replication	2	0.278	0.014	0.106	0.233	2.104	0.001
Variety	11	36.73*	4.563**	6.344 **	11.528**	104.63*	1.036**
Error	22	1.533	0.107	0.211	0.309	3.078	0.002

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level