GROWTH AND YIELD PERFORMANCE OF LOCAL AND MODERN AROMATIC RICE IN *BORO* SEASON

MS THESIS

BY

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CERTIFICATE

*This is to certify that the thesis entitled '**GROWTH AND YIELD PERFORMANCE OF LOCAL AND MODERN AROMATIC RICE IN BORO SEASON'** submitted to the Department of Agricultural Botany, 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 bona-fide research work carried out by **JHARJHARI CHAKMA**, Registration No.**19-10254** 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.

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TO

MY BELOVED PARENTS

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ABSTRACT

The field experiment was conducted at the Research Farm of the Department of Agricultural Botany, Sher-e-Bangla Agricultural University, during the period from November 2019 to May 2020 to evaluate the growth and yield performance of local and modern aromatic rice in *Boro* season. The experiment comprised of single factor where nine aromatic rice varieties were used as the test crops. The varieties were as follows: i) BRRI dhan5 (Dulabhog), ii) BRRI dhan34, iii) BRRI dhan37, iv) BRRI dhan38, v) BRRI dhan70, vi) BRRI dhan75, vii) BRRI dhan80, viii) BRRI dhan50 and ix) Kataribhog-1. Data were collected on different aspects of growth, yield attributes and yield of aromatic rice. Significant differences existed among different aromatic rice varieties with respect to yield and yield attributing parameters. The result revealed that BRRI dhan80 exhibited its superiority to other tested variety in terms of seed yield (4.63 t ha^{-1}). The higher amount of yield from BRRI dhan80 was possibly aided by the highest number of leaves $hill^{-1}$ at harvest (57.00), the lowest number of non-effective tillers $hill^{-1}$ at harvest (1.09), the highest weight of 1000-grain (26.13 g), the highest biological yield (9.76 t ha^{-1}) and harvest index (47.40%) than other tested varieties in this experiment. On the other hand, the variety BRRI dhan5 (Dulabhog) returned with significantly the lowest grain yield (2.29 t ha^{-1}) among all the varieties under study. The highest yield advantage was recorded from BRRI dhan80 over check variety Kataribhog-1 which was 47.92%. In case of BRRI dhan75, yield advantage over check variety Kataribhog-1 was 38.34% and BRRI dhan70 showed 34.50% higher yield over the check variety. BRRI dhan37 showed 3.19% yield advantage. These four varieties showed positive yield advantage over the check variety under study. BRRI dhan5 (Dulabhog), BRRI dhan34, BRRI dhan38 and BRRI dhan50 did not have positive yield advantage over check variety Kataribhog.

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LIST OF ABBREVIATIONS

%	Percent
AEZ	Agro-Ecological Zone
BRRI	Bangladesh Rice Research Institute
BR 5	BRRI dhan 5
Cont'd	Continued
CV%	Percentage of Coefficient of Variance
DAF	Days after flowering
DAT	Days after transplanting
DF	Degree of freedom
et al.	and others
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
IRRI	International Rice Research Institute
Kg	Kilogram
LAI	Leaf area index
LSD	Least significant difference
m^2	Square meter
MMT	Million metric tons
Mt/ha	Metric ton per hectare
NSB	National Seed Board
PI	Panicle Initiation
PVT	Proposed Variety Trial
SGA	Small Grain Aromatic
T. *Aman*	Transplanted Aman
t ha^{-1}	Ton per hectare
viz.	Namely

CHAPTER 1

INTRODUCTION

Over half of the world's population relies mostly on rice (*Oryza sativa* L.) for nutrition (Khush, 2005; Shrestha *et al*., 2020). It is cultivated in more than 100 nations and is the primary food for more than half of the world's population (Meral and Erturk, 2017). About 65% of people on the planet eat rice as their main food source which accounts for 20% of the average global calorie consumption and 30% of the population in Asian countries (Akter *et al*., 2014; Asbur, 2013). In Asia, more than 90% of this rice is consumed (Islam *et al*., 2021). Twenty percent of the protein and twenty percent of the energy consumed globally comes from rice (Kueneman, 2006). Many farmers chose to grow rice instead of other crops due to its wide ecosystem adaptability and lower risk of cultivation. Due to the growing global population, 14,886 million tons (MT) of food must be produced by the year 2050 in order to satisfy the demand (Islam and Karim, 2019). The most significant food crop in Bangladesh is rice. Millions of Bangladeshis live culturally, socially, and economically around the rice crop, which is crucial to the nation's food and nutritional security (Sarkar *et al*., 2014). It contributes more than 80% of the calories and almost 50% of the protein in the average Bangladeshi's diet, making up 95% of the cereal they consume (Yusuf, 1997). In Bangladesh, it is consumed as astaple food. With 11.55 million hectares of farmed gross land, the nation achieves autarky to supply its 169.04 million population's rice needs (Kabir *et al*., 2020; Nasim *et al*., 2021). With production and consumption of 34.6 and 35.8 million metric tons (MMT) of rice in 2020-2021, respectively, Bangladesh is the third-largest rice market worldwide (Al Mamun *et al*., 2021; Saha *et al*., 2021). Being recently placed in the third position worldwide in rice production, behind China and India (Rahman *et al*., 2021), in 2021, 56.75 million matrictonnes of rice were produced in the country (FAO, 2022). More than 4,000 landrace varieties of rice are grown in Bangladesh across the nation. A few of these stand out for their superior qualities, such as their fineness, scent, flavor, and protein content (Kaul *et al*., 1982). There is an upward shift in demand for quality rice worldwide as people change their eating habits due to improvement in economic conditions and consciousness (Rashid *et al*., 2017). Rice grain quality is mostly determined by the features of the milling quality, size, shape, appearance, nutritional content, cooking and eating characteristics (Tan *et al*., 1999). However, the majority of premium cultivars have low yields compared to coarse and

medium rice (Shakeel *et al*., 2005; Sinha *et al*., 2018). Aromatic rice has recently been made available on the international market. Aromatic rice is known for its characteristic fragrance when cooked (Ashrafuzzaman *et al*., 2009). The most valuable rice in Bangladesh's agricultural trade markets is aromatic rice, which has little grains that have a nice aroma and a soft feel when cooked (Dutta *et al*., 1998). Because fine rice has better nutritional value, palatability, flavor, cooking quality and smell, consumer demand for these types is higher (Kaul *et al*., 1982). Due to the high demand for aromatic rice for both domestic and international trade, aromatic rice cultivation has become more and more popular in Bangladesh in recent years (Das and Baqui, 2000) and it may be exported (Arumugachamy *et al*., 1992). Despite being a minor subgroup of rice, aromatic rice is significant for their superior quality which is the cause that makes these rices sell for considerably more money on the global market (Islam *et al*., 2013). Although a variety of aromatic rice may grow and produce well over a large region, its qualitative characteristics are most apparent in the area where it was originally cultivated (Singh *et al*., 2000). Bangladesh provides a number of great aromatic rice varieties with outstanding eating qualities for normal use as steamed rice as well as for dishes like polao, biriani, jarda, and firni that are offered on special occasions (Hossain *et al*., 2008). Long, slender, fragrant fine grain rice was favoured by the majority of the well-off people (Mannan *et al*., 2012; Sarkar *et al*., 2014). The area of aromatic rice in Bangladesh makes up less than 2% of the country's total rice acreage, despite the generally favorable agroclimatic conditions (Ashrafuzzaman *et al*., 2009). Typically, fragrant rice landraces had tall statures, fewer panicles, heavier stems, poorer yields, and were more prone to lodging and pests (Islam *et al*., 2021). Even though they have a lower yield than other types (Gangaiah & Prasad, 1999), aromatic rice varieties have larger profit margins due to its higher price and reduced cultivation costs (Farook *et al*., 1999). The majority of Bangladesh's aromatic rice cultivars are traditional types that are photoperiod sensitive and cultivated during the transplanting aman season in the rainfed lowland ecology (Islam *et al*., 2012; Das and Baqui, 2000). Traditional fine-grained aromatic rice genotypes are generally taller and provide lesser yields than other varieties (Islam *et al*., 1996). During the Aman season, aromatic rice cultivars occupied 30% of the rice acreage in Bangladesh's northern districts (Islam *et al*., 2012). The majority of the rice types produced in the country during the 1970s and 1980s were classified as coarse/medium whereas in 90’s, The Bangladesh Rice Research Institute (BRRI) created a significant number of fine and fragrant varieties

that are highly sought-after on both domestic and international markets (Tama *et al*., 2015). A few locally adapted, high-quality rice cultivars, including Chiniatop, Kalizira and Kataribhog are available and a few premium quality modern rice varieties, including BRRI dhan5 (Dulabhog), BRRI dhan34, BRRI dhan37, BRRI dhan38, and BRRI dhan50 were released by the Bangladesh Rice Research Institute (BRRI) (Kader *et al*., 2018). There are many health benefits of these aromatic rice varieties as they possess more vitamin and fiber in their outer bran layers (Shozib *et al*., 2019). Besides, traditional scented rice varieties are proved to have higher amount of Fe and Zn and helps in the bioavailability of iron (Chaudry *et al*., 2001). BR5 known as Dulabhog which is a small grain aromatic high yielding rice variety (HYV) possess the highest level of antioxidant properties (Dutta *et al*., 2012). Chinigura is the most common aromatic rice variety, accounting for more than 70% of farms in the northern districts of Naogaon and Dinajpur (Baqui *et al*., 1997). Dinajpur, Naogaon, Chittagong, and Sherpur held the top three spots in 2002–03 for producing aromatic rice, respectively (Talukder *et al*., 2004). Nevertheless, the cost of fine rice, particularly fragrant rice, is two to three times greater than that of coarse rice (Biswas *et al*., 1992). Due to its high prices and export possibilities, fragrant rice production is growing in popularity in Bangladesh (Dutta *et al*., 2002). Despite their cost and yield, it is also preferred by some customers. With the use of new cultivars, farmer' s net income increased by 23% (Shrestha *et al*., 2002). The development of higher yielding aromatic rice varieties through character selection in breeding programs or the modification of agronomic cultural management approaches are required to improve the current situation. A crucial part of rice breeding involves knowledge of morpho-physiological traits. To accomplish the aforementioned goals, detailed knowledge of the morpho-physiological traits of aromatic rice genotypes and their relationship to grain yield is required. However, Bangladesh has little study on rice cultivars that are aromatic. Besides, most of the aromatic rice varieties in Bangladesh are grown on transplanted *Aman* season. On the basis of the aforementioned claim, the current research program has been launched to look into the differences in morpho-physiological traits of traditional and HYV aromatic rice cultivars and their relationship to the growth and yield in *Boro* season. The following objectives were set for the current experiment in light of this context.

Objectives

1) To evaluate the growth and yield performance of different aromatic rice varieties in *Boro* season.
2) To compare yield and yield components of different aromatic rice varieties with check variety (Kataribhog-1).

CHAPTER II

REVIEW OF LITERATURE

Asian countries in the tropics and subtropics produce 90% of the world's rice (Mejia, 2006). Rice is the most important food crop of the developing world and the staple food of more than half of the world's population, many of whom are also extremely vulnerable to high rice prices. The rice industry in Bangladesh represents 70 percent of the agricultural gross domestic product, and is the primary income source for over 48 percent of the rural population (Sayeed and Yunus, 2018). Bangladesh has developed many high yielding rice varieties. But a few works has done on high quality rice cultivars. Aromatic rice (*Oryza sativa* L.) is known for its characteristic fragrance when cooked (Abdul *et al*., 2012). This paper reviews on some of the literatures relevant to "Growth and yield performance of local and modern aromatic rice in *Boro* season".

Variety effect on growth and yield parameters

A research was done by Islam *et al.* (2021) to know the the effect of fertilizer management on growth and yield performance of aromatic fine rice varieties. Two components made up the experiment: fertilizer management and aromatic fine rice. Four varieties were used namely Kalizira, Kataribhog, Tulshimala and BRRI dhan34 with four fertilizer treatments recommended dose of fertilizers (T_1), cowdung @ 10 t ha^{-1} (T_2), 50% of recommended dose of fertilizers + 50% cow-dung (T_3), 75% of recommended dose of fertilizers + 50% cow-dung (T_4). The findings demonstrated that BRRI dhan34 significantly outperformed other research projects in terms of effective tillers per hill (18.46), panicles per hill (26.67cm), grains per panicle (146.30), harvest index (40.73 percent), grain protein content (6.23%), grain yield (2.79 t ha^{-1}), straw yield (4.06 t ha^{-1}), and biological yield (6.85 t ha^{-1}).

Kader *et al.* (2020) recorded that, A new rice variety, BRRI dhan80, which is jasmine type, aromatic, high yielding, long slender grain, and exportable is better than the existing premium quality rice varieties because it is ideal for Bangladesh's rain-fed low land ecology. The proposed variety trial (PVT) that was held in the farmer's field has been conceded by the variety in a reasonable manner. As a result, the National Seed Board (NSB) of Bangladesh approved this variety for commercial cultivation during the wet season (Transplanted *Aman* season) in 2017. It is a modern plant type with a 120 cm plant height and matures in 130–135 days. The key feature of this variety is

having good quality grain, aroma, ten days earlier maturing than control variety. The proposed variety exposed around 1.0 t/ha higher yield than check variety namely BRRI dhan37. The deep blackish green leaf, the erect to semi-erect flag leaf, the long, thin fragrant grain with colored tip, and the presence of anthocyanin pigmentation/coloration on stem nodes are distinguishing characteristics of this variety. It produces grain yields between 4.5 and 5.0 t/ha. The variety's thousand grain weight is 26.2 grams, and it features colorful grain tips and sharp awns. According to this study, the jasmine type, exportable, aromatic rice variety (BRRI dhan80) is a great variety for growing during the wet season, thus farmers will gain economically more if they choose BRRI dhan80 for large-scale production.

Saha *et al.* (2020) conducted an experiment at the Agronomy Field Laboratory of the Bangladesh Agricultural University from November 2016 to June 2017 to determine the impact of planting spacing on the yield performance of several fragrant rice varieties during the *Boro* season. Three varieties- BRRI dhan50, Basmati, and BRRI dhan63- and six planting spacings- 25 cm by 20 cm, 25 cm by 15 cm, 20 cm by 20 cm, 20 cm by 15 cm, 15 cm by 15 cm, and 20 cm by 10 cm - were used in the experiment. The tallest plant (73.78 cm), which was comparable to Basmati, was found in BRRI dhan50, and the shortest one (65.52 cm) was found in BRRI dhan63. Plant height variation may result from genetic variations. Various cultivars have different heights, according to a group of researchers (Jisan *et al*., 2014; Chowdhury *et al*., 2016). The maximum values of total tillers m^2 (384.9) and effective tillers m^2 (343.5) were observed in Basmati and BRRI dhan50, respectively, while the lowest values of respective tillers were discovered in BRRI dhan63. Tiller mortality throughout the vegetative stages was the cause of the decrease in the number of tillers in BRRI dhan63. The largest number of grains $panicle^{-1}$ among the varieties was generated by Basmati, at 93.0, which was comparable to BRRI dhan50's performance (91.67), while BRRI dhan63, which is statistically equivalent to BRRI dhan50, produced the lowest number of grains $panicle^{-1}$, at 91.17%. The highest 1000-grain weight (21.58 g) was obtained in BRRI dhan50 and the lowest 1000-grain weight (18.78 g) was obtained in Basmati.

An experiment was conducted by Halder *et al.* (2018) at the Agronomy Field of Patuakhali Science and Technology University, Dumki, Patuakhali from June to December, 2013 to find out the effect of variety and planting density on the yield and

yield attributing characters of local aromatic rice. In the experiment, there were three local aromatic rice varieties (Chinigura, Shakhorkhora and Kalizira) and four planting densities were viz. S_1 (25 cm × 20 cm), S_2 (20 cm × 20 cm), S_3 (20 cm × 15 cm) and S_4 (20 cm × 10 cm) applied. The study found that the local aromatic rice variety, Shakhorkhora produced the highest number of grains per panicle (131) and 1000-grain weight (13.8 g), consequently higher grain (2.63 t ha^{-1}) which was followed by Kalizira (2.56 t ha^{-1}) and straw yield (4.21 t ha^{-1}). On the other hand, greater numbers of tillers per hill (14.8), grains per panicle (140 nos.) and grain yield were discovered at 20 cm × 20 cm spacing.

According to Kader *et al.* (2018), BRRI dhan70 is an improved version of the currently available premium quality rice BRRI dhan37. It is a new aromatic, high yielding, extra-long narrow grain containing Aman rice variety. The anticipated variety trial, which was carried out in farmer's fields, has successfully concluded with BRRI dhan70. Because of this, in 2015 the National Seed Board (NSB) authorized the commercial growing of this type in Bangladesh during the rainy season (T. *Aman*). The straw-colored extra-long, extra-slender, very elongative, and aromatic cooked rice is BRRI dhan70's key distinguishing attribute The growth duration of BRRI dhan70 is 130 days whereas BRRI dhan37's is 10-15 days later than it. Thousand grain weight of the variety is 20 gm and it has colored grain tip and pointed awn. The variety's unique trait is its tolerance for lodging. Its flag leaf is tall and upright and rich green. With the right management, BRRI dhan70 can yield 4.8–5.0 t/ha, which is roughly 1.0-1.35 t/ha more than BRRI dhan37. Farmers can profit from growing the exportable aromatic rice BRRI dhan70 because it is a great variety for cultivation during the wet (T. *Aman*) season.

Three varieties viz. BRRI dhan28, BRRI dhan29 and Binadhan-14 and four water management methods were used in an experiment by Murshida *et al*. (2017) to determine how variety and water management system affected the growth and yield performance of boro rice. At 100 DAT, BRRI dhan29 had the highest plant height, most tillers per $hill^{-1}$, dry matter per shoot $hill^{-1}$, and dry matter per root $hill^{-1}$ while Binadhan-14 had the lowest values. With the exception of 1000-grain weight, variety significantly affected all of the crop attributes under consideration. The BRRI dhan29 had the highest grain yield, while the Binadhan-14 had the lowest figure.

In an experiment, Rashid *et al.* (2017) tested the yield performance of seven varieties of aromatic rice grown in Bangladesh: Jirakatari, Chiniatab, Chinigura, Kataribhog,

Kalizara, Badshabhog, and BRRI dhan34. The Chinigura variety had the maximum plant height (167.0 cm), while Chiniatab had the lowest (120.1 cm). Chinigura produced the largest number of total tiller hill^{-1} (16.1), while Kalizara produced the lowest number (11.4) of total tiller hill^{-1}. Number of full grains in panicle^{-1} was highest in the variety Kataribhog (255.6) and lowest in the variety Badshabhog (130.7). The cultivar Kataribhog generated the lowest 1000-grain weight (11.4 g), whereas Badshabhog produced the highest (18.3 g). The lowest grain yield (1.83 t ha^{-1}) and the maximum grain yield (2.54 t ha^{-1}) were both obtained from Kalizara and Kataribhog respectively. The two varieties, BRRI dhan34 and Kataribhog were found suitable in terms of yield out of the seven aromatic rice.

Chowdhury *et al*. (2016) conducted an experiment to determine the impact of variety and nitrogen level on the yield performance of fine aromatic rice. In the experiment , three different varieties were used: Kalizira, Binadhan-13, and BRRI dhan34. The yield of fragrant rice was strongly impacted by variety. The highest grain yield (3.33 t ha^{-1}) was found in 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}).

According to Dutta *et al.* (2016), all coarse grain types viz. BRRI dhan3, BRRI dhan11, and BRRI dhan22 showed faster grain growth rates than fine grain variants viz. Nizersail, Pajam and Badshabhog. The largest grain, BRRI dhan3, had the highest rate of grain development, and the smallest grain, Badshabhog, had the lowest.

According to Bony *et al*., (2015) growth and yield characteristics including yield differs from variety to variety. An experiment was carried out to assess the performance of the local varieties of aromatic rice Kalijira, Khaskani, Kachra, Raniselute, Morichsail and Badshabhog. The crop growth traits, yield, and attributes that contributed to yield differed greatly among the rice varieties. Morichsail variety had the tallest plants (116.00 cm), and Khaskani variety had the shortest. The variety Khaskani had the maximum number of filled grains panicle^{-1}(100) and Raniselute had the lowest number. The variety Kalijira generated the lowest 1000-grain weight (13.32 g), while Raniselute produced the highest (32.09 g). The maximum grain yield (2.53 t ha^{-1}) was produced by the variety Morichsail, followed by Kachra (2.41 t ha^{-1}), Raniselute (2.13 t ha^{-1}) and Badshabhog (2.09 t ha^{-1}) and Kalijira (1.80 t ha^{-1}) with the lowest grain yield. According to the results of the experiment, some beneficial traits may be present in local cultivars of aromatic rice that can be enhanced through breeding.

A study was conducted by Saha *et al*. (2015) to evaluate the extent of variability among the small grain aromatic (SGA) rice (*Oryza sativa* L.) genotypes for yield and yield components. Twenty four popular SGA rice genotypes were used for yield and yield contributing characters in BRAC Agricultural Research and Development Centre, Gazipur, Bangladesh. BRRI dhan34 was used as check variety. Highest grain yield per plant was found in Chinikanai-1 followed by Kalijira PL-9, Kalijira PL3 and Badshabhog. Chinikanai-1 had the highest number of grains per panicle.

According to Hussain *et al.* (2014), Crop genotypes are the most important factor in crop production systems. They have an impact on crop productivity due to their increased yield potential and resilience to insects, diseases, and other pests under a variety of climatic situations. An experiment was carried out in 2012 to assess various rice varieties development and production characteristics. In this experiment, four varieties were evaluated in a randomized complete block design (RCBD) with three replications. The varieties used in this study were IRRI- 28, NERICA-4, Koshihikari and Nipponbare. With three seedlings per hill, all varieties were transplanted at a spacing of 30 x 15 cm. Koshihikari was the tallest (117 cm), and Nipponbare was the shortest (102 cm), according to data on numerous growth and yield factors. Higher SPAD value, number of spikelets/panicle (106), and harvest index values were obtained with NERICA-4 (0.47). IRRI-28 produced the highest straw weights (11.53 t/ha) and paddy yields (6.79 t/ha) as well as lowest harvest index. This experiment clearly showed the varietal differences.

Jisan *et al.* (2014) carried out an experiment at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during transplant *Aman* season. The experiment was done to evaluate the yield performance of some local and HYV aromatic rice varieties based on different nitrogen application. In the experiment, four rice varieties viz. BRRI dhan49, BRRI dhan52, BRRI dhan56, BRRI dhan57 were used and four levels of Nitrogen viz. 0, 46, 60 and 75 kg ha^{-1} were applied. Between the varieties, BRRI dhan52 produced the tallest plant (117.20 cm), the most effective tillers $hill^{-1}$ (11.28), the most grains $panicle^{-1}$ (121.5), and the highest 1000-grain weight (23.65 g), whereas BRRI dhan57 generated the characteristics with the lowest values. The BRRI dhan52 produced the highest grain yield (5.69 t ha^{-1}), followed by the BRRI dhan49 (5.15 t ha^{-1}), and the BRRI dhan57 produced the lowest yield (4.25 t ha^{-1}).

Sarkar (2014) recorded that number of total tiller per hill increased with the advancement of vegetative growth stages. He also found that hybrid rice cultivars produced a comparatively higher number of tillers per hill which led to give higher yield than local cultivars.

Sarkar *et al.* (2014) conducted an experiment at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh, to study the yield and quality of aromatic fine rice as affected by variety and nutrient management during the period from June to December 2013. The experiment was consisted of three aromatic fine rice varieties viz. BRRI dhan34, BRRI dhan37 and BRRI dhan38 and eight nutrient managements viz. control (no manures and fertilizers), recommended dose of inorganic fertilizers, cowdung at 10 t ha^{-1}, poultry manure at 5 t ha^{-1}, 50% of recommended dose of inorganic fertilizers + 50% cowdung, 50% of recommended dose of inorganic fertilizers + 50% poultry manure, 75% of recommended dose of inorganic fertilizers + 50% cowdung and 75% of recommended dose of inorganic fertilizers + 50% poultry manure. BRRI dhan34 was superior to all other varieties having the tallest plant (142.7 cm), the highest number of effective tillers hill (10.02), number of grains panicle (152.3), panicle length (22.71 cm), 1000-grain weight (15.55 g) and grain yield (3.71 t ha^{-1}). The highest grain protein content (8.17%) was recorded in BRRI dhan34 whereas the highest aroma was recorded BRRI dhan37 and BRRI dhan38. The highest number of effective tillers $hill^{-1}$ (11.59), number of grains panicle (157.6), panicle length (24.31 cm) and grain yield (3.97 t ha^{-1}) were obtained from the nutrient management of 75% recommended dose of inorganic fertilizers + 50% cowdung (5 t ha^{-1}).The highest grain yield (4.18 t ha^{-1}) was recorded in BRRI dhan34 combined with 75% recommended dose of inorganic fertilizers + 50% cowdung, 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). From this study, it was found that aromatic fine rice variety BRRI dhan34 combined with 75% of recommended dose of inorganic fertilizers + 50% cowdung performed better in terms of yield components and yield.

In an experiment, Haque *et al*. (2013) compared three hybrid rice types (BRRI hybrid dhan2, Heera 2, and Tia) to BRRI dhan48 in order to assess some physiological features and yield. In comparison to BRRI dhan48, hybrid varieties gathered more dry matter in the shoots at anthesis, more chlorophyll in the flag leaves at 2, 9, 16, and 23

days after flowering (DAF), a higher rate of photosynthetic activity in the flag leaves at 2 DAF, and longer panicles. At 2, 9, 16, and 23 DAF in their flag leaf, Heera 2 and BRRI hybrid dhan2 maintained a considerably greater chlorophyll a, b ratio than Tia and BRRI dhan48. In the examined hybrids compared to the inbreds, shoot reserve remobilization to grain showed a higher degree of sensitivity to raising of minimum temperature. The test hybrid's grain filling percentage was low because to ineffective flag leaf photosynthetic activities and inadequate shoot reserve translocation to grain. No matter when they were planted throughout the growing season, the hybrids in the study had significantly lower grain yields (36.7%) than the inbred BRRI dhan48.

According to Hossain *et al*. (2013), the five rice cultivars that were studied, displayed significant differences in the majority of characteristics that affected yield. The highest panicle length, number of grain panicles^{-1}, and grain yield ha^{-1} were obtained by the modern cultivar BRRI dhan16. The indigenous cultivar Pari produced the fewest tiller plants^{-1}, panicle lengths^{-1}, grain panicle^{-1}, and grain yield ha^{-1} at the same period.

Islam *et al.* (2013) found that the crop growth characteristics, yield, and yield-contributing traits of the many rice cultivars differed greatly. The experiment was carried out at the Field Laboratory of Agrotechnology Discipline, Khulna University, Khulna, Bangladesh, during the *Aman* season of 2006 using six indigenous aromatic rice cultivars, namely Kalijira (V_1), Khaskani (V_2), Kachra (V_3), Raniselute (V_4), Morichsail (V_5), and Badshabhog (V_6) as six treatments, in accordance with a Randomized Complete Block Design with three replications. The highest plant height (116.00 cm) was obtained from the variety Morichsail and the lowest in the variety Khaskani (63.70 cm). In case of tillers, the variety Kalijira had the most tillers per square meter (404.20), whereas the variety Khaskani had the fewest (108.90). Number of filled grains panicle^{-1} was found highest (100) with the variety Khaskani and the lowest was recorded in the variety Raniselute (42.20). Raniselute produced the highest 1000-grain weight (32.09 g) whereas Kalijira produced lowest (13.32 g). The variety Morichsail was recorded to have 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 found in Kalijira. According to the results of the study, there are some beneficial traits in native fragrant rice cultivars that can be enhanced through breeding.

In an experiment, Sarker *et al*. (2013) examined the morphology, yield, and yield-contributing traits of four Boro rice varieties, of which three were indigenous to the region, namely Bashful, Poshursail, and Gosi, and one was a high yielding variety (HYV) BRRI dhan28. Among the cultivars examined, the BRRI dhan28 stood out as being much better. The BRRI dhan28 was shorter than the local cultivars, had more tillering capacity, and more leaves, all of which contributed to its superior growth characteristics and higher yields. In comparison to local cultivars, the HYV BRRI dhan28 produced more grains per panicle and the bolder grains also contributed to a higher grain yield. Additionally, BRRI dhan28 exhibited a higher total dry mass than local variations. Greater grain yield (7.41 t ha^{-1}) was produced by the BRRI dhan28 than Bashful, Poshurshail, and Gosi, respectively. Gosi demonstrated a better yielding capacity than Bashful and Poshursail among the indigenous rice cultivars.

A study was conducted by Mannan *et al.* (2012) at the Bangladesh Rice Research Institute Farm, Gazipur, in boro season. The study was done on four traditional aromatic rice varieties namely Kalijira, Kataribhog, Chinigura and Badshabhog. According to the study, Chinigura was shorter and Kalijira and Badshabhog had taller plants, although Chinigura generated more tillers at all growth stages early, middle, and late than any of the other two. The highest quantity of dry matter was found in Chinigura, and the least was found in Kataribhog. Despite Kataribhog displayed early flowering and a lesser number of panicles, Badshabhog had a higher number of grains $panicle^{-1}$ than Chinigura, which had late flowering and produced much more panicles while statistically being identical to Kalijira. While Badshabhog had the lightest grain, Kataribhog had the heaviest grain $hill^{-1}$. Chinigura and Kalijira had nearly comparable grain yields. The fact that there were fewer panicles and grain $panicle^{-1}$ in Kataribhog may be the cause of the lower grain yield. From the study, it was found that, varietal difference plays a role in growth and yield.

Fatema *et al.* (2011) conducted an experiment on forty five aromatic rice genotypes to evaluate the genetic variability and diversity on the basis of nine characters. The genotypes for all the characters had significant variations. Thousand grain weight was found to contribute maximum towards genetic diversity in 45 genotypes of aromatic rice.

A field experiment was done by Hossain *et al.* (2011) during *Aman* season. The goal of the study was to determine the influence of transplanting date on the physical and

chemical properties of grain of five local and three modern aromatic rice varieties of Bangladesh. The varieties were Kataribhog, Radhunipagal, Chinigura, Badshabhog, Kalizera, BRRI dhan34, BRRI dhan37 and BRRI dhan38. The following physical and chemical properties were assessed in the study: protein content, amylose content, milling outturn, head rice outturn, 1000-grain weight, length, width, elongation, and volume expansion ratios of the grains. The highest weight of 1000 grains, grain length, length breadth ratio and, volume expansion ratio were found in BRRI dhan38 while the highest protein and amylose contents were found in Kalizira and BRRI dhan34, respectively.

A study was performed by Amin and Haque (2009) from July to December 2001. Four distinct ages of seedlings- 15, 25, 35, and 45 days old were transplanted on the same day while maintaining a 25 cm x 15 cm spacing between two indigenous varieties, Kalizira and Tulshimala, and two improved varieties, BRRI (Bangladesh Rice Research Institute) dhan38 and BRRI dhan37. At 60 days after transplanting, BRRI dhan37 had the tallest plants, followed by Tulshimala and Kalizira in age (DAT). However, a 35-day-old Kalizira seedling produced the largest plant height during harvest. At all DATs but 15 DAT, BRRI dhan38 and BRRI dhan37 seedlings, both 35 days old, generated the most tiller hills^{-1}. However, only BRRI dhan38 with 35-day-old seedlings produced the highest results during harvest. At 45, 60, and 75 DAT, the 35-day-old seedling BRRI dhan38 had the highest LAI (Leaf Area Index). However, the 45-day-old seedling of BRRI dhan37 displayed the greatest value of LAI at 15 DAT. The 45-day-old seedling from Kalizira produced the lowest LAI at 75 DAT, which was statistically comparable to the 15-day-old seedling from Tulshimala. The 35-day-old seedling from BRRI dhan38 produced the most grain (4.30 t ha^{-1}), followed by the seedling from BRRI dhan37 (4.00 t ha^{-1}).

A study was conducted by Ashrafuzzaman *et al.* (2009) at the field of Bangladesh Agricultural University, Mymensingh during June to December, 2007 to evaluate the growth performance and grain quality of six aromatic rice varieties BRRI dhan34, BRRI dhan38, Kalizira, Chiniatop, Kataribhog and Basmati grown under rainfed conditions. Plant height varied significantly among the varieties.The highest height was recorded in Kalizira (107.90 cm) which was significantly similar to BRRI dhan38 (107.80 cm) and BRRI dhan34 (106.70 cm). Chiniatop was found to be the shortest (95.30 cm). The longest flag leaf (34.45 cm) was found in Basmati and Kalizira gave

the shortest (25.28 cm) flag leaf. In this study, Chiniatop had the highest (10.8 mm) grain length where BRRI dhan34 had shortest length (6.8 mm), which was statistically identical with Kalizira (6.9 mm). The highest grain breadth was found in Basmati (2.5 mm) followed by Kataribhog (2.3 mm). The lowest grain breadth was recorded in BR38 (1.3 mm) which was statistically similar to BRRI dhan34 and Kalizira (2.0 mm). BRRI dhan34 showed the highest number of panicles per hill (11.67) which was statistically similar to Kalizira (11.33). Basmati gave the lowest number of panicles per hill. Different varieties showed significant differences in grain yield. BRRI dhan34 gave the highest grain yield and Basmati gave the lowest . The genotypes, which produced higher number of effective tillers per hill and higher number of grains per panicle also showed higher grain yield in rice. Significant difference of 1000- grain weight was found among the varieties. The highest 1000-grain weight was obtained from BRRI dhan38 (20.13 g) and the lowest was from BRRI dhan34 (12.17 g). The highest harvest index was found in BRRI dhan34 (34.94%) and the lowest harvest index was found in Basmati (31.51%). However, it was recorded that Basmati required shorter days to maturity and Kalizira longest days to maturity. This study found that, variety BRRI dhan38 had the best performance for grain yield whereas Basmati and Kataribhog gave the lowest record in grain yield.

In order to examine the growth and yield of inbred and hybrid rice with clonal tillers of various ages, Obaidullah *et al*. (2009) undertook a field experiment. They discovered that clonal tillers that were 25 days old had the maximum grain yield (5.10 t ha^{-1}) and that clonal tillers that were 40 days old had the lowest grain yield (4.31 t ha^{-1}). Irrespective of variety, clonal tillers that were 25 to 35 days old performed better. Hybrid variety which was transplanted with 25 days old clonal tiller gave noticeably higher grain yield.

Shahidullah *et al.* (2009) found that tiller number of aromatic traditional rice variety is higher at earlier stage whereas mortality is higher before panicle initiation stage.

An experiment was carried out by Sikdar *et al.* (2008) at the Bangladesh Agricultural University's Agronomy Field Laboratory in Mymensingh to assess the effect of nitrogen (N) level on the quality of aromatic rice and fertility status of the post harvest soil. The experiment used three different varieties- Kalizira, Badshabhog, and Tulshimala and three different nitrogen concentrations- 40, 60, and 80 kg ha^{-1}. Kalizira had the highest N content (1.45%) and protein (8.62%) of grain whereas the lowest N

content (1.43%) and protein (8.50%) were recorded from Badshabhog which was statistical similar to Tulshimala.

An experiment was conducted by Hossain *et al.* (2008) at Hajee Mohammad Danesh Science and Technology University Farm, Dinajpur, Bangladesh in *Aman* season (July-December) of 2007. This experiment was done to observe the yield and quality of ten popular aromatic rice varieties of Bangladesh. The experiment was laid out in a randomized complete block design with four replications with the varieties namely Kataribhog (Philippines), Kataribhog (Deshi), Badshabhog, Chinigura, Radhunipagal, Kalizira, Zirabhog, Madhumala, Chiniatab and Shakhorkora. All of the quality and yield-contributing factors varied greatly among the different fragrant rice cultivars. Highest plant height (165.8cm) was found in Chinigura whereas the lowest (137.1cm) found in Chiniatab. Maximum number tillers hill^{-1} (12.5) was observed in Chinigura and it was identically similar to Radliunupagal. The minimum panicle length (20.7 cm) was found in Kataribhog (Philippines). The highest number of grains panicle^{-1} (136.8) was recorded from Badshabhog and the lowest number of grains panicle^{-1} (78.1) was found in Kataribhog (Deshi). The Kataribhog (Philippines) produced the highest grain production, which was closely followed by Badshabhog. In terms of quality, Zirabhog produced more head rice than Badshabhog or Chiniatab. Bold type appeared on all of the tested variants. Brown rice had a grain protein concentration that varied between 6.6 and 7.0 percent. Due to varietal diversity, aroma intensity varied. High levels of aroma were present in Kalizira, Badshabhog, and Chiniatab, whereas moderate levels of aroma were present in the other species.

Hossain *et al*. (2008) conducted an experiment to examine the impact of various nitrogen levels on the productivity of four rice types during the transplanting aman season (monsoon). The experiment was done at Mymensingh, Bangladesh. Nitrogen was applied 30, 60, 90 and 120 kg ha^{-1} while aromatic rice cultivars viz. BRRI dhan38, Kalizira, Badshabhog and Tulsimala were grown. The performance of various types varied remarkably. Maximum height was obtained from variety Tulsimala (153.00 cm) which is significantly diffrent from other varieties and the lowest height was obtained from variety BRRI dhan38. The most grains panicle^{-1} was produced by Kalizira (135.90). Among the cultivars BRRI dhan38 produced the most grain (4.00 t ha^{-1}).

Islam *et al.* (2008) conducted an experiment to investigate the influence of spacing on the yield and yield attributes of some varieties of aromatic rice. The experiment was

done at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during July to December 2001 which was comprised of three varieties namely, 'Kalizira', 'Badshabhog' and 'Tulshimala'and four different spacing viz.8 cm x 25 cm, 12 cm x 25 cm, 16 cm x 25 cm and 20 cm x 25 cm. 'Badshahbhog' produced the highest grain yield (2.90 t ha^{-1}) which was consequence of the highest number of effective tiller $hill^{-1}$, number of grains $panicle^{-1}$ and 1000-grain weight.

Amin *et al*. (2007) found that parameters related to yield and yield contributing characters were affected by variety. Effective tillers per hill, panicle length, total spikelet per panicle, grain per panicle, 1000 grain weight and grain yield were markedly different from variety to variety. In his study, he founnd that, BRRI dhan38 performed better than Kalizira,Tulsimala, BRRI dhan37 in terms of yield and yield contributing characters.

According to Samsuzzamn (2007), the height of traditional aromatic rice and hybrid rice plants ranged from 82.46 to 90 cm. It was found that, height of traditional aromatic rice varieties were more or less different than that of hybrid rice varieties.

An experiment was done by Hossain *et al.* (2005) at Hajee Mohammad Danesh Science and Technology University farm, Dinajpur, Bangladesh during *Aman* season 2004. The study was conducted to evaluate the relationship between grain yield and morphological parameters of five local and three modern aromatic rice cultivars. The varieties used in this experiment are Kataribhog, Radhunipagal, Chinigura, Badshabhog, Kalijira, BRRI dhan34, BRRI dhan37 and BRRI dhan38. The highest height was found in Chinigura (162.8 cm) variety which is statistically similar to Kataribhog (158.8 cm) whereas the lowest height was obtained in BRRI dhan37 (121.6 cm) and BRRI dhan38 (123.7 cm). The total number of tiller $hill^{-1}$ was lowest in Kalijira (9.8) which was statistically similar to Kataribhog, Badshabhog, BRRI dhan34, BRRI dhan38 and the highest number was recorded in Chinigura (12.5). The number of fertile tillers $hill^{-1}$ was found in BRRI dhan37 (11.4) which was statistically similar with Radhunipagal, Badshabhog,Chinigura, BRRI dhan38 and the lowest number of fertile $tillers^{-1}$ was obtained from Kalizira (8.7) which was statistically similar to Kataribhog. The highest number of grain $panicle^{-1}$ was recorded in BRRI dhan34 (125.8) and the lowest was found in BRRI dhan34 (73.8). Maximum 1000 grain weight was obtained from BRRI dhan38 (19.23g) and the lowest 1000 grain weight was observed in BRRI dhan34 which is statistically similar to Badshabhog and Chinigura. Kataribogh gave the

highest straw yield (8.9 t $ha^{-1)}$ and the lowest straw yield (5.8 t ha^{-1}) was found in Kalizera identically followed by BRRI dhan37 and BRRI dhan38. According to the findings, BRRI dhan34 and Kataribogh are suitable for the Dinajpur region in terms of yield.

Plant height and grain yield had a negative correlation, according to an experiment by Mahdavi *et al.* (2004). Because of reduced lodging and improved assimilate translocation in newer aromatic cultivars, plant height was not a limiting factor for grain output.

Dongarwar *et al.* (2003) conducted an experiment to compare the hybrid rice KJTRH-1 to two traditional cultivars, Jaya and Swarna, in how they responded to four different fertilizer rates, such as 100:50:50, 75:37.5:37.5, 125:62.5:62.5, and 150:75:75 kg NPK ha^{-1}. They found that KJTRH-1 produced a significantly higher yield (49.24 t ha-1) than Jaya (39.64 t ha^{-1}) and Swarna (46.06 t ha^{-1}).

In a study done in the *Boro* season of 1999, Siddiquee *et al*. (2002) compared the growth time, yield, and quality of inbred and hybrid rice. Aalok 6201 had the maximum grain yield followed by BRRI dhan29 and IR68877H which were statistically comparable. The grain yield of BRRI dhan28, which was statistically comparable to Loknath503, was the lowest. The studied hybrid rice and BRRI dhan28 exhibited shorter growth times than BRRI dhan29. The examined cultivars had milling out turns ranging from 67 to 70%. The maximum milling out turn (73%) for parboiled rice was observed in BRRI dhan28 and IR68877H, while Loknath 503 had the lowest milling out turn (70%) and BRRI dhan28 and BRRI dhan29 had the most (70%) for unparboiled rice. All of the hybrid rice that was examined were medium bold, however BRRI dhan29 and BRRI dhan28, either parboiled or not, were medium slender and long slender, respectively. Among the cultivars, BRRI dhan29 had a greater amylose content (%) and IR68877H had a higher protein content (%) under both parboiled and unparboiled conditions. This experiment showed the difference between hybrid and inbred rice in respect of their growth timing, yield and quality.

The crop performance of hybrid, inbred, and locally modified rice varieties was investigated in an experiment by Uddin *et al*. (2001), who found that variety had a substantial impact on all crop characters under consideration. Sonarbangla-1, Alok 6201, and Habigonj were the top three performers in terms of 1000-grain weight.

According to BRRI (2000), different aromatic rice varieties like Basmati 406, Kataribhhog, BRRI dhan34 and Basmati were found to have differences in plant height. The results showed that Basmati 406 had the tallest plant height (126 cm), whereas Kataribhog had the shortest one (115 cm).

Chowdhury *et al*. (1995) experimented on seven varieties of rice, of which three was local (Maloti, Nizersail and Chandrashail) and four was improved (BRRI dhan3, BRRI dhan11, Pasam and Mala). It was discovered that improved varieties produced greater grain and straw yields than the local variety.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted in the Experimental Field of the Department of Agricultural Botany, Sher-e-Bangla Agricultural University (SAU) at *Boro* season, 2019-2020. The goal of the experiment was to evaluate the growth and yield performance of local and modern aromatic rice in *Boro* season. The following headings provide more information about the materials and methods used in this experiment, including the experimental period, location, soil and climate conditions, materials utilized, treatment and design, crop growth, data collection, and data processing procedures.

3.1 Description of the experimental site

3.1.1 Experimental period

The field experiments were conducted during the period of November, 2019 to May, 2020.

3.1.2 Experimental site

The current study was carried out at Sher-e-Bangla Agricultural University's farm in Sher-e-Bangla Nagar, Dhaka. The site is 8.2 meters above sea level and is located at 23^0 77' N latitude and 90^0 35' E longitude. The experimental site is shown in Appendix I.

3.1.3 Soil characteristics

The soil of the research field belongs to “The Modhupur Tract”, AEZ 28 is slightly acidic in reaction with low organic matter content. The experimental area was above flood level and sufficient sunshine with having available irrigation and drainage system during the experimental period. Soil sample from 0-15 cm depth were collected from experimental field and the soil analysis were done from Soil Resources Development Institute (SRDI), Dhaka. Soil pH was 6.3 and had organic carbon 0.41%. The physical properties and nutritional status of soil of the experimental plot are given in Appendix III.

3.1.4 Climatic condition

The experimental site was located in a subtropical climate with three different seasons: winter (November to February), pre-monsoon (March to April), and monsoon (May to

October) (Edris *et al.*, 1979). In Appendix II, the specific meteorological information for the experiment period, including air temperature, relative humidity, rainfall, and sunlight hour, is described.

3.2 Experimental details

3.2.1 Planting material

Total Nine aromatic rice varieties were used as the test crops in this experiment .

3.2.2 Treatment of the experiment

Nine aromatic rice varieties used in this experiment and they were:

i)T_1 = BRRI dhan5

ii)T_2 = BRRI dhan34

iii)T_3 = BRRI dhan37

iv)T_4 = BRRI dhan38

v)T_5 = BRRI dhan70

vi)T_6 = BRRI dhan75

vii)T_7 = BRRI dhan80

viii)T_8= BRRI dhan50

ix)T_9 = Kataribhog-1

3.2.3 Experimental design and layout

The single factor experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The layout of the experiment was prepared by distributing the nine aromatic rice varieties. There were 27 plots of size 1 m × 1 m in each of 3 replications. The treatments of the experiment were assigned at random into each replication following the experimental design. Layout of the experiment was done with inter plot spacing of 0.50 m and inter block spacing of 0.75 m. Two seedlings hill^{-1} were used during transplanting. The layout of the experimental field has been shown in Appendix IV.

3.3 Growing of crops

3.3.1 Seed sprouting

Healthy seeds were picked using the specific gravity method, submerged in water for 24 hours, and then tightly bagged. After 48 hours, the seeds began to grow. 72 hours later, they were sown in a nursery bed.

3.3.2 Raising of seedlings

The nursery bed was prepared by puddling with repeated ploughing followed by laddering. The sprouted seeds were sown in seed bed at 23 November, 2019 as uniformly as possible. The seed was then quickly covered, and after that a gentle watering was applied. Irrigation was gently provided to the bed as and when needed. No fertilizer was used in the seed bed. When necessary, weeding and plant protection measures were implemented.

3.3.3 Land preparation

The experimental plot was prepared by three successive ploughing and cross ploughing. Each ploughing was followed by laddering to have a good puddle field. All kinds of weeds and residues of previous crop were removed at final ploughing. Making individual plots for transplanting and finally leveled all the plots.

3.3.4 Manures

In the current study, well-decomposed farmyard manure was treated in accordance with the treatments during the final land preparation phase, barely three days before zinc application.

3.3.5 Fertilizers

The recommended doses of N, P_2O_5, K_2O, and S were administered as follows: 180 kilogram urea, 160 kg TSP, 170 kg MP ha^{-1} , and 90 kg gypsum. At the time of the last land preparation before transplanting, the entire amount of phosphorus, half of the potassium and one third of the nitrogen were applied. Two installments were used to apply the remaining one third of the N and half of the K.

3.3.6 Transplanting

On 3 January, 2020, 40-day-old rice seedlings were transplanted into experimental plots, with one $hill^{-1}$ for hybrids and two $hill^{-1}$ for inbreds being spaced at 20 cm x 15 cm and 25 cm x 15 cm, respectively.

3.4 Intercultural operation

To ensure the crop's regular growth, intercultural operations were conducted. As and when required, plant protection measures were taken. Intercultural activities included the following:

3.4.1 Gap filling

During the transplanting process, a few seedlings from the nursery were placed next to the irrigation channels in order to fill in any gaps. On top of that, within 10 days of

transplantation, seedlings in certain hills that had died off were replaced by new, healthy seedlings.

3.4.2 Weeding

From four weeks (30 DAT) following transplanting, weeds were manually removed from the plots and the plots were kept weed-free as and when required. At the Panicle Initiation (PI) stage, the second weeding was taken (60 DAT).

3.4.3 Irrigation

To ensure the seedling's successful establishment, a thin film of water was kept on the surface during transplantation. From the third day on, a 2 to 3 cm depth of water was maintained up to the panicle initiation stage; however, during the top dressing of nitrogen, the water was drained out and re-flooded after 48 hours to maintain a 5 cm depth of water up to physiological maturity. Water was gradually drained after the dough stage to make the crop easier to harvest.

3.4.4 Plant protection measures

There were hardly any insect-pest infestations during the period, however to maintain normal crop growth, Basudin was administered at the tillering stage @ 17 kg ha^{-1} and Diazinon 60 EC @ 850 ml ha^{-1} to suppress stem borer and rice bug.

3.5 Harvesting, Threshing and Cleaning

When 85% to 90% of the grains turn a golden yellow tint, the crop is considered mature. To calculate the yield of each treatment, 1 m^2 of each plot's center was collected and converted into t ha^{-1}. Each plot's harvested crop was packed and neatly labelled before being carried to the threshing floor. The bundles were dried in the sunlight, threshed, and the grains were washed after that. After being properly dried in the sun, the weights of the grain and straw for each plot were recorded. Prior to harvest, five randomly chosen hills outside of each plot's sample area were cut down to the ground in order to gather information on yield contributing characters.

3.6 Sampling

Five representative hills were chosen at random from each plot's second rows on each side and then tagged for sampling. On the tagged hills, the biometric information and post-harvest observations were noted.

3.7 Data recording

The following data were collected during the research period:

3.7.1 Plant height

At 40 DAT, 80 DAT (days after transplanting), and the harvesting stage, the plant's height was measured in centimeters (cm). The average of five randomly chosen plants from the inner rows of each plot were used to calculate the data. The height was measured from the surface of the ground to the tip of the panicle or flag leaf.

3.7.2 Number of total tillers hill^{-1}

Total tillers which had at least one leaf visible were counted. It includes both productive and unproductive tillers. Number of tillers hill^{-1} was recorded at 40, 80 DAT (Days after transplanting). It was counted from the average of same 5 hills pre-selected at random from the inner rows of each plot.

3.7.3 No. of Leaves hill^{-1}

Number of leaves hill^{-1} was recorded at 40, 80 DAT and at harvest. The average of five randomly chosen plants from the inner rows of each plot were used to calculate the data.

3.7.4 Effective tillers hill^{-1}

Total no. of panicle bearing tillers in a plant was counted at the time of harvesting.

3.7.5 Non-effective tillers hill^{-1}

The tillers having no panicle were regarded as non-effective tiller.

3.7.6 Leaf Area Index

At the time of harvest, the leaf area index (LAI) was manually estimated. The average of five plants taken from the middle of each row was used to collect the data. In order to calculate the final data, a correction factor of 0.75 was multiplied (Yoshida,1981).

3.7.7 SPAD value

A chlorophyll meter (Minolta-52, Japan) was used to record SPAD values from each plot at 7 days after flowering (DAF). The SPAD value was measured five times for each evaluation from three randomly chosen leaves at different positions per plant and the average was used for analysis.

3.7.8 Days to maturity

When 80% of the grains in a plot turn golden yellow, it is said that the plant is mature. From the date of sowing, the days to maturity were counted.

3.7.9 Filled grains panicle^{-1}

If any kernel was present, the panicle was regarded as fertile. On each panicle, the total number of filled grains was recorded.

3.7.10 Unfilled grains panicle^{-1}

If there was no kernel present in a panicle, it was called sterile. The number of total unfilled grains present on each panicle was recorded.

3.7.11 Weight of 1000 grain

From the total cleaned harvested grains of each individual plot, one thousand cleaned dried seeds were counted at random and weighed with a digital electric balance when the grain contained 14% moisture and the mean weight was expressed in grams.

3.7.12 Total grains panicle^{-1}

From a plot's five randomly chosen hills, the total number of filled and unfilled grains were counted together and then average number of total grains panicle^{-1} was recorded.

3.7.13 Sterility percentage

At the harvesting, 10 panicles were harvested at maturity from five randomly chosen hills in each of the treatments and the number of filled, unfilled and total grains were counted. Spikelets fertility percentage was then calculated as-

$$\text{Sterility percentage} = \frac{\text{No. of unfilled grains in the panicle}}{\text{Total no. of grains in the panicle}} \times 100$$

3.7.14 Grain yield

Each plot area's grain was completely sun dried until it reached a constant weight. Next, based on net plot area, yield per hectare was calculated**.**

3.7.15 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 ton ha^{-1}.

3.7.16 Biological yield

Biological yield was determined using the following formula -

Biological yield = Grain yield + Straw yield

3.7.17 Harvest Index

The Harvest Index was calculated using the following formula, which indicates the proportion of economic yield to biological yield:

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

3.8 Statistical Analysis

The data obtained for different characters were statistically analyzed to observe the significant difference among different aromatic rice varieties Using the MSTAT- C statistical analysis program, the variance of each recorded parameter was recorded. At a 5% level of probability, the Least Significant Difference (LSD) Test was used to distinguish the means value difference.

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to find out the growth and yield performance of local and modern aromatic rice in *Boro* season. The analytical results have been presented and discussed with the help of tables and graphs and possible interpretations given under the following headings:

4.1 Plant height

The plant height (cm) of aromatic rice was significantly influenced by different varieties at 40 DAT, 80 DAT and at harvest (Table 1). The results revealed that at 40 DAT, 80 DAT and at harvest, BRRI dhan37 showed the tallest plant (40.50 cm, 86.20 cm and 115.55 cm, respectively). On the other hand, at 40 DAT, 80 DAT and at harvest, the shortest plant (24.75 cm, 50.10 cm and 86.75 cm, respectively) was recorded from BRRI dhan50. The genetic makeup of a variety may be the cause of variation in plant height. Shahidullaha *et al*. (2009) and Sarkar *et al*. (2014) found that the cultivars varied in their plant height, which is consistent with the findings.

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

Treatments	Plant height (cm) at		
	40 DAT	80 DAT	Harvest
BR5 (Dulabhog)	38.50 b	77.50 b	112.50 b
BRRI dhan34	35.30 c	56.70 f	93.80 e
BRRI dhan37	40.50 a	86.20 a	115.55 a
BRRI dhan38	28.60 f	53.80 g	94.20 e
BRRI dhan70	24.88 g	75.80 c	111.70 b
BRRI dhan75	31.50 e	65.60 e	98.50 d
BRRI dhan80	33.60 d	67.50 d	104.40 c
BRRI dhan50	24.75 g	50.10 h	86.75 f
Kataribhog-1	35.10 c	54.60 g	98.63 d
LSD (0.05)	**1.10**	**1.13**	**1.10**
CV (%)	**1.96**	**9.80**	**6.40**

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

4.2 Number of total tillers hill^{-1}

Different varieties of aromatic rice showed significant difference on the number of total tillers hill^{-1} of rice varieties at 40 DAT and 80 DAT (Table 2). The result revealed that

at 40 DAT and 80 DAT, the highest number of total tillers hill^{-1} (20.30 and 24.70, respectively) were recorded from BRRI dhan37. On the other hand, the lowest number of total tillers hill^{-1} at 40 DAT (11.40) were recorded from BRRI dhan38 while at 80 DAT, the lowest number of total tillers hill^{-1} (16.05) was recorded from BRRI dhan34 which was statistically similar to BRRI dhan50 (16.80). Similar findings were made by Sarkar *et al*. (2014) and Roy *et al*. (2014), who discovered that varietal differences significantly affected the quantity of tillers hill^{-1}.

Table 2. Effect of variety on number of total tillers hill^{-1} of aromatic rice at different days after transplanting

Treatments	Number of total tillers hill^{-1} at	
	40 DAT	80 DAT
BR5 (Dulabhog)	15.50 c	22.00 bc
BRRI dhan34	12.70 d	16.05 e
BRRI dhan37	20.30 a	24.70 a
BRRI dhan38	11.40 f	18.50 d
BRRI dhan70	16.70 b	19.50 d
BRRI dhan75	17.50 b	23.00 b
BRRI dhan80	17.50 b	21.50 c
BRRI dhan50	12.60 de	16.80 e
Kataribhog-1	11.50 ef	22.51 bc
LSD (0.05)	**1.10**	**1.10**
CV (%)	**4.23**	**3.11**

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

4.3 Number of effective tillers hill^{-1}

The number of effective tillers hill^{-1} of aromatic rice was significantly influenced by different varieties (Figure 1). The result revealed that the highest number of effective tillers hill^{-1} (21.88) was recorded from BRRI dhan37. On the other hand, the lowest number of effective tillers hill^{-1} (12.23) was recorded from BRRI dhan50. Islam *et al*. (2009) and Bisne *et al.* (2006) also found varietal effect on number of effective tillers per hill.

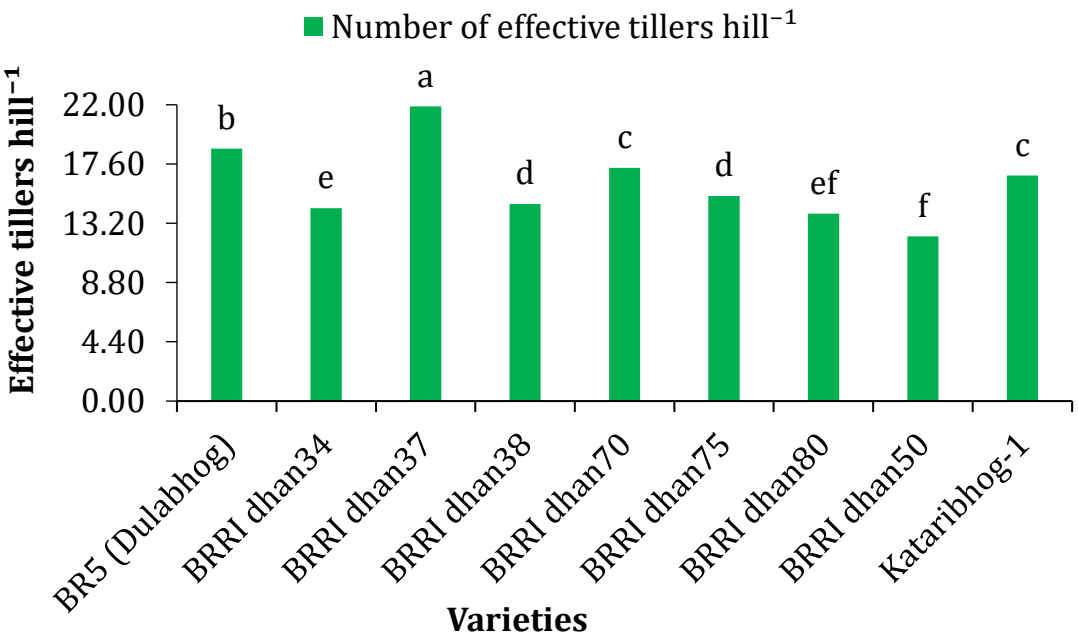

Figure 1. Effect of variety on number of effective tillers hill $^{-1}$ of aromatic rice. (LSD value = 1.10)

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

Different varieties of aromatic rice showed significant difference on the number of non-effective tillers hill^{-1} of rice varieties (Figure 2). Islam *et al*. (2009) reported the same trend. Here, the result revealed that the highest number of non-effective tillers hill^{-1} (6.31) was recorded from BRRI dhan34. On the other hand, the lowest number of non-effective tillers hill^{-1} (1.09) was recorded from BRRI dhan80.

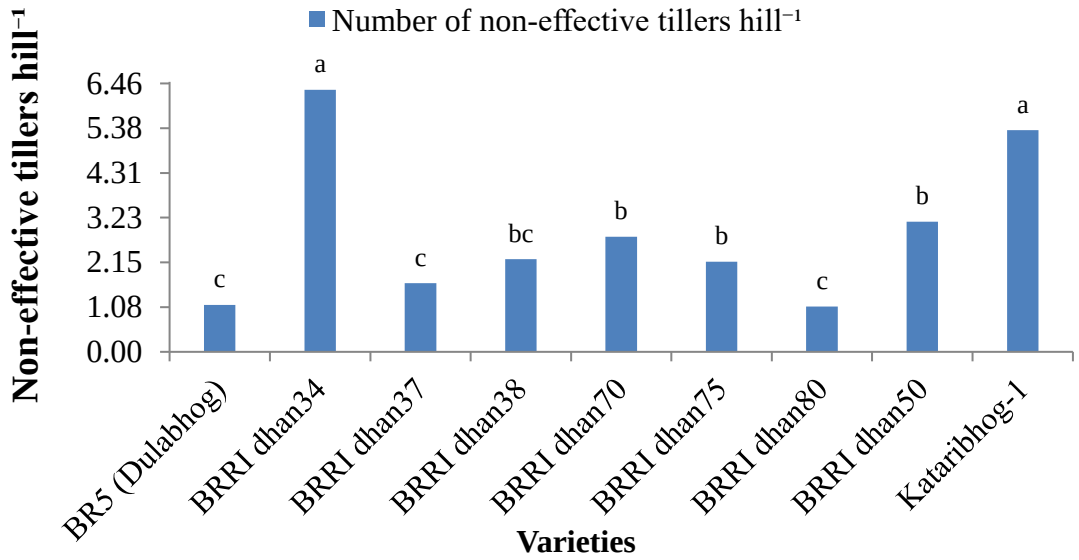

Figure 2. Effect of variety on number of non-effective tillers hill^{-1} of aromatic rice. (LSD value = 1.11)

4.5Number of leaves hill^{-1}

Different varieties of aromatic rice showed significant difference on the number of leaves hill^{-1} of rice varieties at 40 DAT, 80 DAT and at harvest (Table 3). The result revealed that at 40 DAT, 80 DAT and at harvest, the highest number of leaves hill^{-1} (66.50, 61.00 and 57.00, respectively) was observed in BRRI dhan80. On the other hand, the lowest number of leaves hill^{-1} at 40 DAT (47.70) was recorded from BRRI dhan34 which was statistically similar to BRRI dhan38 (47.80). At 80 DAT, the lowest number of leaves hill^{-1} (45.60) was recorded from BRRI dhan38. The lowest number of leaves hill^{-1} at harvest (42.00) was recorded from BRRI dhan38 which was statistically similar to Kataribhog-1 (43.00). Sarkar *et al*. (2014) also reported the same result with similar study that showed varietal effect can cause difference in number of leaves per hill.

Table 3. Effect of variety on number of leaves hill^{-1} of aromatic rice at different days after transplanting

Treatments	Number of leaves hill^{-1} at		
	40 DAT	80 DAT	Harvest
BR5 (Dulabhog)	55.50 e	58.50 b	55.00 b
BRRI dhan34	47.70 g	50.60 d	47.00 e
BRRI dhan37	63.50 b	57.50 b	53.00 c
BRRI dhan38	47.80 g	45.60 f	42.00 f
BRRI dhan70	57.30 d	55.00 c	51.00 d
BRRI dhan75	60.50 c	58.00 b	55.00 b
BRRI dhan80	66.50 a	61.00 a	57.00 a
BRRI dhan50	57.60 d	58.00 b	54.00 bc
Kataribhog-1	52.60 f	48.00 e	43.00 f
LSD (0.05)	**1.10**	**1.17**	**1.11**
CV (%)	**1.13**	**1.17**	**1.26**

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

4.6 Leaf area index

The leaf area index of aromatic rice was significantly influenced by different varieties (Figure 3). The results revealed that BRRI dhan37 showed the highest leaf area index (5.23) which was statistically similar to BRRI dhan75 (5.23). On the other hand, the lowest leaf area index (3.23) was recorded from BRRI dhan38. Kulandaivel *et al.* (2004) and Mustafa *et al.* (2011) also noted the similar finding.

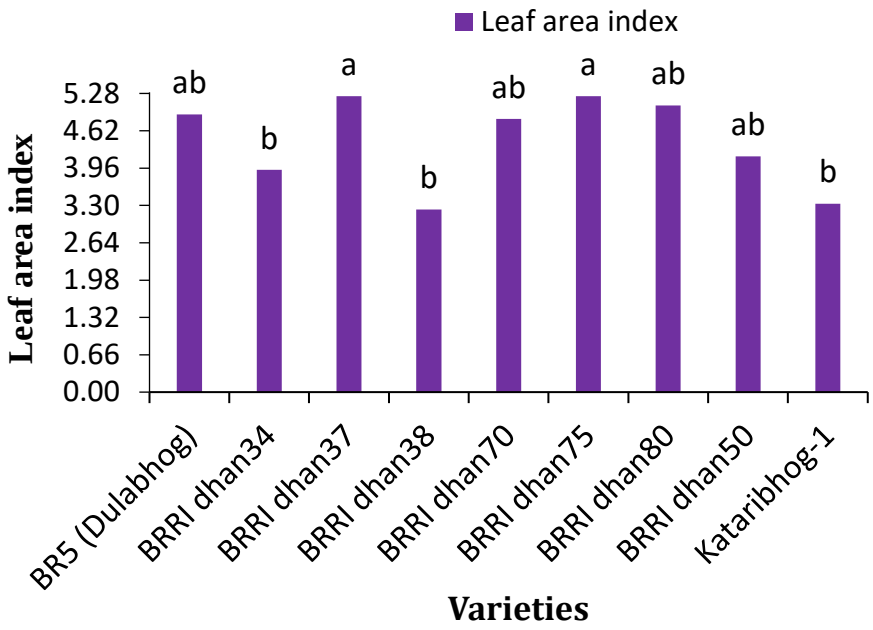

Figure 3. Effect of variety on leaf area index of aromatic rice. (LSD value = 1.13)

4.7 SPAD value

Different varieties of aromatic rice showed significant difference on the chlorophyll content of aromatic rice (Figure 4). The results revealed that BRRI dhan37 showed the highest chlorophyll content (48.98) which was statistically similar to BR5 (Dulabhog) (48.57). On the other hand, the lowest chlorophyll content (43.43) was recorded from Kataribhog-1. The findings of Islam *et al*. (2017), who discovered variation in chlorophyll concentration due to varietal difference, were similar to the results of the current study.

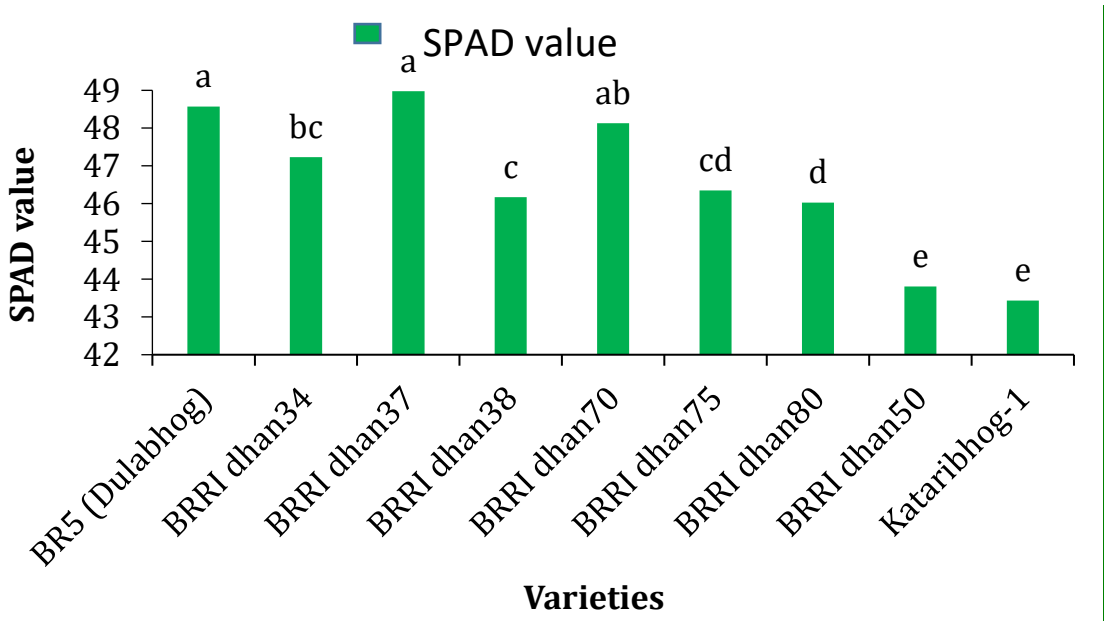

Figure 4. Effect of variety on SPAD value of different aromatic rice. (LSD value = 1.10)

4.8 Days to maturity

Different varieties of aromatic rice showed significant difference on days to maturity of aromatic rice (Figure 5). The results revealed that Kataribhog-1 showed the highest number of days to maturity (165 d). On the other hand, the lowest number of days to maturity (115 d) was recorded from BRRI dhan75. Similar findings were made by Islam (2011) with present study.

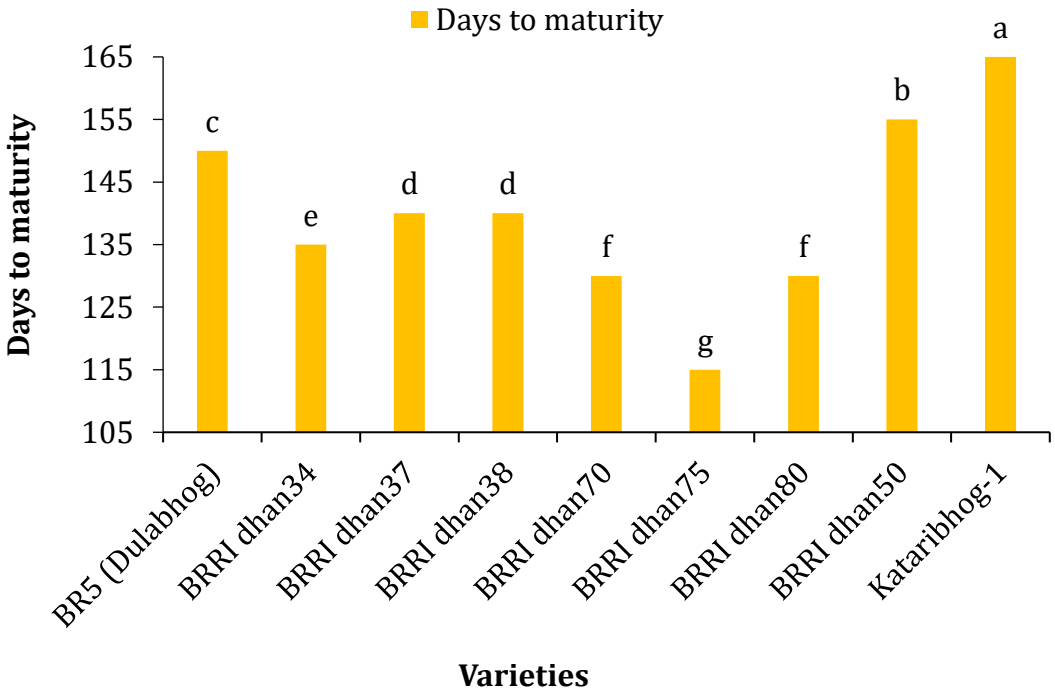

Figure 5. Effect of variety on days to maturity of aromatic rice. (LSD value = 1.10)

4.9 Filled grains panicle^{-1}

The number of filled grains panicle^{-1} of aromatic rice was significantly influenced by different varieties (Table 4). The results revealed that BRRI dhan37 showed the highest number of filled grains panicle^{-1} (210.00). On the other hand, the lowest number of filled grains panicle^{-1} (77.00) was recorded from BRRI dhan38. The findings of the current study were consistent with those found by Murthy *et al*. (2004) and Bhowmick and Nayak (2000).

4.10 Unfilled grains panicle^{-1}

Different varieties of aromatic rice showed significant difference on number of filled grains panicle^{-1} (Table 4). The results revealed that BRRI dhan34 showed the highest number of unfilled grains panicle^{-1} (33.00). On the other hand, the lowest number of unfilled grains panicle^{-1} (8.00) was recorded from BRRI dhan75.

4.11 Weight of 1000-grain

The weight of 1000-grains of aromatic rice were significantly influenced by different varieties (Table 4). The results revealed that BRRI dhan80 showed the highest weight of 1000-grains (26.13 g). On the other hand, the lowest weight of 1000-grains (11.53 g) were recorded from BR5 (Dulabhog) variety. The variations in grain weight between the different rice varieties have also been noted by Rashid *et al*. (2017), Rahman *et al*. (2002) and Sharma *et al*. (1999).

Table 4. Effect of variety on filled grains panicle^{-1}, unfilled grains panicle^{-1} and weight of 1000 grains of aromatic rice

Treatments	Filled grains panicle^{-1}	Unfilled grains panicle^{-1}	Weight of 1000-grain (g)
BR5 (Dulabhog)	161.00 b	27.00 b	11.53 e
BRRI dhan34	123.00 c	33.00 a	13.33 d
BRRI dhan37	210.00 a	16.00 d	15.74 c
BRRI dhan38	77.00 h	11.00 f	15.33 c
BRRI dhan70	121.00 d	13.00 e	22.52 b
BRRI dhan75	95.00 g	8.00 g	21.63 b
BRRI dhan80	115.00 e	10.00 f	26.13 a
BRRI dhan50	115.00 e	23.00 c	15.11 c
Kataribhog-1	101.00 f	24.00 c	14.75 c
LSD (0.05)	**1.13**	**1.25**	**1.10**
CV (%)	**5.10**	**3.48**	**3.68**

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

4.12 Total grains panicle^{-1}

Different varieties of aromatic rice showed significant difference on number of total grains panicle^{-1} (Figure 6). The results revealed that BRRI dhan37 showed the highest number of total grains panicle^{-1} (226). On the other hand, the lowest number of total grains panicle^{-1} (88) was recorded from BRRI dhan38. Similar finding is also found out by Rashid *et al*. (2017).

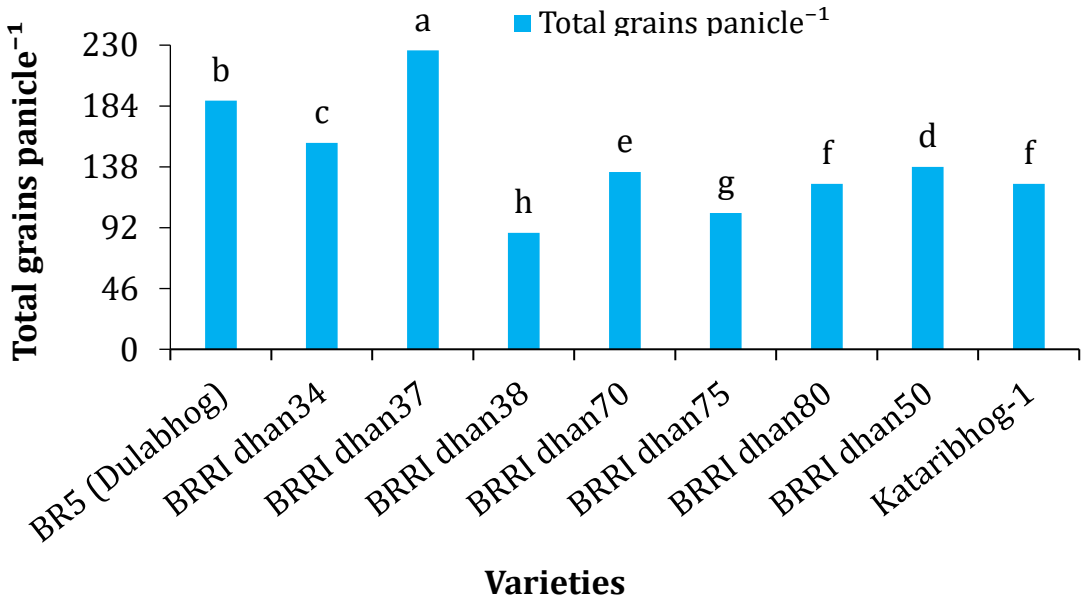

Figure 6. Effect of variety on total grains panicle^{-1} of aromatic rice. (LSD value = 2.21)

4.13 Sterility percentage

The sterility percentage of aromatic rice was significantly influenced by different varieties (Figure 7). The results revealed that BRRI dhan34 showed the highest sterility percentage (21.15%). On the other hand, the lowest sterility percentage (7.08%) was recorded from BRRI dhan37. Karim *et al*. (2007) also suggested that sterility percentage of different varieties are influenced.

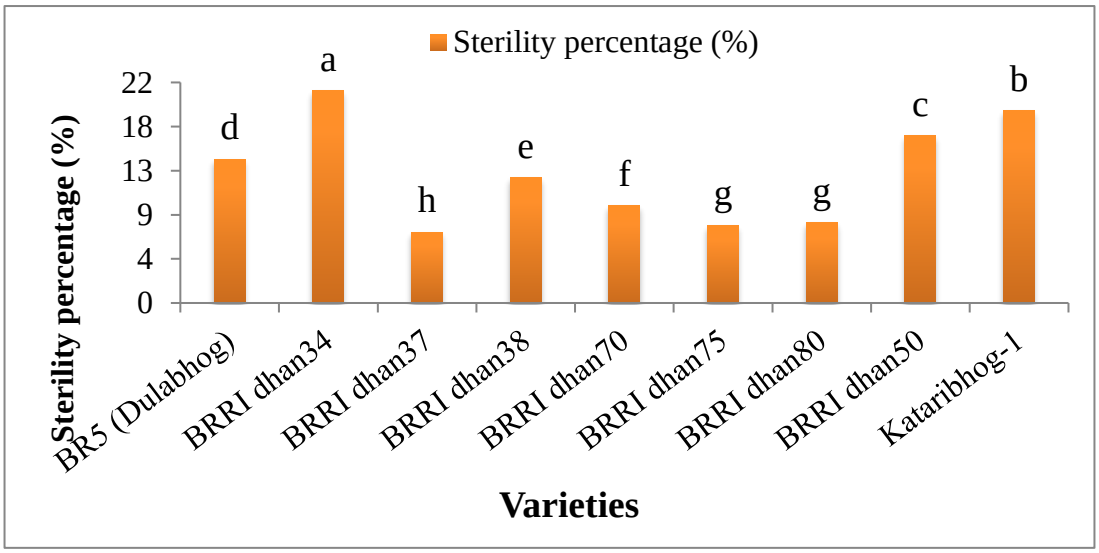

Figure 7. Effect of variety on sterility percentage (%) of aromatic rice. (LSD value = 0.67)

4.14 Grain yield

Different varieties of aromatic rice showed significant difference on grain yield (Table 5). The results revealed that BRRI dhan80 showed the highest grain yield (4.63 t ha^{-1})

which was statistically similar to BRRI dhan75 (4.33 t ha^{-1}) and BRRI dhan70 (4.21 t ha^{-1}). On the other hand, the lowest grain yield (2.29 t ha^{-1}) was recorded from BR5 (Dulabhog) which was statistically similar to BRRI dhan34 (2.45 t ha^{-1}), BRRI dhan50 (2.71 t ha^{-1}) and BRRI dhan38 (2.75 t ha^{-1}). Rashid *et al* (2017) and Islam *et al.* (2013) also stated that grain yield differed significantly among the varieties.

4.15 Straw yield

The straw yield of aromatic rice was significantly influenced by different varieties (Table 5). The results revealed that BRRI dhan37 showed the highest straw yield (6.13 t ha^{-1}) which was statistically similar to Kataribhog-1 (6.05 t ha^{-1}). On the other hand, the lowest straw yield (4.81 t ha^{-1}) was recorded from BR5 (Dulabhog) which was statistically similar to BRRI dhan34 (4.93 t ha^{-1}) and BRRI dhan75 (4.93 t ha^{-1}). Similar result was found by Hossain *et al*. (2008), Islam *et al*. (2013) and Rashid *et al*. (2017).

4.16 Biological yield

Different varieties of aromatic rice showed significant difference on biological yield (Table 5). The results revealed that BRRI dhan80 showed the highest biological yield (9.76 t ha^{-1}) which was statistically similar to BRRI dhan70 (9.54 t ha^{-1}) and BRRI dhan37 (9.36 t ha^{-1}). On the other hand, the lowest biological yield (7.10 t ha^{-1}) was recorded from BR5 (Dulabhog) which was statistically similar to BRRI dhan34 (7.38 t ha^{-1}). The result reported from the present study was same with the findings of Hossain *et al*. (2008) and Islam *et al*. (2013).

Table 5. Effect of variety on Grain, Straw and Biological yield of aromatic rice varieties

Treatments	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})
BR5 (Dulabhog)	2.29 d	4.81 b	7.10 c
BRRI dhan34	2.45 d	4.93 b	7.38 bc
BRRI dhan37	3.23 bcd	6.13 a	9.36 ab
BRRI dhan38	2.75 d	5.89 ab	8.64 abc
BRRI dhan70	4.21 abc	5.33 ab	9.54 ab
BRRI dhan75	4.33 ab	4.93 b	9.26 abc
BRRI dhan80	4.63 a	5.13 ab	9.76 a
BRRI dhan50	2.71 d	5.39 ab	8.10 abc
Kataribhog-1	3.13 cd	6.05 a	9.18 abc
LSD (0.05)	**1.10**	**1.12**	**2.21**
CV (%)	**9.32**	**11.82**	**14.67**

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

4.17 Harvest index

The harvest index of aromatic rice was significantly influenced by different varieties (Figure 8). The results revealed that BRRI dhan80 showed the highest harvest index (47.40%) which was statistically similar to BRRI dhan75 (46.72%) and BRRI dhan70 (44.08%). On the other hand, the lowest harvest index (31.68%) was recorded from BRRI dhan38 which was statistically similar to BR5 (Dulabhog) (32.24%) and BRRI dhan50 (32.91%). The obtained result is similar to those which were found by Roy *et al.* (2014), Islam *et al*. (2013) and Hossain *et al* (2008).

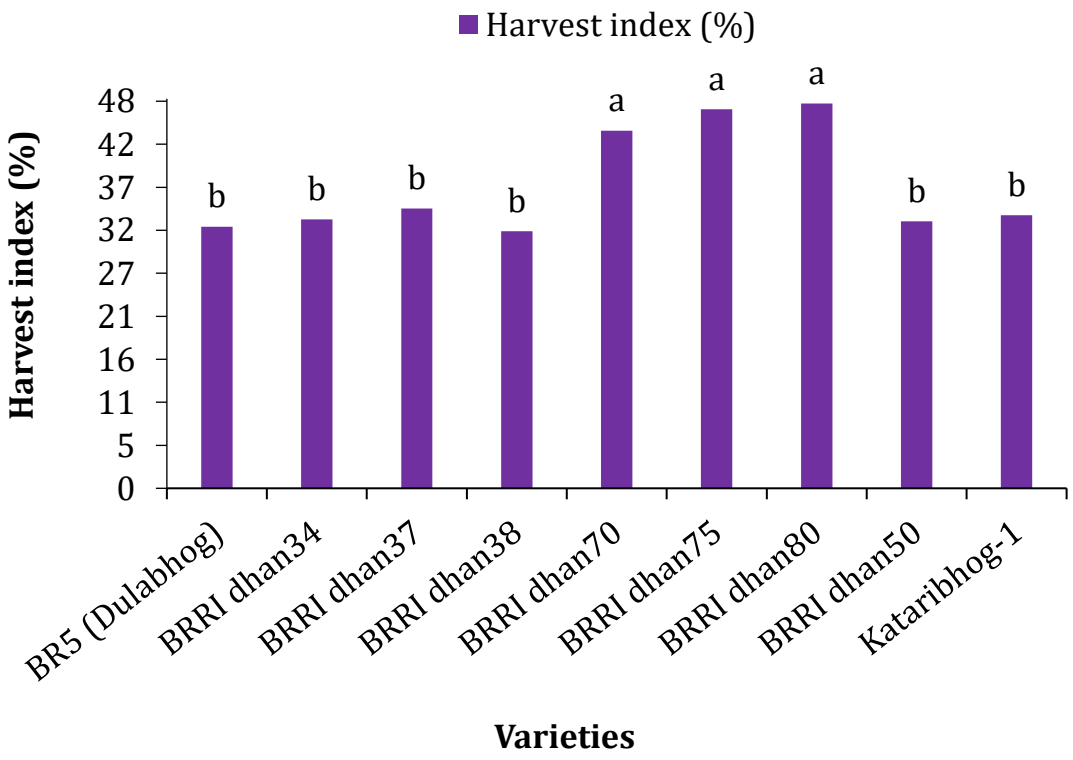

Figure 8. Effect of variety on harvest index (%) of aromatic rice. (LSD value = 3.53)

4.18 Yield advantages of HYV aromatic rice over check variety

A comparative performance of yield advantage of high yielding aromatic rice varieties over the check variety has been presented in tabular form in Table 6.

The yield hectare^{-1} for high yielding aromatic rice varieties ranged from 2.29 t (BR5 (Dulabhog) to 4.63 t (BRRI dhan80), with a mean of 3.33 t ha^{-1}.

The highest yield advantage was recorded from BRRI dhan80 over check variety Kataribhog-1 which was 47.92%. In case of BRRI dhan75, yield advantage over check variety Kataribhog-1 was 38.34% and BRRI dhan70 showed 34.50% higher yield over

the check variety. BRRI dhan37 showed 3.19% yield advantage. These four varieties showed positive yield advantage over the check variety under study.

BR5 (Dulabhog), BRRI dhan34, BRRI dhan38 and BRRI dhan50 did not have positive yield advantage over check variety Kataribhog-1.

From an on-farm evaluation trial in India, Mishra (2003) revealed that 17 released indica hybrids had a yield advantage of 18% to 44.9% above the standard check.

Table 6. Yield performance of selected aromatic rice varieties and check variety

Aromatic rice varieties	Grain yield (t ha^{-1})	Yield advantage over check variety (%)
BR5 (Dulabhog)	2.29	−26.84
BRRI dhan34	2.45	−21.73
BRRI dhan37	3.23	3.19
BRRI dhan38	2.75	−12.14
BRRI dhan70	4.21	34.50
BRRI dhan75	4.33	38.34
BRRI dhan80	4.63	47.92
BRRI dhan50	2.71	−13.42
Mean	3.33	
Check variety		
Kataribhog-1	3.13	_

4.19 Functional relationships among different parameters

a) Relationship between weight of 1000-grain and grain yield

Functional relationship analysis between weight of 1000-grain and grain yield revealed that, increase in weight of 1000-grain of aromatic rice was positively correlated with corresponding increase in grain yield (Figure 9). The higher the weight of 1000-grain, the higher the possibility of more grain yield of aromatic rice. The R-squared for the functional relationship model is 0.94, which means 94% of the variance in grain yield (t ha^{-1}) can be explained by weight of 1000-grain (g). The remaining 6% can be attributed to unknown, lurking variables or inherent variability.

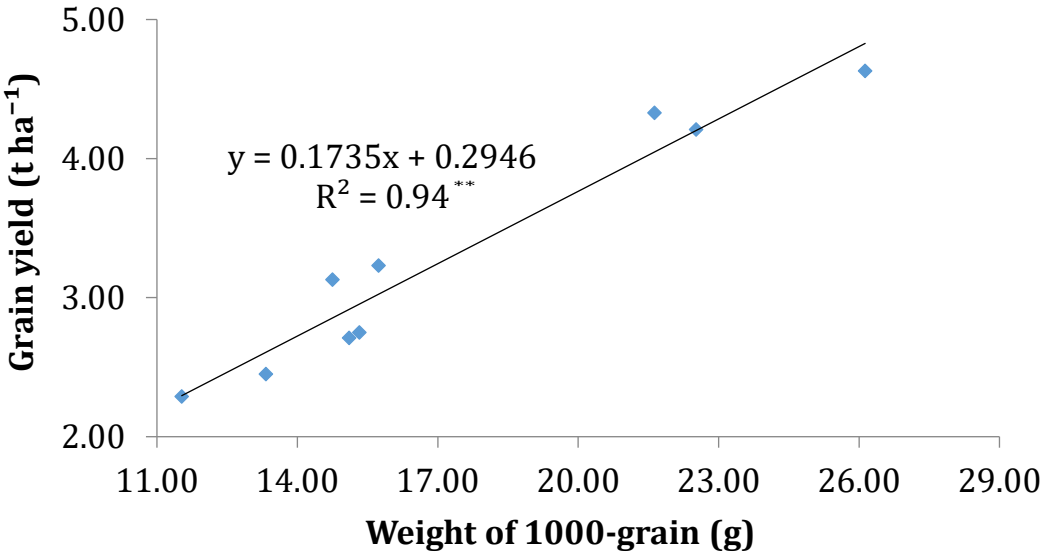

Figure 9. Relationship between the grain yield (t ha^{-1}) and weight of 1000-grain (g) for aromatic rice varieties. R^2 calculated as 5% significance.

b) Relationship Between grain yield and harvest index

Functional relationship analysis between grain yield and harvest index revealed that, increase in grain yield of aromatic rice was positively correlated with corresponding increase in harvest index (Figure 10). The higher the grain yield, the higher the possibility of greater harvest index of aromatic rice. The R-squared for the functional relationship model is 0.92, which means 92% of the variance in harvest index (%) can be explained by grain yield (t ha^{-1}). The remaining 8% can be attributed to unknown, lurking variables or inherent variability.

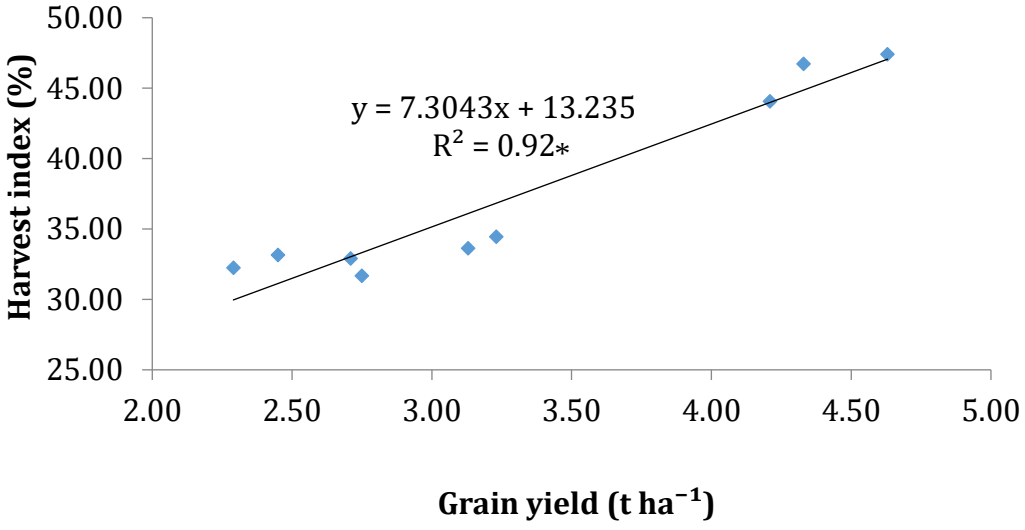

Figure 10. Relationship between the harvest index (%) and grain yield (t ha^{-1}) for aromatic rice varieties. R^2 calculated as 5% level of significance.

CHAPTER V

SUMMARY AND CONCLUSION

The field experiment was conducted at the Research Farm of the Department of Agricultural Botany, Sher-e-Bangla Agricultural University, during the period from November 2019 to May 2020 to evaluate the growth and yield performance of local and modern aromatic rice in *Boro* season. The experiment comprised of single factor where nine aromatic rice varieties were used as the test crops. The varieties were as follows: i) BRRI dhan5 (Dulabhog), ii) BRRI dhan34, iii) BRRI dhan37, iv) BRRI dhan38, v) BRRI dhan70, vi) BRRI dhan75, vii) BRRI dhan80, viii) BRRI dhan50 and ix) Kataribhog-1. This experiment was laid out in a randomized complete block design (RCBD) with three replications. Data were collected on different aspects of growth, yield attributes and yield of aromatic rice.

Significant differences existed among different aromatic rice varieties with respect to yield and yield attributing parameters. The result revealed that BRRI dhan80 exhibited its superiority to other tested variety in terms of seed yield (4.63 t ha^{-1}). The higher amount of yield from BRRI dhan80 was possibly aided by the highest number of leaves $hill^{-1}$ at harvest (57.00), the lowest number of non-effective tillers $hill^{-1}$ at harvest (1.09), the highest weight of 1000-grains (26.13 g), the highest biological yield (9.76t ha^{-1}) and harvest index (47.40%) than other tested varieties in this experiment. Among other varieties, BRRI dhan75 gave significantly better result compared with other varieties except BRRI dhan80 in some parameters like- number of leaves $hill^{-1}$ at harvest, leaf area index, days to maturity, number of unfilled grains $panicle^{-1}$, 1000-grains weight, sterility percentage, grain yield, biological yield and harvest index. On the other hand, the variety BRRI dhan5 (Dulabhog) returned with significantly the lowest grain yield (2.29 t ha^{-1}) among all the varieties under study.

The highest yield advantage was recorded from BRRI dhan80 over check variety Kataribhog-1 which was 47.92%. In case of BRRI dhan75, yield advantage over check variety Kataribhog-1 was 38.34% and BRRI dhan70 showed 34.50% higher yield over the check variety. BRRI dhan37 showed 3.19% yield advantage. These four varieties showed positive yield advantage over the check variety under study. BRRI dhan5 (Dulabhog), BRRI dhan34, BRRI dhan38 and BRRI dhan50 did not have positive yield advantage over check variety Kataribhog-1.

Functional relationship analysis between weight of 1000-grains and grain yield revealed that, increase in weight of 1000-grains of aromatic rice was positively correlated with corresponding increase in grain yield. The higher the weight of 1000-grains, the higher the possibility of more grain yield of aromatic rice. Similarly, increase in grain yield of aromatic rice was positively correlated with corresponding increase in harvest index. The higher the grain yield, the higher the possibility of greater harvest index of aromatic rice.

CONCLUSION

- BRRI dhan80 had highest grain yield compared to other varieties contributed by 1000 grain weight (26.13g) and biological yield (9.76 t ha^{-1}).
- It exhibited yield advantage (47.92%) over Kataribhog-1. BRRI dhan75, BRRI dhan70 and BRRI dhan37 also showed similar trend.
- BRRI dhan5 (Dulabhog) variety performed the worst among the nine varieties.

RECOMMENDATION

Considering the results of the present experiment, further studies in the following areas are suggested:

- BRRI dhan80 is to be cultivated for achieving higher yield in *Boro* season.
- Additional experiments with these varieties can be conducted in the transplanted *Aman* season.
- To justify the result further experiment can be done at different location in Bangladesh.

CHAPTER VI

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APPENDICES

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

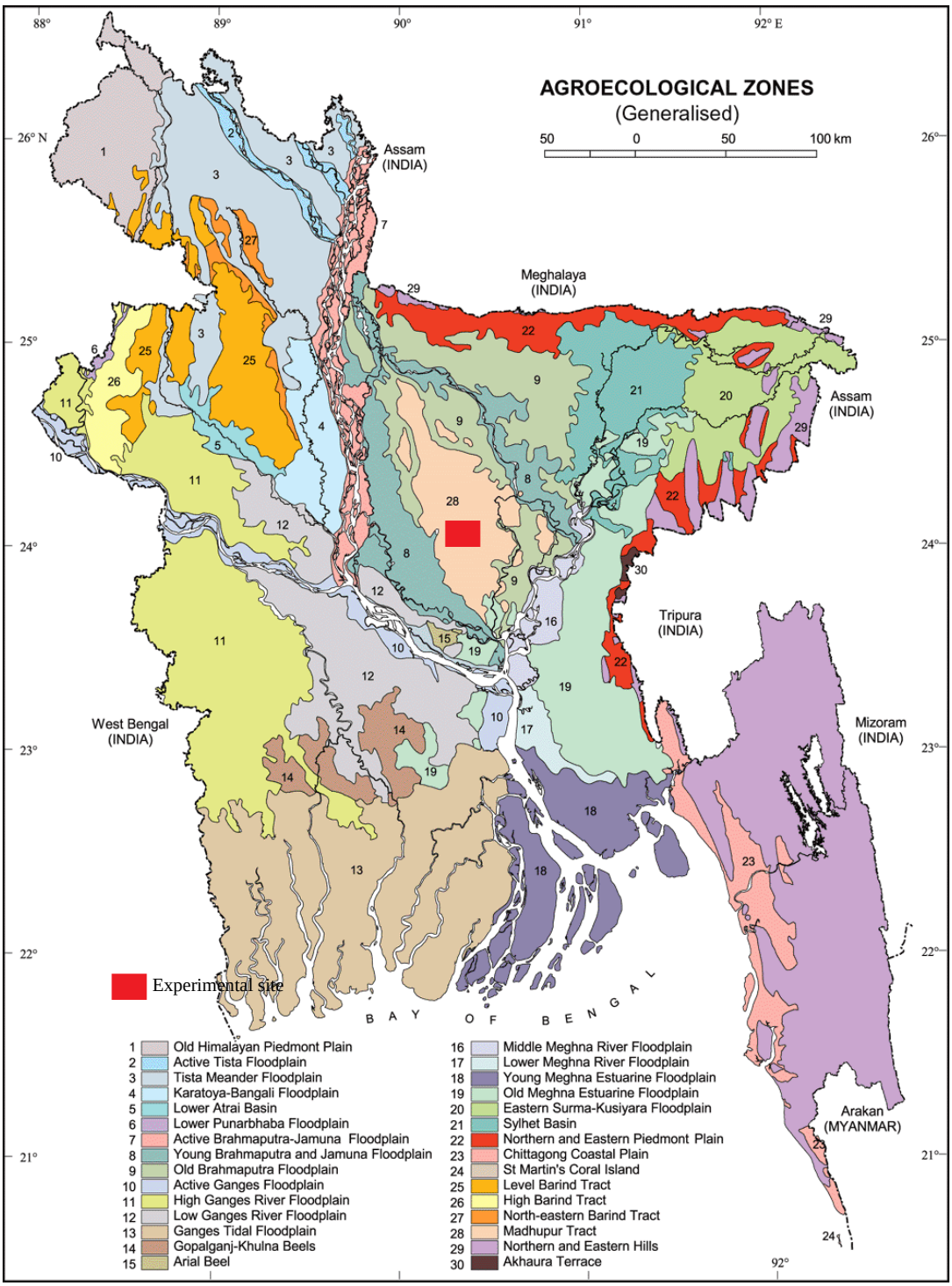

Figure 11. Experimental site

Appendix II. Monthly records of air temperature, relative humidity and rainfall during the period from November, 2019 to May, 2020

Year	Month	Air temperature (°C)			Relative humidity (%)	Rainfall (mm)
		Max	*Min*	*Mean*		
2019	November	28.60	8.52	18.56	56.75	14.40
2019	December	25.50	6.70	16.10	54.80	0.0
2020	January	23.80	11.70	17.75	46.20	0.0
2020	February	22.75	14.26	18.51	37.90	0.0
2020	March	35.20	21.00	28.10	52.44	20.4
2020	April	34.70	24.60	29.65	65.40	165.0
2020	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-28	Modhupur Tract
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 for experimental field

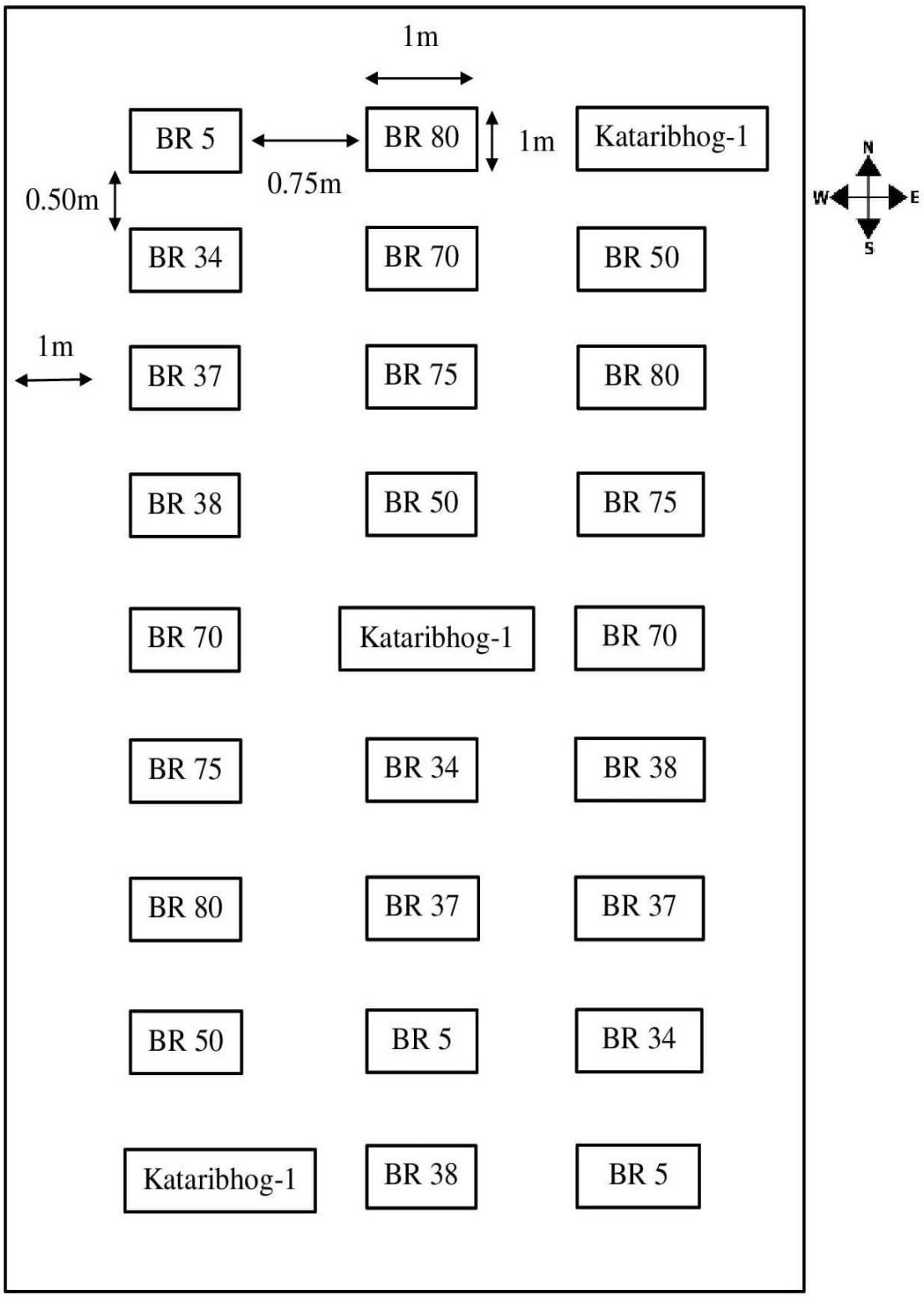

Figure 12: Layout of the experimental field

Appendix V. Analysis of variance (mean square) of plant height of aromatic rice

Source of variation	Degrees of freedom	Mean Square value of		
		Plant height at 40 DAT	Plant height at 80 DAT	Plant height at harvest
Varieties	**8**	469.71*	656.54*	1211.26*
Replications	**2**	0.02	0.02	0.02
Error	**16**	0.41	0.41	0.41
Total	**26**			

* indicates significant at 5% level of probability

Appendix VI. Analysis of variance (mean square) of total tillers per hill of aromatic rice

Source of variation	Degrees of freedom	Mean Square value of	
		Total tillers per hill at 40 DAT	Total tillers per hill at 80 DAT
Varieties	**8**	29.98*	26.13*
Replications	**2**	0.02	0.02
Error	**16**	0.41	0.41
Total	**26**		

* indicates significant at 5% level of probability

Appendix VII. Analysis of variance (mean square) of number of leaves hill^{-1} of aromatic rice

Source of variation	Degrees of freedom	Mean Square value of		
		Number of leaves hill^{-1} at 40 DAT	Number of leaves hill^{-1} at 80 DAT	Number of leaves hill^{-1} at harvest
Varieties	8	126.06*	85.63*	90.58*
Replications	2	0.02	0.02	0.02
Error	16	0.41	0.41	0.41
Total	26			

* indicates significant at 5% level of probability

Appendix VIII. Analysis of variance (mean square) of effective and non-effective tillers leaf characteristics of aromatic rice

Source of variation	Degrees of freedom	Mean Square value of			
		Number of effective tillers hill^{-1}	Number of non-effective tillers hill^{-1}	Leaf area index	Chlorophyll content
Varieties	**8**	25.55*	9.97*	1.89*	11.49*
Replications	**2**	0.02	0.02	0.02	0.02
Error	**16**	0.41	0.41	0.41	0.41
Total	**26**				

* indicates significant at 5% level of probability

Appendix IX. Analysis of variance (mean square) of yield attributes of aromatic rice

Source of variation	Degrees of freedom	Mean Square value of					
		Number of filled grains panicle^{-1}	Number of unfilled grains panicle^{-1}	Number of total grains panicle^{-1}	Weight of 1000-grains	Sterility percentage	Days to maturity
Varieties	**8**	4693.33*	228.00*	5422.58*	71.48*	82.03*	675*
Replications	**2**	0.02	0.02	0.09	0.02	9.9324 E-05	0.02
Error	**16**	0.41	0.41	1.63	0.41	0.15	0.41
Total	**26**						

* indicates significant at 5% level of probability

Appendix X. Analysis of variance (mean square) of yield and harvest index of aromatic rice

Source of variation	Degrees of freedom	Mean Square value of			
		Grain yield	Straw yield	Biological yield	Harvest index
Varieties	**8**	2.28*	0.77*	2.80*	131.9261*
Replications	**2**	0.02	0.02	0.09	0.30
Error	**16**	0.41	0.41	1.63	4.17
Total	**26**				

* indicates significant at 5% level of probability