STUDY ON YIELD AND GRAIN QUALITY OF SOME AROMATIC RICE VARIETIES

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CERTIFICATE

This is to certify that the thesis entitled **"STUDY ON YIELD AND GRAIN QUALITY OF SOME AROMATIC RICE VARIETIES"** submitted to the Department of Agronomy, 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 **AGRONOMY**, embodies the result of a piece of bonafide research work carried out by **TANJIM AL MASUD**, Registration No. **17-08311** 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.

Dated: December, 2018
Dhaka, Bangladesh

(Prof. Dr. Tuhin Suvra Roy)
Supervisor
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Dedicated to
My
Beloved Parents

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STUDY ON YIELD AND GRAIN QUALITY OF SOME AROMATIC RICE VARIETIES

ABSTRACT

A field experiment was conducted at Agronomy field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from June to December 2017 with seventeen aromatic rice varieties *viz*., V_1= Chiniatap 1, V_2 = Chiniatap 2, V_3 = Kataribhog 1, V_4 = Kataribhog 2, V_5 = BRRI dhan34, V_6 = BRRI dhan37, V_7 = BRRI dhan38, V_8 = BR5/Dulabhog, V_9 = Khoisanne, V_{10} = Sadasanne, V_{11} = Zirabhog, V_{12} = Begun bichi, V_{13} = Shakkhorkhora, V_{14} = Chinigura, V_{15} = Kalijira, V_{16} = Badshabhog, V_{17} = Modhumala to study on growth, yield and grain quality of some aromatic rice varieties. The experiment was laid out in a Randomized complete Block Design (RCBD) with three replications. Regarding growth and yield parameters, the highest number of total tillers hill^{-1} (23.33), leaf area index (5.38), flag leaf length (30.12 cm), number of effective tillers hill^{-1} (21.67), panicle length (32.00 cm), number of grains panicle^{-1} (230.3), number of filled grains panicle^{-1} (212.7), grain yield (3.42 t ha^{-1}), straw yield (6.19 t ha^{-1}) and number of biological yield (9.610 t ha^{-1}) were found in the variety, V_6 (BRRI dhan37) but the highest 1000 grains weight (22.80 g) and the highest harvest index (37.48%) were found in V_{17} (Modhumala) and V_5 (BRRI dhan34), respectively. The lowest number of effective tillers hill^{-1} (13.33), panicle length (24.67 cm), grain yield (1.583 t ha^{-1}), straw yield (4.083 t ha^{-1}), biological yield (5.667 t ha^{-1}) and harvest index (27.89%) were found in the variety, V_{17} (Modhumala). Regarding quality parameters, the highest hulling percentage (82.86%), milling degree (90.32%) and broken rice percentage (6.257%) found in the variety V_6 (BRRI dhan37) but the highest rice breadth (2.757 mm), boiled rice breadth (3.133 mm), protein percentage (10.03%) were found in the variety, V_{17} (Modhumala) whereas, the highest (1.727 mm) elongation ratio, rice length (6.217 mm), boiled rice length (8.600 mm), moisture percentage (13.67%), grain length (8.333 mm), milling recovery (72.29%) were found in the variety V_2 (Chiniatab 2), V_3 (Kataribhog 1), V_7 (BRRI dhan34), V_8 (BR5/dulabhog), V_9 (Khoisanne) and V_{16} (Badshabhog), respectively compared to all other varieties. From the above findings, it can be concluded that the rice variety V_6 (BRRI dhan37) showed the best performance in terms of yield and on the basis of grain quality parameters such as protein and amylose content, V_{17} (Modhumala) showed best performance. So, variety V_6 (BRRI dhan37) can be considered as best for yield purpose and V_{17} (Modhumala) for high protein and less amount of amylose among the studied varieties of aromatic rice.

LIST OF CONTENTS

LIST OF CONTENTS (Cont'd)

LIST OF CONTENTS (Cont'd)

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF APPENDICES

ABBREVIATIONS AND ACRONYMS

AEZ	=	Agro-Ecological Zone
BBS	=	Bangladesh Bureau of Statistics
BCSRI	=	Bangladesh Council of Scientific Research Institute
cm	=	Centimeter
CV %	=	Percent Coefficient of Variation
DAS	=	Days After Sowing
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 Celceous
%	=	Percentage
NaOH	=	Sodium hydroxide
GM	=	Geometric mean
mg	=	Miligram
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. Among the leading rice growing countries of the world, Bangladesh ranks fourth in both rice area and production (BRRI, 2007). It is the staple food of more than half of the world's population.

About 75.01% of total cropped area of Bangladesh is used for rice production, with annual production of 34.71 million tons from 11.28 million hectares of land (BBS, 2015). Most of the aromatic rice varieties in Bangladesh are of traditional type, photoperiod sensitive and are grown during Aman season in the rain fed low land ecosystem (Baqui and Das, 2000). In Northern districts of Bangladesh, 30% of the rice lands were covered by aromatic rice cultivars during Aman season (Islam *et al.*, 2012). In respect of production of aromatic rice, Dinajpur, Naogaon, Chittagong and Sherpur had 1st, 2^{nd}, 3^{rd} and 4^{th} position respectively in 2002-03 (Talukder *et. al.*, 2004). Aromatic rice varieties are rated best in quality and fetch much higher price in international market.

Growth is directly related to various morpho-physiological processes such as photosynthesis, respiration, enzyme activity etc. The growth analysis means the calculation of the components viz. CGR, RGR, AGR, etc. These components are widely used by plant physiologists and provide same indices of the plant responses to its environment. The yield of rice depends on its different growth parameters i.e. leaf area index, dry matter production and its partitioning, tillering, etc (Idris and Matin, 1990). Again the yield of rice also depends on high dry matter production, leaf area index, leaf area duration (LAD), crop growth rate (Yusuf, 1997).Aromatic and non-aromatic rice varieties are grown in Bangladesh and each of them possesses some special characteristics. The grain of some varieties are very small, some are fine, some of them are of different colors and some of

them have special appeal for their aroma. Aroma development in rice grain is influenced by both genetic and environmental factors. The biochemical basis of aroma was identified as 2-acetyl- 1-pyrroline (Tanchotikul and Hsieh, 1991). Aromatic rice is also named as scented rice or fragrant rice because of its natural chemical compounds which give it a distinctive scent or aroma when cooked. Aromatic rice commands a higher price than non-aromatic rice. Thus, aromatic or scented rice plays a vital role in international rice trading. Bangladesh has a bright prospect for export of fine rice thereby earning foreign exchange (Islam *et al.*, 2012). Fine rice is mainly used by the people for the preparation of palatable dishes like polau, khir, firny and jarda. The demand of aromatic rice in this country is increasing due to its special appeal for aroma and acceptability although grain yield is low. Aromatic rice is the most highly valued rice commodity in Bangladesh agricultural trade markets having small grain and pleasant aroma with soft texture upon cooking (Dutta *et al*., 1998). However, the price of fine rice, especially the aromatic rice is 2-3 times higher than that of coarse rice (Biswas *et al.*, 1992). Though it's yield is low but it requires less input compared to coarse rice.

It is, therefore, to evaluate the performance of yield and grain quality as no cultural practices have been undertaken as a factor(s) of study so there is no scope to develop appropriate cultural practices to potential yield. But research works on local aromatic rice genotypes is limited in Bangladesh in relation to their yield and grain quality characteristics. With conceiving the above scheme in mind, the present research work has been undertaken in order to fulfilling the following objectives:

1. To study the yield performance of 17 aromatic rice varieties.
2. To determine protein, moisture, amylose and aroma content of different aromatic rice varieties.

CHAPTER II

REVIEW OF LITERATURE

One of the major reasons of yield reduction of rice is varietal performance. 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:

Effect of variety

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.

Murshida *et al*. (2017) conducted an experiment with three varieties (cv. BRRI dhan28, BRRI dhan29 and Binadhan-14) and four water management systems to examine the effect of variety and water management system on the growth and yield performance of boro rice. At 100 DAT, the highest plant height, maximum number of tillers hill^{-1}, dry matter of shoot hill^{-1} and dry matter of root hill^{-1} were

obtained from BRRI dhan29 and the lowest values were found in Binadhan-14. Variety had significant effect on all the crop characters under study except 1000-grain weight. The highest grain yield was obtained from BRRI dhan29 and the lowest value was recorded from Binadhan-14.

Chowdhury *et al*. (2016) conducted an experiment 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. Variety significantly influenced the yield of aromatic rice. 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}).

Yuni Widyastuti *et al.* (2015) conducted a study with twenty-four experimental hybrid rice varieties. The results showed that grains yields were affected by locations, seasons, and genotypes. The genotypes × locations × seasons interaction effect was significant; therefore, the best hybrid was different for each location and season. A7/PK36 hybrid has the best performance in Batang during the dry season, while A7/PK40 and A7/PK32 are the best hybrids in the rainy season. In Sukamandi, nine hybrids were identified as better yielder than that of the check cultivar in the dry season, but not so in the rainy season.

Jisan *et al*. (2014) carried out an experiment 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. Among the varieties, BRRI dhan52 produced the tallest plant (117.20 cm), highest number of effective tillers $hill^{-1}$ (11.28), grains $panicle^{-1}$ (121.5) and 1000-grain weight (23.65 g) whereas the lowest values of these parameters were produced by BRRI dhan57. Highest grain yield (5.69 t ha^{-1}) was obtained from BRRI dhan52 followed by BRRI dhan49 (5.15 t ha^{-1}) and the

lowest one (4.25 t ha^{-1}) was obtained from BRRI dhan57.

Hasan *et al.* (2014) carried out an experiment to study the performance of two aman rice varieties (BRRI dhan31 and BRRI dhan41) under different planting methods (line sowing with sprouted seeds by drum seeder, haphazard transplanting and transplanting in line). The highest no. of total tillers m^{-2} (421.12), effective tillers m^{-2} (410.65) and grain yield (5.08 t ha-1) were recorded due to effect of the interaction of line sowing method with sprouted seeds by drum seeder and the variety BRRI dhan41.

Sarkar *et al*. (2014) 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.

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.

Haque *et al.* (2013) conducted an experiment to evaluate some physiological traits and yield of three hybrid 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.

Anwar and Begum (2010) reported that time of tiller separation of rice significantly influenced plant height, total number of tiller $hill^{-1}$, number of bearing tillers and panicle length but grain and straw yields were unaffected. Therefore, Sonarbangla-1 appeared to be tolerant to tiller separation and separation should be done between 20 to 40 DAT without hampering grain yield.

Abou-Khalif (2009) conducted an experiment for physiological evaluation of some hybrid 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}). Hybrid variety Sonarbangla-1 and inbred modern variety BRRI dhan 31 and BRRI hybrid dhan-l to compare the growth and yield behavior of hybrid and inbred rice varieties under controlled condition. BRRI dhan 3l had about 10-15% higher plant

height, very similar tillers/plant, 15-25% higher leaf area at all days after transplanting (DAT) compared to Sonarbangla-1. Sonarbangla-1 had about 40% higher dry matter production at 25 DAT but had very similar dry matter production at 50 and 75 DAT, 4-11% higher rooting depth at all DATs, about 22% higher root dry weight at 25 DAT, but 5-10% lower root dry weight at 50 and 75 DAT compared to BRRI dhan31. The photosynthetic rate was higher (20 μ mol m^{-2} sec^{-1}) in BRRI dhan3l at 35 DAT (maximum tillering stage) but at 65 DAT, Sonarbangla-l had higher photosynthetic rate of 19.5 μ mol m^{-2} sec^{-1}. BRRI dhan3l had higher panicles $plant^{-1}$ than Sonarbangla-1, but Sonarbangla-1 had higher number of grains $panicle^{-1}$, 1000-grain weight and grain yield than BRRI dhan 31.

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.BRRI dhan32 and Sonarbangla-1; and (b) tiller separation days: 20, 25, 30, 35 and 40 days after mother plant transplantation. Maximum filled grains $panicle^{-1}$ (144.28) was observed from the tiller separation at 20 DAT. Total and effective tillers $hill^{-1}$ was affected by tiller separation beyond 30 DAT. Delayed tiller separation extended the flowering and maturity duration. Therefore, it was concluded that earlier tiller separation (20-30 DAT) resulted higher grain yield in hybrid variety but no such variations was observed in inbred variety.

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.

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%.

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

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

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

of filled grains and had lower spikelet sterility (25.85%) compared to the others.

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.

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

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

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.

Bhowmick and Nayak (2000) conducted an experiment with two hybrids (CNHR2 and CNHR3) and two high yielding varieties (IR36 and IR64) of rice and five levels of nitrogenous fertilizers. They observed that CNHR2 produced more number of productive tillers (413.4 m^{-}) and filled grains $panicle^{-1}$ (111.0) than other varieties, whereas IR36 gave the highest 1000- grain weight (21.07 g) and number of panicles m^{-} than other tested varieties. In a trial, varietal differences in

harvest index and yield examined using 60 Japanese varieties and 20 high yielding varieties bred in Asian countries. It was reported that harvest index varied form 36.8% to 53.4%. Mean values of harvest index were 43.5% in the Japanese group and 48.8% in high yielding group. Yield ranged from 22.6 g plant^{-1} to 40.0g plant^{-1}.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted at the experimental field of Sher-e-Bangla Agricultural University, Dhaka during the period from July 2017 to December 2017.This chapter deals with a brief description on experimental site, climate, soil, landpreparation, layout, experimental design, intercultural operations, data recording andtheir analysis.

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 17 aromatic rice varieties were considered as the treatment for the present study. The respected varieties were as follows:

1) V_1 = Chiniatap 1
2) V_2 = Chiniatap 2
3) V_3 = Kataribhog 1
4) V_4 = Kataribhog 2
5) V_5 =BRRI dhan34
6) V_6 = BRRI dhan37
7) V_7= BRRI dhan38
8) V_8 = BR5(Dulabhog)
9) V_9 = Khoisanne
10) V_{10}= Sadasanne
11) V_{11}= Zirabhog
12) V_{12} = Begun bichi
13) V_{13} =Shakkhorkhora
14) V_{14} =Chinigura
15) V_{15} =Kalijira
16) V_{16} =Badshabhog
17) V_{17} =Modhumala

3.5 Plant materials and collection of seeds

Seventeen local aromatic rice varieties viz. Chiniatap 1,Chiniatap 2,Kataribhog 1,Kataribhog 2, BRRI dhan34,BRRI dhan37, BRRI dhan38, BR5(Dulabhog), Khoisanne, Sadasanne, Zirabhog, Begun bichi,Shakkhorkhora,Chinigura,Kalijira, Badshabhog, and Modhumala were used as plant materials for the present study. The seeds of local varieties was 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 July 12, 2017 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 last week of July 2017 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 and manure 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
Borax	10

The fertilizers N, P, K, S, Zn and B in the form of urea, TSP, MP, gypsum, zinc sulphate and borax, respectively were applied. The entire amount of TSP, MP, gypsum, zinc sulphate and borax 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

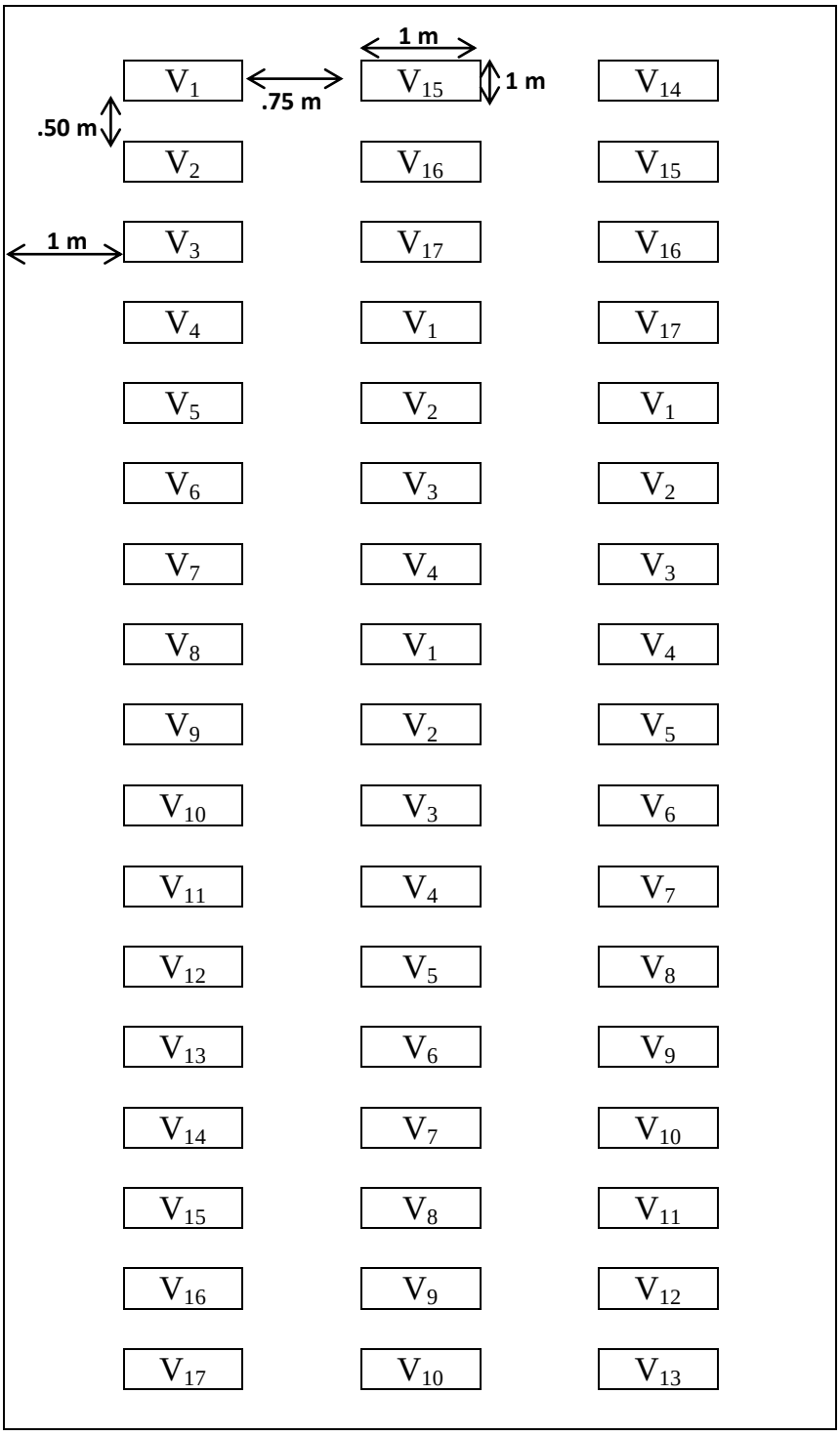
The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Each block was first divided into 17 sub plots where varieties of rice were assigned. Thus the total number of unit plots was 17×3=51. The size of the unit plot was 1m × 1m. The distance maintained between the row was 0.75m and between column was 0.5m. The treatments (varieties) were randomly assigned to the plots within each block.

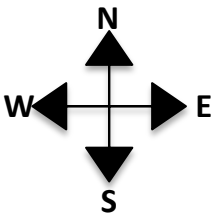
3.11 Uprooting of seedlings

The nursery bed was made wet by application of water one day before uprooting the seedlings. The seedlings were uprooted on August 6, 2017 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 August 6, 2017 with a spacing 20 cm from row to row and 15 cm from hill to hill.





Plot size = 1 m × 1 m
Sub-plot to sub-plot = 0.5 m
Plot to plot = 0.75 m

Factor:
V_1= Chini atap 1,
V_2 = Chini atap 2,
V_3 =Katari bhog 1,
V_4 =Katari bhog 2,
V_5 =BRRI dhan34,
V_6 = BRRI dhan37,
V_7 =BRRI dhan38,
V_8 =BR5 Dulabhog,
V_9 =Khoisanne,
V_{10} =Sadasanne,
V_{11} = Zirabhog,
V_{12} =Begun bichi,
V_{13} = Shakkhorkhora,
V_{14} =Chinigura,
V_{15} =Kalijira,
V_{16} = Badshabhog,
V_{17} = Modhumala

Figure 1. Layout of the experimental plot

3.13 Intercultural operations

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

3.14 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.

3.15 Gap filling

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

3.16 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.

3.17 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.

3.18 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}.

3.19 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.

3.20 Recording of data

The following data were recorded during the study period.

3.21 Detailed procedure of recording data

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

3.20.1 Growth parameters

1. Plant height (cm)
2. Number of leaves hill^{-1}
3. Number of total tillers hill^{-1}
4. Leaf area index
5. Flag leaf length (cm)
6. Flag leaf breadth (cm)
7. Flag leaf area (cm^2)

3.20.2 Yield and yield contributing parameters

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

4. Panicle length (cm)
5. Number of total grains panicle^{-1}
6. Number of filled grains panicle^{-1}
7. Number of unfilled grains panicle^{-1}
8. Sterility percentage
9. Weight of 1000 grain (g)
10. Grain yield (t ha^{-1})
11. Straw yield (t ha^{-1})
12. Biological yield (t ha^{-1})
13. Harvest index (%)

3.20.3 Grain quality parameters

1. Paddy weight (g)
2. Brown rice weight (g)
3. Milled rice weight (g)
4. Head rice weight (g)
5. Broken rice weight (g)
6. Hulling percentage (%)
7. Milling recovery (%)
8. Milling degree (%)
9. Head rice recovery (%)
10. Broken rice percentage (%)
11. Grain length (mm)
12. Kernel length (mm)
13. Kernel breadth (mm)
14. Boiled rice length (mm)
15. Boiled rice breadth (mm)
16. Elongation ratio (mm)
17. Protein percentage (%)

18. Moisture percentage (%)
19. Amylose percentage (%)
20. Aroma

3.20.1.1 Plant height

The height of plant was recorded in centimeter (cm) at the time of 25, 50, 75 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 plant.

3.20.2.2 Number of leaves hill^{-1}

Number of leaves hill^{-1} was counted from the average of same 4 hills pre-selected at random from the inner rows of each plot.

3.20.3.3 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 4 hills pre-selected at random from the inner rows of each plot.

3.20.4.4 Leaf area index

LAI = leaf length × leaf breadth × correction value 0.76

3.20.5.5 Flag leaf length (cm)

Flag leaf length was measured with a meter scale from 4 pre-selected plants from the inner rows of each plot.

3.20.6.6 Flag leaf breadth (cm)

Flag leaf breadth was measured with a meter scale from 4 pre-selected plants from the inner rows of each plot.

3.20.7.7 Flag leaf area (cm^2)

Flag leaf area was calculated by multiplying length and breadth of the leaf from 10 selected plants and the mean values were recorded.

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

The total number of effective tillers $hill^{-1}$ was counted from 4 selected plants at harvest and average value was recorded.

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

The total number of non-effective tillers $hill^{-1}$ was counted from 4 selected plants at harvest and average value was recorded.

3.20.2.3 Number of total grains $panicle^{-1}$

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

3.20.2.4 Number of filled grains $panicle^{-1}$

The total number of filled grains was collected randomly from selected 4plants of a plot and then average number of filled grains $panicle^{-1}$ was recorded.

3.20.2.5 Number of unfilled grains $panicle^{-1}$

The total number of unfilled grains was collected randomly from selected 4 plants of a plot and then average number of unfilled grains $panicle^{-1}$ was recorded.

3.20.2.6 Sterility percentage

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

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

3.20.2.7 Panicle length (cm)

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

3.20.2.8 Weight of 1000 grains (g)

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.

3.20.2.9 Grain yield (t ha^{-1})

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.

3.20.2.10 Straw yield (t ha^{-1})

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}.

3.20.2.11 Biological yield (t ha^{-1})

Biological yield was determined using the following formula

Biological yield = Grain yield + Straw yield

3.20.2.12 Harvest index (%)

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

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

3.20.3.1 Grain quality characteristics

1. Paddy weight (g)

Seventeen aromatic paddy (100 g) was weighed by digital weighing machine and recorded in gram (g).

2. Brown rice weight (g)

After removing husk brown rice was weighed by digital weighing machine and recorded in gram (g).

3. Milled rice weight (g)

After milling of brown rice milled rice was weighed by digital weighing machine and recorded in gram (g).

4. Head rice weight (g)

Unbroken head rice were identified after milling of 100 g brown rice of each variety and weighed by digital weighing machine and recorded in gram (g).

5. Broken rice weight (g)

Broken head rice were identified after milling of 100 g brown rice of each variety and weighted by digital weighing machine and recorded in gram (g).

6. Hulling percentage (%)

One-hundred grams of dried (12% moisture) paddy grain samples I,e.rough rices were dehulled in a satake laboratory sheller. Moisture was determined by grain analyzer. The samplewas poured into the hopper. Samples with many partially

filled grains of reduced thickness, usually require two passes and the weight of the dehusked kernels were recorded. Hulling percentage was computed as:

$$\text{Hulling percentage (HP)} = \frac{\text{Weight of dehusked kernel}}{\text{Weight of paddy}} \times 100$$

7. Milling recovery or milling percentage (%)

The dehulled brown rice sample was poured into the hopper. Then the resulting brown rice was milled in MeGill mill number 2 . Milling out turn was calculated with the following formula.

Milling recovery was computed by dividing the weight of milled rice recovered by the weight of the rough rice i.e. paddy sample.

$$\text{Milling recovery} = \frac{\text{Weight of milled rice}}{\text{Weight of rough rice}} \times 100$$

8. Milling degree (%)

According to Rice Knowledge Bank milling degree is computed on the basis of the amount of bran removed from the brown rice. To obtain the weight of brown rice, using laboratory huller the paddy samples were dehulled. Then using an abrasive whitener, dehulled samples were milled. The milling degree was computed using the following equation:

$$\text{Milling degree} = \frac{\text{Weight of milled rice}}{\text{Weight of brown rice}} \times 100$$

9. Head rice recovery (%)

According to Rice Knowledge Bank using a grain grader, separate the broken grains from the whole grains. Compute the percentage of the milling recovery component using the following equation:

$$\text{Head rice recovery} = \frac{\text{Weight of head rice}}{\text{Weight of paddy sample}} \times 100$$

10. Broken rice percentage (%)

According to Rice Knowledge Bank using a grain grader, separate the broken grains from the whole grains. Compute the percentage of the broken rice using the following equation:

$$\text{Broken rice percentage} = \frac{\text{Weight of broken grains}}{\text{Weight of paddy sample}} \times 100$$

11. Grain length (mm)

The lengths of ten randomly select paddies were measured with the help of a slide calipers and the average value was expressed in mm.

12. Kernel length (mm)

The lengths of ten randomly select paddies were measured with the help of a slide calipers and the average value was expressed in mm.

13. Kernel breadth (mm)

Thebreadth of ten randomly select paddies were measured with the help of a slide calipers and the average value was expressed in mm.

14. Kernel boiled

Operation	Purpose	Duration
Boiling	To cook rice sample at 100^0 C temperature	20 min
Cooling	Rice sample were kept at room temperature for cooling	10 min
Headspace generation	To accumulate adequate volatile compounds before sampling	30 sec
Releasing vapor	Sensor array is exposed to release the vapor of aromatic rice.	80 sec
Purging	Cleaning the sensor surface with blow of fresh air so that the sensor output returns to the baseline value.	80 sec

15. Boiled rice length (mm)

After the rice is cooked then the length and breadth of the perfect boiled kernels were calculated.

16. Boiled rice breadth (mm)

After the rice is cooked then the length and breadth of the perfect boiled kernels were calculated.

17. Elongation ratio (mm)

Each sample was cooked in a water bath at 100**°C** for 20 min. The cooked rice was then transferred to a petridish lined with filter paper. Ten cooked whole rice were measured by a digital verneer caliper.

$$ER = \frac{\text{Average length of cooked rice grains (mm)}}{\text{Average length of raw rice grains (mm)}}$$

18. Protein percentage (%)

The 100 seeds of each variety were de- husked by hand to get them as brown rice and then protein % were calculated with the help of test Kjeldahl meter.

Protein was measured grain analyzer Infraec^{TM} [24]

19. Moisture percentage (%)

Moisture was measured grain analyzer Infraec^{TM} [24]

20. Amylose percentage (%)

Amylose content of rice sample was carried out using method by Juliano(1971). Amylose in starch is released by treatment with dilute alkali. By the addition of Tri-iodide ion, amylose produces blue color. Then the absorbance of blue color produced in aqueous solution was measured:

Regents used under determination:-

a) Acetic Acid, 1 N
b) NaOH, 1 N
c) Ethanol, 95%
d) Stock iodine solution, 0.2% in 2.0% KI
e) Amylose, purified (NBC, Stein Hall, Sigma)

Hundred mg of rice powder was accurately taken into a 100 mL volumetric flask and 1 mL (95%) ethanol and 9 mL NaOH (1N) were added carefully. Then the flask was incubated overnight at room temperature to gelatinize the starch and then made the volume up to the mark with distilled water. About 5 mL portion of the starch solution was pipette into another 100 mL volumetric flask and 1 mL (1N) glacial acetic acid; 2 mL of iodine solution were added and made the volume up to the mark with distilled water. Shake the mixture and after waiting 20

minutes, absorbance was measured at 620 nm in a spectrophotometer (Spectronic 20).

$$\text{Amylose (\%)} = \frac{\text{Absorbance} \times \text{slope} \times \text{dilution factor} \times 100}{\text{Weight of sample (mg)}}$$

Amylose was measured grain analyzer Infraec^{TM} [24]

21. Aroma

In 5 g of rice 15 ml of water was added, soaked for 10 min and cooked for 15 min, transferred into a Petri dish and placed in refrigerator for 20 min. Then the cooked rice was smelled by a random panel which shows strongly scented(SS), moderate scented(MS), mild-scented(MiS). Ten (10) undergraduate and post-graduate students were randomly selected to take the smell from random panel. Based on their highest number responses the varieties were categorized in SS, MS, and MiS as described above.

22. Statistical analysis

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

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to study morpho-physiological attributes and yield performance of different aromatic rice genotypes. The results obtained from the study have been presented, discussed and compared 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 difference presented in the (Table 1 and Appendix IV). Plant height increased progressively with the advancement of time and growth stages. At vegetative stage, 25 DAT, among the varieties the highest (54.47) plant height was observed in the variety, V_{17} (Modhumala). On the other hand, the lowest (38.4) plant height was observed in V_{13} (Shakkhorkhora) which was statistically similar to the variety, V_5(BRRI dhan34). At 50 DAT, among the varieties the highest (105.8) plant height was observed in V_{17} (Modhumala). On the other hand, the lowest (76.20) plant height was observed in the variety, V_5 (BRRI dhan34). At the reproductive phase (75 DAT), the highest plant height was achieved from (Modhumala) V_5 (139.2cm) and the shortest plant was recorded in V_{14}(112.1cm) followed by V_3(112.6cm) and V_{16}(112.6cm) same statistical rank, V_7 (113.2cm) and V_9(113.3cm) also statistically similar. At harvest, among the varieties the highest (162.8cm) plant height was observed in the variety, V_{16} (Badshabhog) which wasstatisticaly same with V_{17}(Modhumala). On the other hand, the lowest (137.3cm) plant height was observed in the variety,V_9 (Khoisanne) which was statisticaly same with V_2(Chini Atab2). Simillar results was also reported by Sinha *et al*. (2009) , Sarker *et al.* (2013) and (Anwar and

Begum, 2010). Which supported the present study. They studied the performance of aromatic rice varieties and found that plant height varied significantly among the varieties after transplanting which increased up to maturity, justifying the present experiment.

Table1. Plant height of 17 aromatic rice varieties

Treatment	Plant height (cm) at			
	25 DAT	50 DAT	75 DAT	Harvest
V_1	48.33 b	84.67 e	114.3 fg	154.5 de
V_2	40.33 gh	87.33 cd	129.5 b	153.7 de
V_3	40.83 g	81.27 g	112.6 h	138.1 g
V_4	47.33 bc	88.23 c	127.5 c	149.5 f
V_5	39.00 hi	76.20 i	114.3 fg	156.3 cd
V_6	48.73 b	88.50 c	114.8 f	152.3 e
V_7	48.50 b	84.77 e	113.2 gh	154.1 de
V_8	40.67 g	79.00 h	115.3 f	152.8 e
V_9	43.33 f	80.83 g	113.3 gh	137.3 g
V_{10}	43.67 f	80.67 g	114.4 fg	155.7 cd
V_{11}	46.43 cd	82.63 f	114.0 fg	157.8 bc
V_{12}	44.33 ef	81.83 fg	114.2 fg	157.8 bc
V_{13}	38.40 i	91.67 b	126.1 d	159.9 b
V_{14}	45.67 de	84.67 e	112.1 h	159.9 b
V_{15}	48.47 b	90.50 b	123.6 e	157.5 bc
V_{16}	45.33 de	86.33 d	112.6 h	162.8 a
V_{17}	54.47 a	105.8 a	139.2 a	162.7 a
$LSD_{0.05}$	1.430	1.209	1.338	2.693
CV(%)	6.91	7.85	8.68	10.87

Values followed by same letter(s) did not differ significantly at 5% level of probability

V_1= Chiniatap 1, V_2 = Chiniatap 2, V_3 =Kataribhog 1, V_4 =Kataribhog 2, V_5 =BRRI dhan34, V_6 = BRRI dhan37, V_7 =BRRI dhan38, V_8 =BR5 Dulabhog, V_9 =Khoisanne, V_{10} =Sadasanne, V_{11} = Zirabhog, V_{12} =Begun bichi, V_{13} = Shakkhorkhora, V_{14} =Chinigura, V_{15} =Kalijira, V_{16} = Badshabhog, V_{17} = Modhumala

4.1.2 Number of leaves hill^{-1}

Significant difference on total number of leaves hill^{-1} in the rice varieties was observed from vegetative (25 DAT) to reproductive (75 DAT) stage (Table 2 Appendix V). The total number of leaves was continued to increase up to 75 DAT and thereafter declined. For 25 DAT, among the varieties tested, the highest number of leaves hill^{-1} was recorded in V_2 (27.83)and statistically similar number of leaves found in V_7 (27.43). The lowest number of leaves hill^{-1} was recorded in V_{13} (20.33) which was significantly lower than any other variety. For 50 DAT, the highest number of leaves hill^{-1} was recorded in V_2 (70.57) which was significantly higher than any other varieties. The lowest number of leaves hill^{-1} was recorded in V_{16} (43.33) which was significantly lower than any other varieties. For 75 DAT, the highest number of leaves hill^{-1} was recorded in V_2 (69.09) which was significantly higher than any other varieties. The lowest number of leaves hill^{-1} was recorded in V_{17} (41.00) which was lower than any other varieties. At maturity, the highest number of leaves hill^{-1} was recorded in V_2 (65.26) which was significantly higher than any other varieties. The lowest number of leaves hill^{-1} was recorded in V_{17} (37.25) which was significantly lower than any other varieties. Simillar results also reported by Yin and Kropff (1998), Streck *et a.* (2008), Sie *et al.* (1998), Haque *et al.* (2013), Sarker *et al.* (2013) and Abou-Khalif (2009) showed that leaf number varied among seven rice cultivars.Temperature, photoperiod and genetic characteristics are major factors that determine the leaf number in rice.

Table 2. Number of leaves hill^{-1} of 17 aromatic rice varieties

Treatment	Number of leaves hill^{-1} at			
	25 DAT	50 DAT	75 DAT	Harvest
V_1	22.90 ef	53.77 g	57.03 e	54.37 d
V_2	27.83 a	70.57 a	69.09 a	65.26 a
V_3	22.80 efg	67.38 b	62.57 bc	59.66 b
V_4	22.74 efg	60.01 d	56.92 e	53.09 f
V_5	22.64 efg	66.99 b	62.33 cd	59.30 b
V_6	26.75 b	63.69 c	57.95 e	54.04 de
V_7	27.43 ab	60.67 d	61.57 cd	57.82 c
V_8	24.10 d	64.03 c	61.19 d	57.49 c
V_9	21.50 h	60.01 d	62.21 cd	58.03 c
V_{10}	23.34 de	60.75 d	57.81 e	53.54 ef
V_{11}	25.00 c	59.10 de	52.02 g	48.36 h
V_{12}	23.20 ef	56.90 f	53.99 f	51.09 g
V_{13}	20.33 i	57.34 ef	54.53 f	50.78 g
V_{14}	22.43 fg	53.78 g	63.81 b	59.35 b
V_{15}	22.03 gh	52.47 g	62.10 cd	59.76 b
V_{16}	21.35 h	49.33 h	52.20 g	48.37 h
V_{17}	25.50 c	52.00 g	41.00 h	37.25 i
$LSD_{0.05}$	0.8011	1.895	1.339	0.8266
CV(%)	6.70	8.92	7.38	06.96

Values followed by same letter(s) did not differ significantly at 5% level of probability

V_1 = Chiniatap 1, V_2 = Chiniatap 2, V_3 = Kataribhog 1, V_4 = Kataribhog 2, V_5 = BRRI dhan34, V_6 = BRRI dhan37, V_7 = BRRI dhan38, V_8 = BR5 Dulabhog, V_9 = Khoisanne, V_{10} = Sadasanne, V_{11} = Zirabhog, V_{12} = Begun bichi, V_{13} = Shakkhorkhora, V_{14} = Chinigura, V_{15} = Kalijira, V_{16} = Badshabhog, V_{17} = Modhumala

4.1.3 Number of total tillers hill^{-1}

Number of tillers plant-1 of different aromatic rice varieties of different days after transplanting showed significant difference presented in the Table 3 and Appendix VI. At 25 DAT, the highest number of tillers hill^{-1} was produced by V_6 (9.947) which was significantly different from the rest of the varieties. The lowest number of tillers hill^{-1} was found in V_{17} (6.263) which was statistically similar with V_{10} (6.547)and V_{12} (6.497). At 50 DAT, the maximum number of tillers hill^{-1} was produced by V_6 (16.59) which was significantly similar with V_2 (16.03) and V_7 (15.72). The lowest number of tillers hill^{-1} was found in V_{17} (9.807) which was significantly different from the rest of the varieties. At 75 DAT, the highest number of tillers hill^{-1} was found in V_8 (23.00) which was statistically similar with V_7 (22.75), V_5 (22.51), andV_2 (21.96) and significantly different from the rest of the varieties. The lowest number of tillers hill^{-1} was found in V_{17} (14.87) which was significantly different from the rest of the variety. At maturity, the maximum number of tillers hill^{-1} was produced by V_6 (23.33) that was significantly different from the rest of the varieties. The lowest number of tillers hill^{-1} was found in V_{17} (13.33) which was significantly different from the rest of the variety. This result was also supported by Zahid *et al.* (2005) and they reported that a highly significant variation for different traits including the number of productive tillers per plant which was correlated with total yield. This result also was supported by Hossain *et al.* (2008), Obaidullah *et al*. (2009) and Chowdhury *et al*. (2005) and they conducted a study to estimate the relationship between grain yield and morphological parameters in five local and three modern aromatic rice genotypes and found that the highest number of fertile tillers per hill was obtained in BRRI dhan37.This result again also was supported by Enamul *et al.* (2004).

Table 3. Number of tillers hill^{-1} of 17 aromatic rice varieties

Treatment	Number of tillers hill^{-1} at			
	25 DAT	50 DAT	75 DAT	Harvest
V_1	6.817 fg	13.63d	17.63 f	17.67 de
V_2	7.103 f	16.03 ab	21.96 abc	18.00 cd
V_3	7.907 cd	12.91 d	21.35 bcd	16.67 efg
V_4	7.080 f	13.79 d	20.17 de	17.33 def
V_5	7.500 e	15.01 bc	22.51 ab	19.00 bc
V_6	9.947 a	16.59 a	20.16 de	23.33 a
V_7	8.783 b	15.72 ab	22.75 ab	19.00 bc
V_8	7.663 de	15.33 b	23.00 a	19.67 b
V_9	6.763 fg	13.53 d	20.30 de	17.67 de
V_{10}	6.547 gh	13.10 d	19.65 e	15.33 hi
V_{11}	8.677 b	13.88 cd	19.83 de	15.67 ghi
V_{12}	6.497 gh	13.00 d	19.50 e	16.33 fgh
V_{13}	7.933 cd	13.40 d	19.20 e	16.67 efg
V_{14}	6.643 g	13.32 d	19.73 e	16.67 efg
V_{15}	7.683 de	14.00 cd	17.46 f	17.33 def
V_{16}	8.130 c	13.18 d	20.75 cde	14.67 i
V_{17}	6.263 h	9.807 e	14.87 g	13.33 j
$LSD_{0.05}$	0.3449	1.190	1.554	1.251
CV(%)	7.74	8.97	9.05	8.35

Values followed by same letter(s) did not differ significantly at 5% level of probability

V_1 = Chiniatap 1, V_2 = Chiniatap 2, V_3 = Kataribhog 1, V_4 = Kataribhog 2, V_5 = BRRI dhan34, V_6 = BRRI dhan37, V_7 = BRRI dhan38, V_8 = BR5 Dulabhog, V_9 = Khoisanne, V_{10} = Sadasanne, V_{11} = Zirabhog, V_{12} = Begun bichi, V_{13} = Shakkhorkhora, V_{14} = Chinigura, V_{15} = Kalijira, V_{16} = Badshabhog, V_{17} = Modhumala

4.1.4 Leaf area index

Leaf area index of different aromatic rice varieties at different days after transplanting showed significant difference presented in the Table 4 and Appendix VII and significant variation was observed in LAI among the aromatic rice genotypes studied from 55 DAT to 80 DAT. At 25 DAT, all the seventeen aromatic rice varieties showed non-significant difference among them in case of leaf area index. At 50 DAT, among the varieties the highest (5.567) leaf area index was observed in the variety, V_6 (BRRI dhan37) which was identically followed by the variety, V_5 (BRRI dhan34) and V_7 (BRRI dhan38). On the other hand, the lowest (3.127) leaf area index was observed in the variety, V_{17} (Modhumala) which was significantly different from the rest of the varieties. At 75 DAT, among the varieties the highest (5.380) leaf area index was observed in the variety, V_6 (BRRI dhan37) which was followed by the variety, V_7 (BRRI dhan38) and they were statistically similar. On the other hand, the lowest (3.023) leaf area index was observed in the variety, V_{17} (Modhumala) which was significantly different from the rest of the varieties. These variations could be described to genetic, climatic, and nutritional factors as supported by Chandra and Das (2000) and this study also confirms the results of Shahidullah *et al.* (2009) who stated that different aromatic rice genotypes exhibited significant variations for leaf area index (LAI).

Table 4. Leaf area index of 17 aromatic rice varieties

Treatment	Leaf area index (LAI) at		
	25 DAT	50 DAT	75 DAT
V_1	0.7667	4.567e	4.363e
V_2	0.7367	4.200 f	4.107 f
V_3	0.6067	3.553 h	3.433 h
V_4	0.5300	3.477 h	3.343 h
V_5	1.003	5.323 abc	5.117 bc
V_6	1.073	5.567 a	5.380 a
V_7	0.9567	5.443 ab	5.307 ab
V_8	0.9967	5.233 bc	5.013 c
V_9	0.6300	3.550 h	3.383 h
V_{10}	0.7300	4.153 f	4.013 f
V_{11}	0.8467	4.553 e	4.373 e
V_{12}	0.6100	3.707 gh	3.477 gh
V_{13}	0.6400	3.853 g	3.663 g
V_{14}	0.7400	4.193 f	3.993 f
V_{15}	0.9133	5.133 cd	4.927 cd
V_{16}	0.8467	4.930 d	4.757 d
V_{17}	0.4233	3.127 i	3.023 i
$LSD_{0.05}$	NS	0.2630	0.1968
CV(%)	3.65	9.55	8.49

Values followed by same letter(s) did not differ significantly at 5% level of probability

V_1= Chiniatap 1, V_2 = Chiniatap 2, V_3 = Kataribhog 1, V_4 = Kataribhog 2, V_5 = BRRI dhan34, V_6 = BRRI dhan37, V_7 = BRRI dhan38, V_8 = BR5 Dulabhog, V_9 = Khoisanne, V_{10} = Sadasanne, V_{11} = Zirabhog, V_{12} = Begun bichi, V_{13} = Shakkhorkhora, V_{14} = Chinigura, V_{15} = Kalijira, V_{16} = Badshabhog, V_{17} = Modhumala

4.1.5 Flag leaf length

Flag leaf length of different aromatic rice varieties showed significant difference presented in the Table 5 and Appendix VIII.Among the varieties the highest (38.17cm) flag leaf length was observed in the variety, V_6 (BRRI dhan37) and the lowest (30.12cm) flag leaf length was observed in the variety, V_{17} (Modhumala).

4.1.6 Flag leaf breadth

Flaf leaf breadth of different aromatic rice varietie showed different significant difference presented in the Table 5 and Appendix VIII. Among the varieties the highest (1.297cm) flag leaf breadth was observed in the variety, V_3 (Kataribhog 1) and the lowest (0.6467) flag leaf breadth was observed in the variety, V_{17} (Modhumala) which was statistically similar with V_1 chini atab 1 (0.7033cm) variety.

4.1.7 Flag leaf area (cm^2)

Flag leaf area was significantly influenced by different varieties of rice (Table 5 and Appendix VIII). Results revealed that the highest flag leaf area (42.083cm^2) was observed from the variety, V_6 (BRRI dhan 37) which was statistically similar with V_3(Kataribhog 1). where the lowest flag leaf area (19.52cm^2) was observed from the variety, V_{17} (Modhumala) which was significantly different from the rest of the varieties. Simillar result was reported by Sheela *et al.* (1990) and they studied the role of flag leaf on grain yield and spikelet sterility in rice cultivars and concluded that the grain yield and yield related traits were positively related to flag leaf area. Flag leaf plays an important role in grain yield, spikelet fertility, panicle size, grain size and weight. Simillar result reported by Rao (1992), Mohtashami (1998) and Dutta *et al.* (2002). They studied the plant architecture and growth characteristics of fine grain and aromatic rice and concluded that flag leaf area and flag leaf angle may be more related to current photosynthate

synthesis and translocation for grain filling and higher grain fertility in local rice genotypes.

Table 5. Flag leaf characteristics of 17 aromatic rice varieties

Treatment	Flag leaf		
	Flag leaf length (cm)	Flag leaf breadth (cm)	Flag leaf area (cm^2)
V_1	32.88cde	0.703 g	23.13 f
V_2	35.82 b	0.913 e	32.72 c
V_3	33.30 c	1.297 a	43.19 a
V_4	31.60 gh	0.790 f	24.99 ef
V_5	32.40 ef	0.826 f	26.79 d
V_6	38.17 a	1.183 b	45.18 a
V_7	33.27 cd	1.090 cd	36.28 b
V_8	31.53 gh	0.800 f	25.24 e
V_9	32.54 def	1.103 c	35.94 b
V_{10}	31.39 gh	0.800 f	26.67 de
V_{11}	31.15 h	0.933 e	29.09 d
V_{12}	31.96 fg	1.097 c	34.68 bc
V_{13}	31.33 gh	1.193 b	37,38 b
V_{14}	31.61 gh	1.150 bc	36.36 b
V_{15}	33.56 c	1.037 d	34.81 b
V_{16}	31.59 gh	0.813 f	25.71 e
V_{17}	30.12 i	0.646 g	19.52 g
$LSD_{0.05}$	0.7456	0.07438	3.097
CV(%)	9.38	7.40	10.63

Values followed by same letter(s) did not differ significantly at 5% level of probability

V_1 = Chiniatap 1, V_2 = Chiniatap 2, V_3 = Kataribhog 1, V_4 = Kataribhog 2, V_5 = BRRI dhan34, V_6 = BRRI dhan37, V_7 = BRRI dhan38, V_8 = BR5 Dulabhog, V_9 = Khoisanne, V_{10} = Sadasanne, V_{11} = Zirabhog, V_{12} = Begun bichi, V_{13} = Shakkhorkhora, V_{14} = Chinigura, V_{15} = Kalijira, V_{16} = Badshabhog, V_{17} = Modhumala

4.2 Yield and yield contributing parameters

4.2.1 Number of tillers hill^{-1}

Number of total tiller hill^{-1} of different aromatic rice varieties showed significant difference presented in the Table 6 and Appendix IX. Among the varieties, the highest (23.33) number of tiller found in the variety, V_6 (BRRI dhan37) which was significantly different from the rest of the varieties.. On the other hand the lowest (13.33) number tiller found in the variety V_{17} (Modhumala).

4.2.2 Number of effective tiller hill^{-1}

Number of effective tiller hill^{-1} of different aromatic rice varieties showed significant difference presented in the Table 6 and Appendix IX. Among the varieties, the highest (21.67) number of effective tiller found in the variety, V_6 (BRRI dhan37) which was significantly different from the rest of the varieties. On the other hand the lowest (12.67) number of effective tiller found in the variety V_{17} (Modhumala). Similar results were also reported by Yang *et al.* (2001) and Jisan *et al*. (2014).

4.2.3 Number of non-effective tiller hill^{-1}

Number of ineffective tiller hill^{-1} of different aromatic rice varieties showed non significant difference presented in the Table 6 and Appendix IX. Among the varieties, the highest (1.667) number of ineffective tiller found in the variety, V_6 (BRRI dhan37) On the other hand, the lowest (0.3333) number of ineffective tiller was found in the variety V_1 (Chini atab1), V_3 (Kataribogh 1), V_9 (Khoisanne), V_{10} (Sadasanne) V_{11}, (Girabhog), V_{12} (Begun bichi), V_{13} (Shakkhorkhora), V_{14} (Chinigura) and V_{16} (Badshabhog). Similar results were observed by Yang *et al.* (2001) and Siddique *et al.* (2002).

Table 6. Effective and non-effective tillers of rice as influenced by 17 aromatic rice varieties

Treatment	Effective and non-effective tillers			Length of panicle (cm)
	Number of tillers hill^{-1}	Number of non effective tillers hill^{-1}	Number of effective tillers hill^{-1}	
V_1	17.67c	0.3333	17.33cd	31.33 b
V_2	18.00 c	0.6667	17.33 cd	30.67 c
V_3	16.67 de	0.3333	16.33 de	29.00 ef
V_4	17.33 cd	1.000	16.33 de	29.00 ef
V_5	19.00 b	0.6667	18.33 bc	26.33 h
V_6	23.33 a	1.667	21.67 a	32.00 a
V_7	19.00 b	0.6667	18.33 bc	31.00 bc
V_8	19.67 b	1.000	18.67 b	21.00 k
V_9	17.67 c	0.3333	17.33 cd	25.33 i
V_{10}	15.33 gh	0.3333	15.00 fg	25.67 i
V_{11}	15.67 fg	0.3333	15.33 efg	27.67 g
V_{12}	16.33 ef	0.3333	16.00 ef	28.67 f
V_{13}	16.67 de	0.3333	16.33 de	29.33 e
V_{14}	16.67 de	0.3333	16.33 de	27.33 g
V_{15}	17.33 cd	1.000	16.33 de	30.00 d
V_{16}	14.67 h	0.3333	14.33 g	26.67 h
V_{17}	13.33 i	0.6667	12.67 h	24.67 j
$LSD_{0.05}$	0.6776	NS	1.202	0.6043
CV(%)	8.95	111.08	10.33	8.34

Values followed by same letter(s) did not differ significantly at 5% level of probability

V_1 = Chiniatap 1, V_2 = Chiniatap 2, V_3 = Kataribhog 1, V_4 = Kataribhog 2, V_5 = BRRI dhan34, V_6 = BRRI dhan37, V_7 = BRRI dhan38, V_8 = BR5 Dulabhog, V_9 = Khoisanne, V_{10} = Sadasanne, V_{11} = Zirabhog, V_{12} = Begun bichi, V_{13} = Shakkhorkhora, V_{14} = Chinigura, V_{15} = Kalijira, V_{16} = Badshabhog, V_{17} = Modhumala

4.2.4 Panicle length (cm)

Panicle length (cm) of different aromatic rice varieties showed statistically significant difference presented in the Table 6 and Appendix IX. Among the varieties, the highest (32.00cm) number of panicle length found in the variety, V_6 (BRRI dhan37) which was significantly different from the rest of the varieties. And the lowest (24.67) number of panicle length found in the variety, V_{17} (Modhumala) which was significantly different from the rest of the varieties. Similar result was also observed by Sharma (2002), Ashrafuzzaman *et al*. (2009), Sarkar *et al*. (2014), Anwar and Begum (2010) and Abou-Khalif (2009) which supported the present study.

4.2.5 Number of total grains panicle^{-1}

Number of total grains panicle-1 of different aromatic rice varieties showed significant difference presented in the Table 7 and Appendix X. Among the varieties, the highest (230.3) number of grains panicle^{-1} found in the variety, V_6 (BRRI dhan37) which was statistically same with V_7 (BRRI dhan38). On the other hand, the lowest (107.3) number of grains panicle-1 found in the variety V_4 (Kataribhog2) which was statistically same with V_{17} (Modhumala) rice variety.

4.2.6 Number of filled grains panicle^{-1}

Different varieties of aman rice showed significant variation on number of filled grains panicle^{-1} (Table 7 and Appendix X). The highest number of filled grains panicle^{-1} (212.7) was observed from the variety, V_6 (BRRI dhan37) which was significantly different from the rest of the varieties. where the lowest number of filled grains panicle^{-1} (75.67) was observed from the variety, V_4 (Kataribhog2) which was significantly different from the rest of the varieties. Similar result were also observed by Kusutani *et al.* (2000), Fageria and Baligar (2001), Chowdhury *et al*. (2005) and Murthy *et al.* (2004).

4.2.7 Number of unfilled grains panicle^{-1}

Number of unfilled grains panicle^{-1} was significantly varied due to different varieties of rice (Table 7 and Appendix X). It was observed that the highest number of unfilled grains panicle^{-1} (44.67) was observed from the variety, V_7 (BRRI dhan38) which was significantly different from the rest of the varieties. The lowest number of unfilled grains panicle^{-1}(9.00) was observed from the variety, V_{15} (Kalijira) which was significantly different from the rest of the varieties**.** Similar result was also observed by Chowdhury *et al.* (1993), Mallick (1994) and Chowdhury *et al*. (2005).

Table 7. Number of total grains panicle^{-1}, filled grains panicle^{-1}, unfilled grains panicle^{-1} and sterility percentage (%) of 17 aromatic rice varieties

Treatment	Yield and yield contributing parameters			
	Number of total grain's panicle^{-1}	Number of filled grain's panicle^{-1}	Number of unfilled grain's panicle^{-1}	Sterility percentage (%)
V_1	139.7 h	121.3h	18.33 f	13.11 fgh
V_2	173.3 e	151.7 e	21.67 e	12.49 gh
V_3	130.7 i	98.33 j	32.33 c	24.98 a
V_4	107.3 j	75.67 k	31.67 c	23.48 b
V_5	180.0 d	144.3 f	35.67 b	19.79 c
V_6	230.3 a	212.7 a	17.67 fg	7.647 ij
V_7	228.0 a	183.3 b	44.67 a	19.55 c
V_8	190.3 c	162.3 d	28.00 d	14.87 de
V_9	140.3 gh	121.0 h	19.33 ef	13.74 efg
V_{10}	145.3 g	128.0 g	17.33 fg	11.92 h
V_{11}	197.7 b	169.7 c	28.00 d	14.12 ef
V_{12}	143.3 gh	126.0 gh	17.33 fg	11.99 h
V_{13}	166.3 f	153.0 e	13.33 h	7.977 i
V_{14}	127.0 i	109.0 i	18.00 fg	14.05 ef
V_{15}	140.3 gh	131.3 g	9.000 i	6.377 j
V_{16}	171.0 ef	143.3 f	27.67 d	16.12 d
V_{17}	109.0 j	93.33 j	15.67 gh	14.29 ef
$LSD_{0.05}$	5.324	5.478	2.506	1.341
CV(%)	10.60	10.8 6	8.77	7.88

Values followed by same letter(s) did not differ significantly at 5% level of probability

V_1 = Chiniatap 1, V_2 = Chiniatap 2, V_3 = Kataribhog 1, V_4 = Kataribhog 2, V_5 = BRRI dhan34, V_6 = BRRI dhan37, V_7 = BRRI dhan38, V_8 = BR5 Dulabhog, V_9 = Khoisanne, V_{10} = Sadasanne, V_{11} = Zirabhog, V_{12} = Begun bichi, V_{13} = Shakkhorkhora, V_{14} = Chinigura, V_{15} = Kalijira, V_{16} = Badshabhog, V_{17} = Modhumala

4.2.8 Sterility percentage

Sterility percentage of different aromatic rice varieties showed significant difference presented in the Table 7 and Appendix X. Among the varieties, the highest sterility percentage (24.29) found in the variety V_3(Katari bhog1), which was significantly different from the rest of the varieties. On the other hand, the

lowest (6.377) sterility percentage found in the variety V_{15}(Kaligira)which was statistically same with V_6(BRRI dhan37) rice variety.

.4.2.9 Weight of 1000 grains (g)

Weight of 1000 grains (g) of different aromatic rice varieties showed significant difference presented in the Table 8 and Appendix XI. Among the varieties, the highest (22.80) 1000 grains weight (g) was found in the variety, V_{17}(Modhumala) which was significantly different from the rest of the varieties. On the other hand, the lowest (9.110) Weight of 1000 grains (g) found in the variety, V_{10}(Sadasanne) which was significantly different from the rest of the varieties. Similar results were also observed by Cheema *et al.* (1998), Mirza *et al*. (1992), Mondal *et al.* (2005), Murshida *et al*. (2017) , Jisan *et al*. (2014) and Sarkar *et al*. (2014).

4.2.10 Grain yield (t ha^{-1})

Different variety of rice had significant influence on grain yield (Table 8 and Appendix XI). In was noted that the highest grain yield (3.420 t ha^{-1}) was observed from the variety, V_6 (BRRI dhan37) which was significantly different from the rest of the varieties. The lowest grain yield (1.583 t ha^{-1}) was observed from the variety, V_{17} (Modhumala) which was statistically same with V_4 (Kataribhog2). Similar result was also observed by Miah *et al.* (1996), Biswas *et al.* (1998), Ashrafuzzaman *et al.* (2009), Rajesh et al. (2008), Murshida *et al*. (2017), Sarker *et al.* (2013) and Haque *et al.* (2013) .

4.2.11 Straw yield (t ha^{-1})

Straw yield of different aromatic rice varieties showed significant difference presented in the Table 8 and Appendix XI. Among the varieties, the highest (6.190) straw yield found in the variety, V_6 (BRRI dhan37)which was significantly different from the rest of the varieties. On the other hand, the lowest

(4.083) straw yield found in the variety, V_{17} (Modhumala)which was significantly different from the rest of the varieties. Similar result was also observed by Chowdhury *et al.* (1995) and Chowdhury *et al.* (2005).

4.2.12 Biological yield (t ha^{-1})

Biological yield of different aromatic rice varieties showed significant difference presented in the Table 8 and Appendix XI. Among the varieties, the highest (9.610) biological yield found in the variety, V_6 (BRRI dhan37) which was significantly different from the rest of the varieties. On the other hand, the lowest (5.667) biological yield found in the variety, V_{17}(Modhumala) which was significantly different from the rest of the varieties. Similar result were also observed by Chowdhury *et al.* (1995). They showed that grain yield was positively correlated with biological yield in rice.

4.2.13 Harvest index (%)

Harvest index (%) of different aromatic rice varieties showed significant difference presented in the Table 8 and Appendix XI. Among the varieties, the highest (37.48) harvest index found in the variety, V_5 (BRRI dhan34) which was significantly different from the rest of the varieties. On the other hand, the lowest (27.89) harvest index found in the variety, V_{17} (Modhumala) which was statistically similar withV_3 (Kataribhog1) and V_4 (Kataribhog2). Similar result were also observed by Kusutani *et al.* (2000), Ashrafuzzaman *et al.* (2009), Bhowmick and Nayak (2000) and Cui *et al.,* (2000).

Table 8. Yield parameters of 17 aromatic rice varieties

Treatment	Yield and yield contributing parameters				
	Weight of 1000 grains (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
V_1	14.95de	2.433f	4.940ef	7.373 e	32.87d
V_2	12.07 gh	2.227 g	4.910 ef	7.137 fg	31.17 e
V_3	13.57 f	1.903 h	4.770 fg	6.673 i	28.50 gh
V_4	13.72 f	1.693 i	4.297 i	5.990 j	28.23 gh
V_5	10.39 i	3.030 b	5.143 d	8.107 c	37.48 a
V_6	15.64 d	3.420 a	6.190 a	9.610 a	35.58 b
V_7	17.18 c	2.967 bc	5.573 bc	8.540 b	34.72 bc
V_8	11.23 hi	2.333 fg	4.783 fg	7.117 fg	32.77 d
V_9	20.08 b	2.303 fg	4.523 h	6.827 hi	33.76 cd
V_{10}	9.110 j	2.413 f	4.800 fg	7.213 ef	33.48 cd
V_{11}	11.11 hi	2.660 e	5.037 de	7.697 d	34.54 bc
V_{12}	10.57 i	2.373 fg	4.570 h	6.943 gh	34.23 bcd
V_{13}	14.02 ef	2.027 h	4.650 gh	6.677 i	30.32 ef
V_{14}	11.93 gh	2.043 h	4.870 ef	6.913 h	29.48 fg
V_{15}	12.91 fg	2.853 cd	5.620 b	8.473 b	33.66 cd
V_{16}	10.98 hi	2.700 de	5.400 c	7.950 c	33.97 cd
V_{17}	22.80 a	1.583 i	4.083 j	5.667 k	27.89 h
$LSD_{0.05}$	1.229	0.1744	0.1744	0.1968	1.574
CV(%)	9.10	6.90	6.37	8.35	9.91

Values followed by same letter(s) did not differ significantly at 5% level of probability

V_1 = Chiniatap 1, V_2 = Chiniatap 2, V_3 = Kataribhog 1, V_4 = Kataribhog 2, V_5 = BRRI dhan34, V_6 = BRRI dhan37, V_7 = BRRI dhan38, V_8 = BR5 Dulabhog, V_9 = Khoisanne, V_{10} = Sadasanne, V_{11} = Zirabhog, V_{12} = Begun bichi, V_{13} = Shakkhorkhora, V_{14} = Chinigura, V_{15} = Kalijira, V_{16} = Badshabhog, V_{17} = Modhumala

4.3 Grain quality parameters

4.3.1 Paddy weight(g)

Paddy weight of 17 aromatic rice varieties showed non significant difference presented in the Table 9 and Appendix XII.

4.3.2 Brown rice weight(g)

Brown rice weight of different aromatic rice varieties showed significant differences presented in the Table 9 and Appendix XII. Among the varieties, the highest (81.76 g) weight of brown rice was found in the variety, V_{11} (Zirabhog) which was statistically same with V_1 (Chiniatab 1) and similar with V_6 (BRRI dhan37), V_{14} (Chinigura), V_{16} (Badshabhog), V_{17} (Modhumala). On the other hand, lowest (75.39 g) weight of brown rice was found in the variety, V_{15} (Kalijira) which was significantly same with V_{12} (Begun bichi) and significantly similar with V_3 (Kataribhog 1), V_4 (Kataribhog 2), V_5 (BRRI Dhan34), V_8 (BR5 dulabhog), V_{13} (Shakkhorkhora).

4.3.3 Milled rice weight(g)

Milled rice weight of different aromatic rice varieties showed significant differences presented in the Table 9 and Appendix XII. Among the varieties, the highest (73.57 g) weight of milled rice was found in the variety, V_{11} (Zirabhog) which was statistically same with V_1 (Chiniatab 1) and similar with V_6 (BRRI dhan37), V_{14} (Chinigura), V_{16} (Badshabhog), V_{17} (Modhumala). On the other hand, lowest (67.43 g) weight of milled rice was found in the variety, V_{12} (Begun bichi) which was statistically same with V_{15} (Kalijira) and similar with V_3 (Kataribhog 1), V_4 (Kataribhog 2), V_5 (BRRI Dhan34), V_8 (BR5 dulabhog), V_{13} (Shakkhorkhora).

4.3.4 Head rice weight(g)

Head rice weight of different aromatic rice varieties showed significant differences presented in the Table 9 and Appendix XII. Among the varieties, the highest (71.08 g) weight of head rice was found in the variety, V_1 (Chiniatab 1) which was significantly different from the rest of the varieties except V_{11}(Zirabhog), V_{14}(Chinigura) which was statistically similar. On the other hand, lowest (63.31 g) weight of head rice was found in the variety, V_5 (BRRI Dhan34) which was statistically same with V_3 (Kataribhog 1), V_4 (Kataribhog 1), V_{15} (Kalijira) and V_{12} (Begun bichi).

4.3.5 Broken rice weight(g)

Broken rice weight of different aromatic rice varieties showed significant differences presented in the Table 9 and Appendix XII. Among the varieties, the highest (6.38 g) weight of broken rice was found in the variety, V_6 (BRRI dhan37) which was significantly different from the rest of the varieties. On the other hand, lowest (1.57 g) weight of broken rice was found in the variety, V_{14} (Chinigura) which was statistically similar with V_1 (Chiniatab 1).

Table 9. Quality parameters of 17 aromatic rice varieties

Treatment	Grain quality parameters				
	Paddy weight(g)	Brown rice weight(g)	Milled rice weight(g)	Head rice weight(g)	Broken rice weight(g)
V_1	102.8	81.60a	73.24 a	71.08a	1.723ij
V_2	103.3	77.74 cd	70.20 cd	65.40 ef	4.217 de
V_3	101.2	76.50 de	68.71 de	63.41 g	4.900 bc
V_4	100.8	76.92 de	69.03 de	64.10 g	4.597 cd
V_5	102.3	76.73 de	69.10 de	63.31 g	5.360 b
V_6	101.9	81.02 ab	73.18 ab	65.32 ef	6.380 a
V_7	101.3	79.12 bc	71.35 bc	66.35 e	4.430 cd
V_8	100.9	75.97 de	68.45 de	65.95 e	2.253 hi
V_9	101.5	77.69 cd	69.87 cd	65.65 e	3.833 ef
V_{10}	100.9	77.81 cd	69.95 cd	65.87 e	3.830 ef
V_{11}	102.2	81.76 a	73.57 a	70.51 ab	2.707 gh
V_{12}	101.2	74.97 e	67.43 e	64.27 fg	2.923 g
V_{13}	101.5	76.59 de	69.07 de	68.28 d	0.4900k
V_{14}	101.8	79.90 ab	72.10 ab	70.22 ab	1.570 j
V_{15}	101.6	75.39 e	67.89 e	63.63 g	4.070 def
V_{16}	101.1	80.94 ab	73.07 ab	69.59 bc	2.967 g
V_{17}	102.0	80.92 ab	72.90 ab	68.93 cd	3.633 f
$LSD_{0.05}$	NS	2.081	1.866	1.180	0.5713
CV(%)	2.37	10.60	9.59	8.38	6.76

Values followed by same letter(s) did not differ significantly at 5% level of probability

V_1 = Chiniatap 1, V_2 = Chiniatap 2, V_3 = Kataribhog 1, V_4 = Kataribhog 2, V_5 = BRRI dhan34, V_6 = BRRI dhan37, V_7 = BRRI dhan38, V_8 = BR5 Dulabhog, V_9 = Khoisanne, V_{10} = Sadasanne, V_{11} = Zirabhog, V_{12} = Begun bichi, V_{13} = Shakkhorkhora, V_{14} = Chinigura, V_{15} = Kalijira, V_{16} = Badshabhog, V_{17} = Modhumala

4.3.6 Hulling percentage (%)

Hulling percentage of different aromatic rice varieties showed significant difference presented in the Table 10 and Appendix XIII. Among the varieties, the highest hulling percentage (82.86) found in the variety V_6 (BRRI dhan37), which was statistically similar with V_{16} (Badshabhog) and V_{11} (Girabhog) but significantly different from the rest of the varieties. On the other hand, the lowest (74.09) hulling percentage found in the variety V_{12} (Begun bichi) which was statistically similar with V_{15} (Kaligira), V_5 (BRRI dhan34), V_2 (Chiniatab2), V_3 (Kataribhog1), V_4 (Kataribhog2), V_8 (BR5 dulabhog), V_9 (Khoisanne), V_{10} (Sadasanne) and V_{13} (Shakkhorkhora).

4.3.7 Milling recovery (%)

Milling recovery of different aromatic rice varieties showed significant difference presented in the Table 10 and Appendix XIII. Among the varieties, the highest milling recovery (72.29) found in the variety V_{16}(Badshabhog), which was statistically similar with V_1(Chini atab1), V_6(BRRI dhan37), V_{11}(Girabhog),V_{17}(Modhumala) but significantly different from the rest of the varieties. On the other hand, the lowest (66.76) milling recovery found in the variety V_{15}(Kaligira) which was statisticaly similar with V_{12}(Begun bichi), V_5 (BRRI dhan34), V_8(BR5 dulabhog), V_3(Kataribhog1),V_2(Chiniatab2) and V_{13}(Shakkhorkhora).

4.3.8 Milling degree (%)

Milling degree of different aromatic rice varieties showed non-significant difference presented in the Table 10 and Appendix XIII. Among the varieties, the highest milling degree (90.32) found in the variety V_6(BRRI dhan37) and numerically the lowest (89.75) milling degree found in the variety V_1(Chini atab1) which was statisticaly same with V_4(Kataribhog2).

4.3.9 Head rice recovery (%)

Head rice recovery of different aromatic rice varieties showed significant difference presented in the Table 10 and Appendix XIII. Among the varieties, the highest head rice recovery (68.96) found in the variety V_{11} (Zirabhog) which was statisticaly similar with V_1 (Chini atab1), V_{14} (Chinigura), V_{16} (Badshabhog), V_{13} (Shakkhorkhora), V_{17} (Modhumala). On the other hand, the lowest (61.88) head rice recovery found in the variety V_5 (BRRI dhan34) which was statisticaly similar with V_2 (Chiniatab2), V_3 (Kataribhog1), V_4 (Kataribhog2), V_6 (BRRI dhan37), V_{12} (Begun bichi) and V_{15} (Kalijira).

4.3.10 Broken rice percentage (%)

Broken rice percentage of different aromatic rice varieties showed significant difference presented in the Table 10 and Appendix XIII. Among the varieties, the highest Broken rice percentage (6.257) found in the variety V_6(BRRI dhan37)which was significantly different from the rest of the varieties. On the other hand, the lowest (0.4767) milling recovery found in the variety V_{13} (Shakkhorkhora) which was significantly different from the rest of the varieties.

Table 10. Quality parameters of 17 aromatic rice varieties

Treatment	Grain quality parameters				
	Hulling percentage (%)	Milling recovery (%)	Milling degree (%)	Head rice recovery (%)	Broken rice percentage (%)
V_1	79.36 bc	71.22 abc	89.75	69.58a	1.903hi
V_2	75.27 de	67.98 fg	90.30	63.39 cde	4.077 de
V_3	75.63 de	67.70 fg	89.81	62.69 de	4.840 bc
V_4	76.35 cde	68.52 ef	89.75	63.62 cde	4.557 cd
V_5	74.97 e	66.85 g	90.05	61.88 e	5.210 b
V_6	82.86 a	71.84 ab	90.32	64.11 cde	6.257 a
V_7	78.08 bcd	70.41 cd	90.18	65.48 bc	4.367 cd
V_8	75.32 de	67.20 g	90.09	65.38 bc	2.230 gh
V_9	76.58 cde	68.84 ef	89.92	64.68 cd	3.780 e
V_{10}	77.14 bcde	69.34 de	89.89	65.28 bc	3.797 e
V_{11}	79.96 ab	71.95 ab	89.97	68.96 a	2.643 fg
V_{12}	74.09 e	66.81 g	89.94	63.51 cde	2.887 f
V_{13}	75.48 de	68.06 efg	90.17	67.29 ab	0.4767j
V_{14}	78.70 bc	70.79 bc	90.23	68.93 a	1.550 i
V_{15}	74.14 e	66.76 g	90.05	62.55 de	4.017 de
V_{16}	79.98 ab	72.29 a	90.28	68.85 a	2.930 f
V_{17}	79.32 bc	71.46 abc	90.09	67.57 ab	3.553 e
$LSD_{0.05}$	3.047	1.322	NS	2.413	0.5466
CV(%)	10.37	8.54	3.31	9.21	6.32

Values followed by same letter(s) did not differ significantly at 5% level of probability

V_1 = Chiniatap 1, V_2 = Chiniatap 2, V_3 = Kataribhog 1, V_4 = Kataribhog 2, V_5 = BRRI dhan34, V_6 = BRRI dhan37, V_7 = BRRI dhan38, V_8 = BR5 Dulabhog, V_9 = Khoisanne, V_{10} = Sadasanne, V_{11} = Zirabhog, V_{12} = Begun bichi, V_{13} = Shakkhorkhora, V_{14} = Chinigura, V_{15} = Kalijira, V_{16} = Badshabhog, V_{17} = Modhumala

4.3.11 Grain length (mm)

Grain length (mm) of different aromatic rice varieties showed statistically significant difference presented in the Table 11 and Appendix XIV. Among the varieties, the highest (8.333mm) grain length found in the variety, V_9 (Khoisanne), which was significantly similar with V_3(Kataribhog1), on the other hand lowest (5.333) grain length found in the variety, V_{12} (Begun bichi) which was significantly different from the rest of the varieties.

4.3.12 Kernel length (mm)

Rice length (mm) of different aromatic rice varieties showed statistically significant difference presented in the Table 11 and Appendix XIV. Among the varieties, the highest (6.217mm) rice length found in the variety, V_3 (Kataribhog1), which was significantly same with V_7(BRRI dhan38) and which was significantly similar with V_4(Kataribhog2),on the other hand lowest (4.077) rice length found in the variety, V_8 (BR5dulabhog) which was statistically similar with V_{12}(Begun bichi), V_{13}(Shakkhorkhora), V_{16}(Badshabhog), V_2(Chini atab2), V_{10}(Sadasanne), V_{15}(Kalijira).

4.3.13 Kernel breadth (mm)

Rice breadth (mm) of different aromatic rice varieties showed statistically significant difference presented in the Table 11 and Appendix XIV. Among the varieties, the highest (2.757mm) rice breadthfound in the variety, V_{17} (Modhumala), which was significantly different from the rest of the varieties. on the other hand lowest (1.843) rice breadth found in the variety, V_{11} (Girabhog) which was significantly same with V_3(Kataribhog1), V_4(Kataribhog2), V_6(BRRI dhan37) andwhich was significantly similar with V_7(BRRI dhan38), V_{10}(Sadasanne), V_{12}(Begun bichi), V_{16}(Badshabhog).

4.3.14 Boiled rice length (mm)

Boiled rice length (mm) of different aromatic rice varieties showed statistically significant difference presented in the Table 11 and Appendix XIV. Among the varieties, the highest (8.600mm) boiled rice length found in the variety, V_4 (Kataribhog2), which was statistically similar with V_7(BRRI dhan38). On the other hand lowest (5.933) boiled rice length found in the variety, V_5 (BRRI dhan34) which was statistically same with V_{10}(Sadasanne) and which was statistically similar with V_{12}(Begun bichi).

4.3.15 Boiled rice breadth (mm)

Boiled rice breadth (mm) of different aromatic rice varieties showed statistically significant difference presented in the Table 11 and Appendix XIV. Among the varieties, the highest (3.133) boiled rice breadth found in the variety, V_{17} (Modhumala), which was significantly same with V_9 (Khoisanne) and V_{13} (Shakkhorkhora). On the other hand lowest (2.067) boiled rice breadth found in the variety, V_3 (Kataribhog1) which was statistically same with V_4 (Kataribhog2), V_5(BRRI dhan34), V_6(BRRI dhan37), V_7(BRRI dhan38) and statistically similar with V_{10} (Sadasanne).

4.3.16 Elongation ratio (mm)

Elongation ratio of different aromatic rice varieties showed statistically significant difference presented in the Table 11 and Appendix XIV. Among the varieties, the highest (1.727) elongation ratio found in the variety, V_2 (Chini atab2), which was significantly different from the rest of the varieties. On the other hand lowest (1.310) elongation ratio found in the variety, V_3 (Kataribhog1) which was statistically similar with V_4(Kataribhog2), V_5(BRRI dhan34), V_6(BRRI dhan37),V_7(BRRI dhan38) and V_{10}(Sadasanne).

Table 11. Quality parameters of 17 aromatic rice varieties

Treatment	Grain quality parameters					
	Grain length (mm)	Kernel length (mm)	Kernel breadth (mm)	Boiled rice length (mm)	Boiled rice breadth (mm)	Elongation ratio (mm)
V_1	6.200ef	4.530cd	2.200 b	7.167 e	3.067 ab	1.580 bc
V_2	6.133 efg	4.450 cde	2.107 bc	7.700 cd	3.033 ab	1.727 a
V_3	8.167 ab	6.217 a	1.880 f	8.167 b	2.067 e	1.310 h
V_4	5.900 fg	5.820 ab	1.860 f	8.600 a	2.067 e	1.477 de
V_5	6.103 efg	4.510 cd	2.023 cde	5.933 j	2.200 e	1.310 h
V_6	7.067 d	5.733 b	1.880 f	8.167 b	2.103 e	1.427 ef
V_7	8.000 b	6.217 a	1.930 ef	8.833 a	2.133 e	1.417 efg
V_8	5.900 fg	4.077 e	2.130 bc	6.700 fg	3.103 ab	1.637 b
V_9	8.333 a	5.780 b	2.073 bcd	7.800 c	3.137 a	1.343 gh
V_{10}	6.300 e	4.487 cde	1.907 ef	6.067 j	2.233 de	1.350 gh
V_{11}	6.867 d	4.540 cd	1.843 f	6.900 f	3.067 ab	1.390 fg
V_{12}	5.333 h	4.173 de	1.943 def	6.167 ij	2.633 c	1.477 de
V_{13}	5.867 g	4.233 de	2.180 b	6.333 i	3.200 a	1.487 de
V_{14}	6.200 ef	4.837 c	2.033 cde	7.467 d	2.433 cd	1.610 b
V_{15}	6.070 efg	4.460 cde	2.183 b	6.600 gh	2.900 b	1.477 de
V_{16}	5.867 g	4.300 de	1.937 def	6.367 hi	2.433 cd	1.477 de
V_{17}	7.467 c	5.447 b	2.757 a	8.267 b	3.133 a	1.513 cd
$LSD_{0.05}$	0.3021	0.4174	0.1391	0.2577	0.2104	0.07438
CV(%)	8.76	9.07	7.19	10.53	9.85	6.76

Values followed by same letter(s) did not differ significantly at 5% level of probability

V_1 = Chiniatap 1, V_2 = Chiniatap 2, V_3 = Kataribhog 1, V_4 = Kataribhog 2, V_5 = BRRI dhan34, V_6 = BRRI dhan37, V_7 = BRRI dhan38, V_8 = BR5 Dulabhog, V_9 = Khoisanne, V_{10} = Sadasanne, V_{11} = Zirabhog, V_{12} = Begun bichi, V_{13} = Shakkhorkhora, V_{14} = Chinigura, V_{15} = Kalijira, V_{16} = Badshabhog, V_{17} = Modhumala

4.3.17 Protein percentage (%)

Protein percentage of different aromatic rice varieties showed statistically significant difference presented in the Table 12 and Appendix XV. Among the varieties, the highest (10.03) Protein percentage found in the variety, V_{17} (Modhumala), which was significantly different from the rest of the varieties. On

the other hand lowest (7.633) Protein percentage found in the variety, V_1 (Chini atab1) which was significantly different from the rest of the varieties.

4.3.18 Moisture percentage (%)

Moisture percentage of different aromatic rice varieties showed nonstatistically significant difference presented in the Table 12 and Appendix XV. Among the varieties, the highest (13.67) Moisture percentage found in the variety, V_8 (BR5dulabhog) and the lowest (12.50) Moisture percentage found in the variety, V_{16} (Badshabhog).

4.3.19 Amylose concentration (%)

Amylose concentration of different aromatic rice varieties showed statistically significant difference presented in the Table 12 and Appendix XV. Among the varieties, the highest (29.97%) Amylose concentration found in the variety, V_1 (Chini atab 1), which was significantly different from the rest of the varieties. On the other hand lowest (19.67) Amylose concentration found in the variety, V_{17} (Modhumala) which was statistically same with V_9 (Khoisanne).

4.3.20 Aroma

Aroma of different aromatic rice varieties showed statistically significant difference presented in the Table 12 and Appendix XV. V_{15} (Kalijira), V_5 (BRRI dhan34), V_{14} (Chinigura) and V_3 (Kataribhog1) showed strongly scented aroma compare to the rest of the varieties. On the other hand V_1 (Chini atab1) showed lowest aroma content among the varieties.

Table 12. Protein, moisture, amylose and aroma of 17 aromatic rice varieties

Treatment	Grain quality parameters			
	Protein percentage (%)	Moisture percentage (%)	Amylose concentration (%)	Aroma
V_1	7.633 g	12.63	29.97 a	Mild sented
V_2	8.000 f	12.60	28.50 b	Moderate sented
V_3	8.967 bc	12.63	22.43 fg	Strongly sented
V_4	8.933 bc	12.60	21.63 h	Moderate sented
V_5	8.367 e	12.67	27.37 c	Strongly sented
V_6	8.467 de	12.60	26.27 d	Moderate sented
V_7	8.367 e	12.93	28.37 b	Moderate sented
V_8	8.767 cd	13.67	23.70 e	Moderate sented
V_9	9.233 b	13.67	19.90 i	Moderate sented
V_{10}	8.500 de	13.57	26.77 cd	Moderate sented
V_{11}	8.267 ef	12.80	28.47 b	Moderate sented
V_{12}	9.000 bc	13.03	22.63 f	Moderate sented
V_{13}	9.000 bc	12.80	23.67 e	Moderate sented
V_{14}	8.767 cd	13.30	23.80 e	Strongly sented
V_{15}	8.933 bc	13.03	21.87 gh	Strongly sented
V_{16}	8.500 de	12.50	26.80 cd	Moderate sented
V_{17}	10.03 a	12.67	19.67 i	Moderate sented
$LSD_{0.05}$	0.3111	NS	0.6997	--
CV(%)	8.04	2.75	9.70	--

Values followed by same letter(s) did not differ significantly at 5% level of probability

V_1 = Chiniatap 1, V_2 = Chiniatap 2, V_3 = Kataribhog 1, V_4 = Kataribhog 2, V_5 = BRRI dhan34, V_6 = BRRI dhan37, V_7 = BRRI dhan38, V_8 = BR5 Dulabhog, V_9 = Khoisanne, V_{10} = Sadasanne, V_{11} = Zirabhog, V_{12} = Begun bichi, V_{13} = Shakkhorkhora, V_{14} = Chinigura, V_{15} = Kalijira, V_{16} = Badshabhog, V_{17} = Modhumala

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted at the Agronomy field of Sher-e-Bangla Agricultural University, Dhaka during the period from July 2017 to November, 2017 to study yield and grain quality of different aromatic rice varieties. The experiment comprised of single factor (variety). Seventeen aromatic rice varieties viz., V_1= Chiniatap 1, V_2 = Chiniatap 2, V_3 = Kataribhog 1, V_4 = Kataribhog 2, V_5 = BRRI dhan34, V_6 = BRRI dhan37, V_7 = BRRI dhan38, V_8 = BR5 Dulabhog, V_9 = Khoisanne, V_{10} = Sadasanne, V_{11} = Zirabhog, V_{12} = Begun bichi, V_{13} = Shakkhorkhora, V_{14} = Chinigura, V_{15} = Kalijira, V_{16} = Badshabhog, V_{17} = Modhumala 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 parameters, physiological parameters, yield with yield contributing characters 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.

Results revealed that in terms of growth parameters, the highest plant height (162.7cm) was obtained from the variety, V_{17} (Modhumala) where the highest number of leaves hill $^{-1}$ (65.26) was obtained from the variety, V_2. Similarly, the highest number of total tillers hill^{-1} (23.33), leaf area index (5.38), flag leaf length (30.12 cm) were found from V_6 (BRRI dhan37), but the highest flag leaf breadth and flag leaf area were found from V_{13} and V_{17} respectively. On the other hand, the lowest plant height (137.3 cm) was found from V_9 but the lowest number of leaves hill^{-1} was found from V_{11}. Again, the lowest tillers hill^{-1} (13.33) and LAI (3.02), flag leaf length (30.12 cm), flag leaf breadth (0.65 cm) and flag leaf area (19.52) were found from V_{17}.

Regarding yield and yield contributing parameters, the highest number of effective tiller (21.67), panicle length (32.00), number of grains panicle^{-1} (230.3), number of filled grains panicle^{-1} (212.7), grain yield (3.420 t ha^{-1}), straw yield (6.190 t ha^{-1}) and number of biological yield (9.610) were found in the variety, V_6 (BRRI dhan37) but the highest sterility percentage (24.29), 1000 grains weight (g) (22.80) and highest harvest index (37.48) were found in V_3(Katari bhog1), V_{17} (Modhumala) and V_5 (BRRI dhan34), respectively. Similarly, the lowest number of effective tiller (13.33), panicle length (24.67), grain yield (1.583 t ha^{-1}), straw yield (4.083), biological yield (5.667) and harvest index (27.89) were found in the variety, V_{17} (Modhumala) but the lowest number of grains panicle^{-1} (107.3) and number of filled grains panicle^{-1} (75.67) were observed from the variety, V_4 (Kataribhog2) whereas the lowest sterility percentage (6.377) and 1000 grains (g) (9.110) were found from V_{15}(Kaligira) and V_{10} (Sadasanne), respectively.

Regarding quality parameters, the highest hulling percentage (82.86), milling degree (90.32) and Broken rice percentage (6.257) found in the variety V_6(BRRI dhan37) but the highest rice breadth (2.757mm), boiled rice breadth (3.133), Protein percentage (10.03) and Amylose concentration (29.97) were found in the variety, V_{17} (Modhumala) whereas the highest (1.727) elongation ratio, rice length (6.217mm), boiled rice length (8.600mm), Moisture percentage (13.67), grain length (8.333mm), milling recovery (72.29) were found in the variety V_2 (Chini atab2), V_3 (Kataribhog1), V_7 (BRRI dhan34), V_8 (BR5dulabhog), V_9 (Khoisanne) and V_{16}(Badshabhog), respectively. Again, the lowest hulling percentage (74.09) and grain length (5.333) were found in the variety, V_{12} (Begun bichi) and the lowest (89.75) milling degree and protein percentage (7.633) were found in the variety, V_1 (Chini atab1) whereas the lowest boiled rice breadth (2.067) and elongation ratio (1.310) found in(4.077), rice breadth (1.843), milling recovery (66.76) and moisture percentage (12.50) were found in the variety, V_5 (BRRI dhan34), V_8 (BR5dulabhog), V_{11} (Girabhog), V_{15} (Kaligira) and V_{16}

(Badshabhog), respectively. Regarding aroma content, V_{15} (Kalijira), V_5 (BRRI dhan34), V_{14} (Chinigura) and V_3 (Kataribhog1) showed strongly scented aroma compared to the rest of the varieties whereas V_1 (Chini atab1) showed minimum aroma content among the varieties. the variety, V_3 (Kataribhog1) but the lowest milling recovery (0.4767) and amylose concentration (19.67) found in the variety, V_{13} (Shakkhorkhora). Likewise, the lowest boiled rice length (5.933), rice length

Considering the above statement, it can be concluded that-

1. Different yield characteristics of seventeen aromatic rice varieties differed significantly.
2. Highest plant height found in V_{16} (Badshabhog) and V_{17} (Modhumala) and highest number of leaves found in V_2 (Chiniatab 2) at harvest. On the other hand lowest plant height and number of leaves found in V_4 (Kataribhog 2) and V_{17} (Modhumala).
3. Variety V_6 (BRRI dhan37) showed highest grain, straw and biological yield in 17 aromatic rice varieties. Between 17 aromatic rice varieties V_{17} (Modhumala) Showed lowest grain, straw and biological yield.
4. In case of hulling percent, milling recovery, head rice recovery and broken rice percentage V_6 (BRRI dhan37) and V_{16} (Badshabhog) Showed best performance.
5. Highest elongation ratio found in V_2 (Chiniatab 2) and lowest elongation ratio showed by V_3 (Kataribhog 1) and V_5 (BRRI dhan34).
6. V_{17} (Modhumala) showed highest protein percentage in 17 aromatic rice varieties with lowest amylose content which makes less stickey cooked rice which is popular in Indian subcontinent.

7. In case of aroma test V_3 (Kataribhog 1),V_5 (BRRI dhan34),V_{14} (Chinigura) and V_{15} (Kalijira) showed Strong-scented aroma.
8. So, V_6 (BRRI dhan37) can be considered as the best for yield purpose and V_{17} (Modhumala) for protein content and less amount of amylose.

To reach a specific conclusion and recommendation the same experiment need to be repeated with more parameters and more research work should be done over different Agro-Ecological Zones (AEZ) of Bangladesh for rational adaptability.

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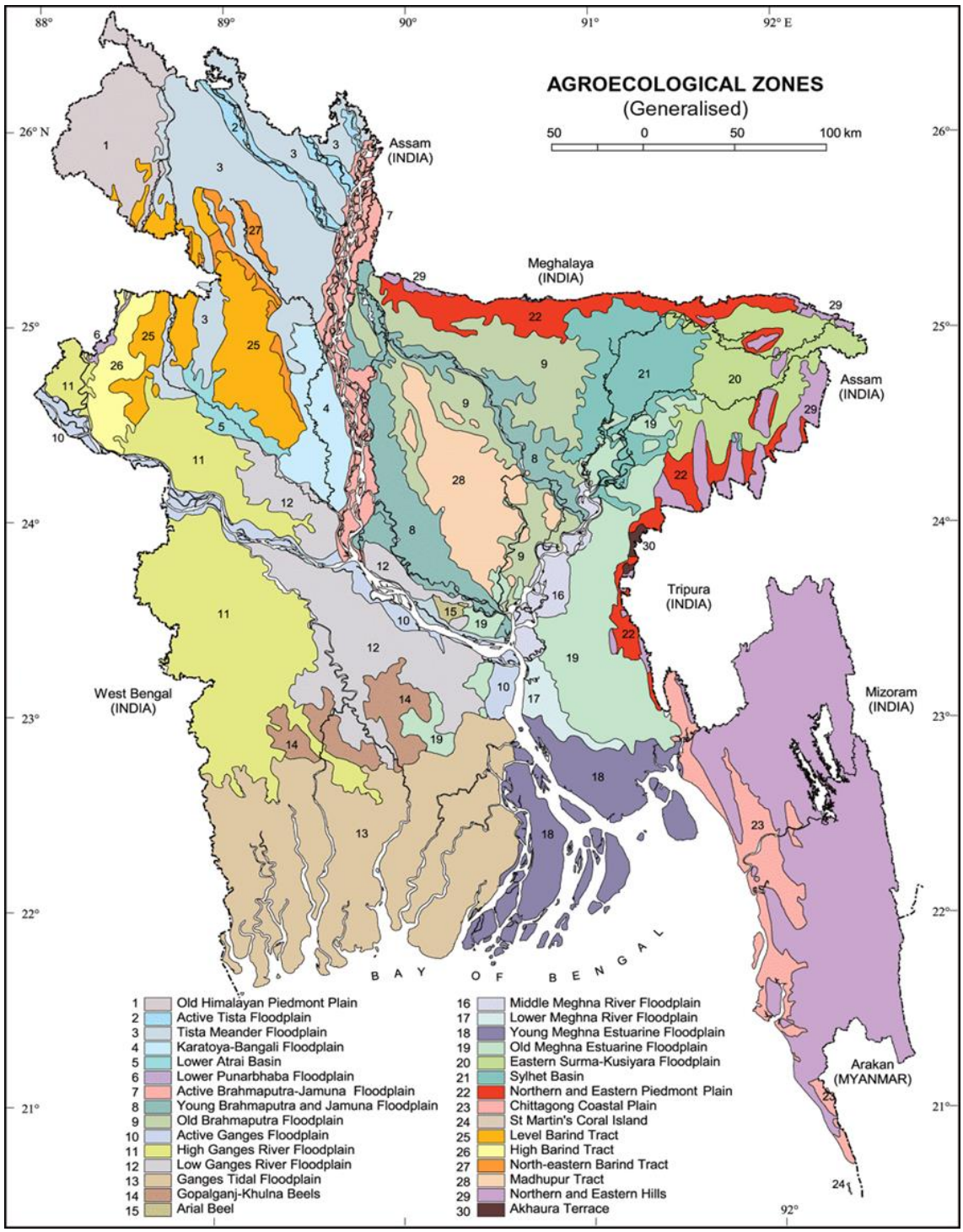
Appendices

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



Appendix II. Monthly records of air temperature, relative humidity, total rainfall and sunshine hours during the period from June to December, 2017

Month(2017)	Air temperature (°C)		Relative humidity (%)	Total rainfall (%)	Sunshine (%)
	Maximum	Minimum			
June	32.4	25.5	81	228	5.7
July	36.8	24.9	87	573	5.5
August	35.2	23.3	85	303	6.2
September	33.7	22.6	82	234	6.8
October	26.6	19.5	79	34	6.5
November	25.1	16.2	77	07	6.7
December	22.6	13.4	74	00	6.6

Source: Bangladesh Meteorologial Department (Climate and weather division) Agargoan, Dhaka-1207

Appendix III. Soil characteristics of experimental field as analyzed by soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Experimental field, SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled

B. Physical and chemical properties of the initial soil.

Characteristics	Value
% Sand	26
% Silt	43
% Clay	31
Textural class	Silty loam
pH	5.9
Catayan exchange capacity	2.64 meq 100g/soil
Organic matter (%)	1.15
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	45

Appendix IV. Plant height of 17 aromatic rice varieties

Source	Degrees of freedom	Plant height			
		25 DAT	50 DAT	75 DAT	At maturity
Replication	2	13.259	28.748	25.844	57.515
Factor A	16	54.260	133.045	0.647	2.622
Error	32	0.739	0.528	186.062	154.830

Appendix V. Number of leaves plant^{-1} of 17 aromatic rice varieties

Source	Degrees of freedom	Number of leaves plant^{-1}			
		25 DAT	50 DAT	75 DAT	At maturity
Replication	2	4.040	2.055	6.044	4.248
Factor A	16	1.232	1.298	0.648	0.274
Error	32	14.124	106.525	120.395	121.957

Appendix VI . Number of tillers hill^{-1} of 17 aromatic rice varieties

Source	Degrees of freedom	Number of tillers hill^{-1}			
		25 DAT	50 DAT	75 DAT	At maturity
Replication	2	0.412	1.220	2.384	44.608
Factor A	16	0.043	0.171	0.373	0.566
Error	32	2.876	7.293	12.888	14.978

Appendix VII. Leaf area index of 17 aromatic rice varieties

Source	Degrees of freedom	Leaf area index (LAI)		
		25 DAT	50 DAT	75 DAT
Replication	2	0.001	0.007	0.000
Factor A	16	0.000	0.005	0.004
Error	32	0.100	1.819	1.740

Appendix VIII. Flag leaf of 17 aromatic rice varieties

Source	Degrees of freedom	Flag leaf		
		Flag leaf length (cm)	Flag leaf breadth (cm)	Flag leaf area (cm^2)
Replication	2	4.616	0.015	27.753
Factor A	16	0.201	0.002	3.467
Error	32	11.117	0.295	320.104

Appendix IX. Effective and non-effective tillers of 17 aromatic rice varieties

Source	Degrees of freedom	Effective and non-effective tillers			
		Number of tiller's per hill	Number of non effective tiller's per hill	Number of effective tiller's per hill	Length of panicle
Replication	2	44.608	2.373	28.647	42.961
Factor A	16	0.566	0.456	0.522	2.232
Error	32	14.978	0.426	11.787	24.228

Appendix X. Filled and un-filled grains of 17 aromatic rice varieties

Source	Degrees of freedom	Filled and unfilled grain			
		Number of total grain's per panicle	Number of filled grain's per panicle	Number of unfilled grain's per panicle	Sterility percentage
Replication	2	54.246	181.431	122.020	10.003
Factor A	16	4059.875	49.848	3.270	6.650
Error	32	600.059	3530.260	255.093	79.151

Appendix XI. Yield parametes of 17 aromatic rice varieties

Source	Degrees of freedom	Yield parameters				
		Weight of 1000 grain's	Grain yield	Straw yield	Biological yield	Harvest index
Replication	2	7.180	0.400	0.875	2.528	2.528
Factor A	16	1.546	0.011	0.047	0.102	0.102
Error	32	39.291	0.721	0.808	2.847	2.847

Appendix XII . Quality parameters of 17 aromatic rice varieties

Source	Degrees of freedom	Quality parameters				
		Paddy weight(g)	Brown rice weight(g)	Milled rice weight(g)	Head rice weight(g)	Broken rice weight(g)
Replication	2	3.695	2.889	2.417	9.080	0.624
Factor A	16	1.949	1.565	1.259	21.034	1.099
Error	32	1.527	15.700	13.189	2.503	6.673

Appendix XIII. Quality parameters of 17 aromatic rice varieties

Source	Degrees of freedom	Quality parameters				
		Hulling percentage	Milling recovery	Milling degree	Head rice recovery	Broken rice percentage
Replication	2	1.222	1.132	0.102	5.852	0.784
Factor A	16	3.357	11.990	0.080	2.105	1.038
Error	32	18.239	1.858	0.104	19.400	6.278

Appendix XIV. Quality parameters of 17 aromatic rice varieties

Source	Degrees of freedom	Quality parameters					
		Grain length (mm)	Rice length (mm)	Rice breadth (mm)	Boiled rice length (mm)	Boiled rice breadth (mm)	Elongation ratio
Replication	2	0.054	0.032	0.009	0.138	0.024	0.005
Factor A	16	0.033	1.700	0.022	0.108	0.016	0.002
Error	32	2.487	0.063	0.143	2.696	0.610	0.041

Appendix XV. Quality parameters of 17 aromatic rice varieties

Source	Degrees of freedom	Quality parameters		
		Protein percentage	Moisture percentage	Amylose concentration
Replication	2	0.241	0.018	1.186
Factor A	16	0.070	0.470	31.113
Error	32	0.863	0.127	0.177

Plates

V_8 = BR5 (dulabhog)

V_9 = Khoisanne

V_{16} = Badshabhog

V_{15} = Kalijira

Plate. 1. Pictures of some aromatic rice varieties

V_5 = BRRI dhan34

V_{10} = Sada sanne

V_9 = Khoi sanne

V_3 = Kataribhog1

V_2 = Chiniatap2

V_{16} = Badshabhog

Plate. 2. Pictures of some panicles of different aromatic rice varieties

V_1 = Chiniatap 1

V_2 = Chiniatap 2

V_3 = Kataribhog 1

V_4 = Kataribhog 2

V_5 = BRRI dhan34

V_6 = BRRI dhan37

V_7 = BRRI dhan38

V_8 = BR5 Dulabhog

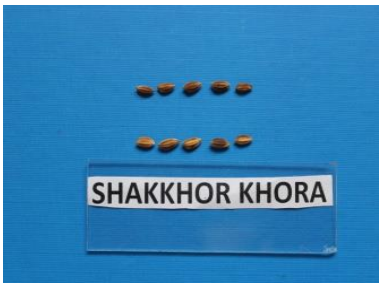
V_9 = Khoi sanne

Plate. 3. Pictures of some grains of different aromatic rice varieties

V_{10} = Sadasanne

V_{11} = Zirabhog

V_{12} =Begun bichi



V_{13} = Shakkhorkhora

V_{14} =Chinigura

V_{15} =Kalijira

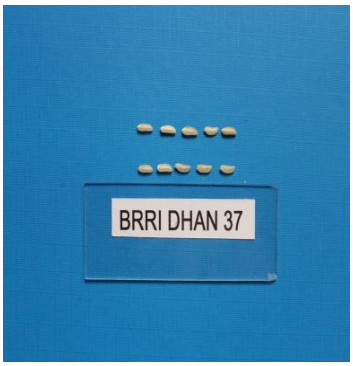
V_{16} =Badshabhog

V_{17} = Modhumala

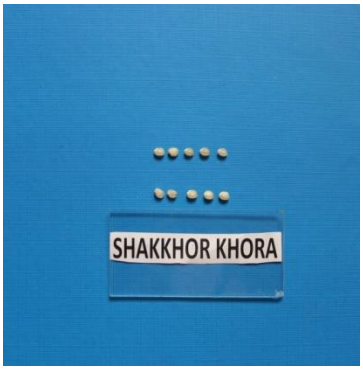
Plate. 4. Pictures of some grains of different aromatic rice varieties

V_1 = Chini atab1

V_7 = BRRI dhan38



V_6 = BRRI dhan37



V_{13} = Shakkhorkhora

V_{12} = Begun bichi

V_{14} = Chini gura

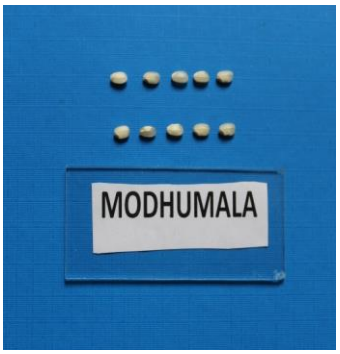
V_{15} =Khalijira

V_{16} = Badshabhog

V_8 = BR5(dulabhog)

Plate. 5. Pictures of some kernels of different aromatic rice varieties

V_2 = Chini atab2



V_{17} = Modhumala

V_5 = BRRI dhan34

V_3 = Kataribhog1

V_4 = Kataribhog2

V_{11} = Girabhog

V_{10} = Sada sanne

V_9 = Khoi sanne

Plate. 6. Pictures of some kernels of different aromatic rice varieties

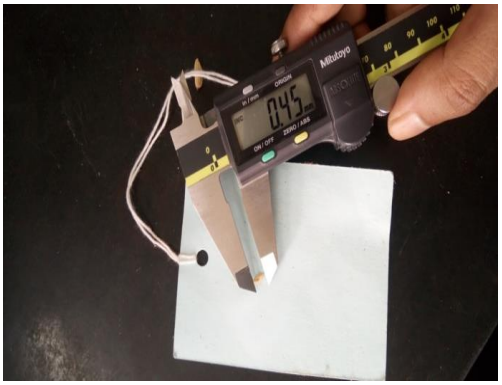


Plate 7. Grain length measurement

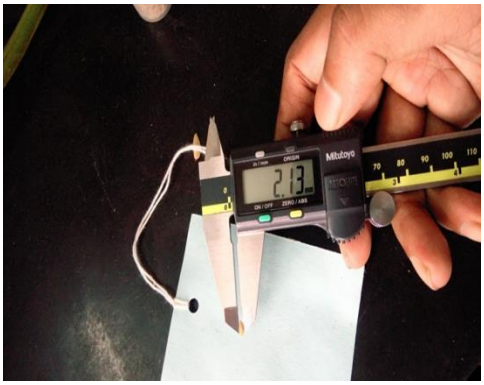


Plate 8. Grain breadth measurement

Plate 9. Kernel length measurement

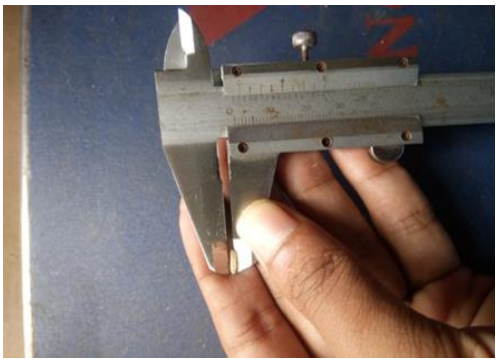


Plate 10. Kernel breadth measurement

Plate 11. Kernel boiling

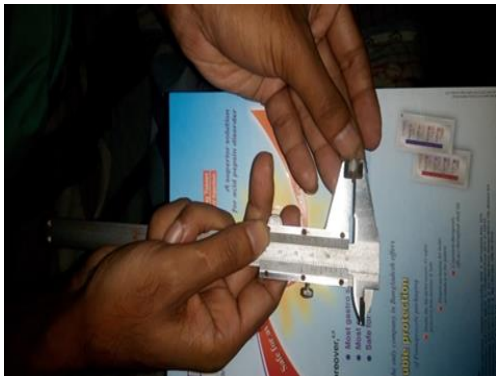


Plate 12. Measuring kernel length and breadth

Plate 13. Protein % calculation by using test Kjeldahl meter

Plate 14. Aroma test after the boiling

Plate 15. Amylose test using by spectrophotometer