# GROWTH AND YIELD PERFORMANCE OF TEN SELECTED RICE VARIETIES IN *AMAN* SEASON


**MD. ABDULLAH AL MAMUN**

**DEPARTMENT OF AGRICULTURAL BOTANY**
**SHER-E-BANGLA AGRICULTURAL UNIVERSITY**
**DHAKA – 1207**


**June, 2020**

# GROWTH AND YIELD PERFORMANCE OF TEN SELECTED RICE VARIETIES IN *AMAN* SEASON

**BY**


**MD. ABDULLAH AL MAMUN**

**Registration No.: 18-09020**


**A Thesis**

Submitted to the Department of Agricultural Botany
Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree
of

**MASTER OF SCIENCE**

**IN**

**AGRICULTURAL BOTANY**

**SEMESTER: January-June, 2020**

**Approved by:**

Prof. Dr. Md. Moinul Haque
**Supervisor**

Prof. Dr. Kamal Uddin Ahamed
**Co-Supervisor**

Dr. Kamrun Nahar
**Chairman**
Examination Committee

Department of Agricultural Botany
Sher-e-Bangla Agricultural University
Sher-e-Bangla Nagar, Dhaka-1207
PABX: 99110351 & 9144270-79

# *CERTIFICATE*

This is to certify that thesis entitled, "**GROWTH AND YIELD PERFORMANCE OF TEN SELECTED RICE VARIETIES IN *AMAN* SEASON**" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE in Agricultural Botany, embodies the result of a piece of Bona Fide research work carried out by Md. Abdullah al Mamun, Registration No.: 18-09020 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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



_______________________________

Prof. Dr. Md. Moinul Haque
**Supervisor**

**Dated:**

**Place; Dhaka, Bangladesh**

Department of Agricultural Botany
Sher-e-Bangla Agricultural University**,**
**Dhaka-1207**

**DEDICATED TO**

**MY**

**BELOVED PARENTS**

# ACKNOWLEDGEMENT

All praises are due to the “Almighty Creator” Who kindly enabled the author to complete the research work and the thesis leading to Master of Science.

The author would like to express his heartiest respect, his deep sense of gratitude and sincere, profound appreciation to his supervisor, **Prof. Dr. Md. Moinul Haque**, Department of Agricultural Botany, Sher-e-Bangla Agricultural University (SAU), Dhaka for his sincere guidance, scholastic supervision, constructive criticism and constant inspiration throughout the course and in preparation of the manuscript of the thesis.

The author would like to express his heartiest respect and profound appreciation to his Co-supervisor, **Prof. Dr. Kamal Uddin Ahamed**, Department of Agricultural Botany, SAU, Dhaka for his utmost cooperation and constructive suggestions to conduct the research work as well as preparation of the thesis.

The author expresses his sincere respect to all the teachers of Department of Agricultural Botany, SAU, Dhaka for providing the facilities to conduct the experiment and for their valuable advice and sympathetic consideration in connection with the study.

The author would like to thank all of friends especially Dipa Roy to help in his research work.

The author expresses her profound gratitude and deepest appreciation to her parents, brothers, sisters, and relatives for their ever-ending prayer, encouragement, sacrifice and dedicated efforts to educate the author to this level.

**June, 2020**

**SAU, Dhaka**

**The Author**

# GROWTH AND YIELD PERFORMANCE OF TEN SELECTED RICE VARIETIES IN *AMAN* SEASON

## ABSTRACT

An experiment was conducted at the Experimental Field of Agricultural Botany Department, Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh, during June, to November, 2019 to evaluate the growth, yield and yield attributing characteristics of ten *Aman* rice varieties of Bangladesh namely; BRRI dhan 80, BRRI dhan 79, BRRI dhan 70, BRRI dhan 56, BRRI dhan 54, BRRI dhan 53, BRRI dhan 52, BRRI dhan 51, BRRI dhan 41 and BRRI dhan 40. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replicates. Parameters on, growth parameter *viz.* plant height and number of tillers hill$^{-1}$(at different days after transplanting); yield contributing characters such as effective tillers hill$^{-1}$, panicle length, number of grains panicle$^{-1}$, filled grains panicle$^{-1}$, thousand grain weight, grain yield, straw yield, biological yield and harvest index were recorded. The plant height and number of tillers hill$^{-1}$ at different days after transplanting varied significantly among the varieties up to harvest, the tallest plant (123.70 cm) was recorded in BRRI dhan 70 and the shortest (81.13 cm) was found in BRRI dhan 41. The maximum number of tillers hill$^{-1}$ (45.60) was observed in BRRI dhan 70 and the minimum (20.40) in BRRI dhan 52. All of the parameters of yield and yield contributing characters differed significantly at 1% level except grain yield, biological yield and harvest index. The maximum number of effective tillers hill$^{-1}$(43.76) was recorded in the variety BRRI dhan 70 while BRRI dhan 40 produced the lowest effective tillers hill$^{-1}$ (17.53). The highest (133.81) and the lowest (42.69) number of filled grains panicle$^{-1}$ was observed in the variety BRRI dhan 70 and BRRI dhan 40 respectively. Thousand grain weights were the highest (26.45 g) in BRRI dhan 70 and the lowest (18.88 g) in BRRI dhan 53. Grain did not differ significantly among the varieties but numerically the highest grain yield (5.01 t ha$^{-1}$) was found in the variety BRRI dhan 54 and the lowest in BRRI dhan 41 (3.78 t ha$^{-1}$).

## LIST OF CONTENTS

# LIST OF TABLES

# LIST OF APPENDICES

## LIST OF ABBREVIATION AND ACRONYMS

| | | |
|---|---|---|
| AEZ | = | Agro-Ecological Zone |
| BARI | = | Bangladesh Agricultural Research Institute |
| BBS | = | Bangladesh Bureau of Statistics |
| FAO | = | Food and Agriculture Organization |
| N | = | Nitrogen |
| B | = | Boron |
| *et al.* | = | And others |
| TSP | = | Triple Super Phosphate |
| MOP | = | Muriate of Potash |
| RCBD | = | Randomized Complete Block Design |
| DAT | = | Days after Transplanting |
| $ha^{-1}$ | = | Per hectare |
| g | = | gram |
| kg | = | Kilogram |
| SAU | = | Sher-e-Bangla Agricultural University |
| SRDI | = | Soil Resources Development Institute |
| wt. | = | Weight |
| LSD | = | Least Significant Difference |
| $^{0}C$ | = | Degree Celsius |
| NS | = | Not significant |
| Max | = | Maximum |
| Min | = | Minimum |
| % | = | Percent |
| NPK | = | Nitrogen, Phosphorus and Potassium |
| CV% | = | Percentage of Coefficient of Variance |

# CHAPTER I

# INTRODUCTION

Main staple food crop in Bangladesh is rice (*Oryza sativa L.*), covering about 75 percent of agricultural land use of the total cropped area. Agriculture contributes in 13.31% of our GDP (BBS, 2019). In tropical and sub-tropical Asian countries, about ninety percent global rice production is occurred (Mejia, 2006). All over the world, rice provides 27% of dietary energy supply and 20% dietary protein (Kueneman, 2006). In the diet of the general people of Bangladesh, it constitutes 95% of the cereal consumed and supplies more than 80% of the calories and about 50% of the protein (Yusuf, 1997). Being the 4th largest rice producer of the world, Bangladesh comprises an area of about 10.27 million hectares for rice production (FAO, 2016). In the year 1971, total rice production in Bangladesh was about 10.59 million tons when the country's population was only about 70.88 million. However, the country is now producing about 35.5 million m tons to feed her 157 million people (BBS, 2016). Thus, Bangladesh will require about 27.26 million tons of rice for the year 2020. The cultivated area of rice decreased for last decade due to increase of cultivation of more profitable contemporary crops. However, the demand of rice has been increasing day by day with increasing population. To fulfill the rice requirement, it is important to increase the rice yield. Under present circumstance can be possible to overcome by increasing high yielding rice production. The objective of this experiment is to determine the best performance of growth and yield of rice variety.

In Bangladesh, rice cultivation is varying according to seasonal changes in the water supply. More than half of the total production (55.5%) is obtained in *Boro* season occurring in April-May and second largest production in *Aman* season (37.9%); occurring in November and December (Asia and pacific commission on agricultural statistics, 2016). Potential for increased rice production strongly depends on the ability to integrate a better crop management for the different varieties into the existing cultivation. Variety itself is a genetic factor which contributes a lot in producing yield and yield components of a particular crop (Mahmud *et al.,* 2013). Among *Aman* rice varieties high yielding modern varieties covered 73.08% and de-husked yield was 2.69 t/ha and local varieties covered 20.99% and de-husked yield was 1.65 t/ha (BBS, 2015). It is the farmers who have gradually replaced the local indigenous low yielding rice varieties by high yielding ones and modern varieties of rice developed by Bangladesh Rice Research Institute (BRRI) and Bangladesh Institute of Nuclear Agriculture (BINA) only because of getting 20 to 30% more yield per unit land area (Shahjahan, 2007). Among the three hill tract districts; Khagrachari occupies about one fifth (2,700 $m^2$) of the total area (Ullah *et al.*, 2012). Currently 37.18% of this area is under irrigation and cropping intensity (CI) is 1.56% (BBS, 2015). Due to unavailability of ground water and extreme irrigation limitation rainfed *Aman* rice is the only hope here; as a result, 62.54% of total rice is grown and maximum production is obtained in this season (DAE, 2016). Less input requirement, short-durated, high yielding and pest resistance varieties have key advantage over local and hybrid. To increase CI and production, there is no alternative for cultivation of short duration variety and adoption of modern agricultural practices. Total area of *Aman* rice cultivation was 28,225 hectares; among them BRRI released varieties were about 22,700-hectare land. Average production was 4.07, 4.04 and 2.58 t/ha of BRRI respectively (DAE, 2016). Mahmud *et al*. (2013) concluded that, rice cultivars differed significantly in all growth characters, such as plant height, tillers number, chlorophyll content, dry matter weight of different plant parts, panicle length, filled grain, unfilled grain, filled grain percentage, 1000-grain weight, grain yield and straw yield. Numbers of seedling(s) per hill had remarkable influence on number of total tillers per hill and total dry matter production. The yield of rice depends on its different growth parameters, i.e.leaf area index, dry matter production and its partitioning, tillering, etc. (Shams, 2002). There are several important factors those have tremendous influence on the growth and development, tiller production, grain formation and other yield contributing characters i.e., age of seedling (Islam and

Ahmed, 1981), spacing (Miah *et al.*, 1990). A number of reports showed that indigenous rice cultivars possess a wide diversity in ecological, morphological and physiological characteristics (Jahan *et al.,* 2003). The yield contributing characters mainly number of effective tillers/hills, number of grains/panicles, grain yield and straw yield were significantly affected when compared to late transplanting. Many of them obtained better results from early transplanting than late transplanting (Oteng-Darko*et al.,* 2013). Most literature suggests that traditional cultivars are of low tillering capacity (Saito and Futakuchi, 2009). Faruk *et al.,* (2009) reported that fourweek-old two seedlings per hill gave high grain yield. Number of seedlings per hill affected all the yield attributes including the number of tillers per hill, grains per panicle, grain yield. Planting a smaller number of seedlings per hill helps to produce healthy tillers which enables normal physiological growth resulting in more panicles with more filled spikelets and thus produces higher grain yield (Rasool *et al.,* 2012). Transplanting with 2 seedlings per hill at a spacing of 20 cm x 20 cm, (Hasanuzaman *et al.,* 2009) obtained higher grain yield than planting with 1, 3 or 4 seedlings per hill. First prerequisite for increasing yield is to ensure abundant growth of a particular crop (Mahmud *et al.,* 2012). Productions of local cultivars are very low and often affected by biotic and abiotic stresses. So, it is not sufficient to fulfill farmers demand and expectations. So far among modern *Aman* rice varieties BRRI has developed 37 (BRKB, 2016). These are mostly suitable for plain lands. All of these may not be suitable for hilly region. Limited or only trail-based rice cultivation has been given so far in improving specific rice variety(s) for the hill tracts. Therefore, the present investigation was undertaken to compare the morphology, relative advantage and performance of some newly released varieties (from research organizations viz. BINA, BRRI) with popular local cultivars.

Based on above proposition, this research work is designed for comparative study on morphological characteristics and yield potential of some *Aman* rice varieties with the following specific objectives:

- To evaluate tillering pattern, leaf area development and leaf chlorophyll content capability of BRRI released ten *Aman* rice varieties;
- To evaluate the yield performance of *afore-said* modern rice varieties.

# CHAPTER II

# REVIEW OF LITERATURE

Tillering phenology and yield contributing characters of modern T. *Aman* rice varieties are numerously rely on improvement of basic ingredients of agriculture. The basic component includes environment, varieties of rice and agronomic practices such as time of planting, spacing, plant density, fertilizer, irrigation etc. Among the mentioned factors effect of seedlings age or time on rice varieties are more responsible for the growth and yield. Appropriate transplanting times are generally more important for T. *Aman* rice. The available relevant reviews related to planting times and varieties in the recent past have been presented and discussed here;

## 2.1 Effect of planting time

Usually planting time depends on for fruitful rice production sensitivity to photoperiod and varietal life duration, environmental factors such as rainfall and temperature. Some review of literature related to planting time with its effect on growth and yield of rice have been mentioned below;

### 2.1.1 Growth parameters

All the growth and yield contributing attributes varied significantly among the six rice varieties. The results revealed that in all rice varieties maximum growth performance observed at 58-68 Days after transplanting and maximum dry matter production was observed at 68 days after transplanting (Khatun *et al.*, 2020).

The sowing date of the rice crop is important for three major reasons. Firstly, optimum temperature and high levels of solar radiation ensures satisfactory vegetative growth. Secondly, the optimum sowing date for each cultivar ensures that the cold sensitive stage occurs when the minimum night temperatures are historically the warmest. Thirdly, exact time sowing guarantees that grain filling occurs when milder autumn temperatures are more likely, hence good grain quality is achieved (Wani *et al.,* 2017)

Wani *et al. (*2017) reported the days taken to reach flowering and harvest varied significantly among the sowing dates. The significantly higher number of days was taken by 15th SMW (standard meteorological week) sown crop, however, was at par with 16th SMW crop while the significantly lowest number of days was taken by 18th SMW sown crop.

Sowing time had a great impact on characteristics of photosynthesis and matter production of direct seeding rice. In contrast of late sowing, early sowing has the beneficial that the accumulation of dry matter is appropriate in the early stage and In the middle stages significantly higher and late stages, so the total dry matter accumulation is significantly maximum and its distribution is reasonable, the export and transformation rate is high and the photosynthetic production capacity is great after heading obtained by (Zhong-yang *et al.,* 2012).

Sowing date provide, the leaf area increased more quickly, the maximum leaf area index became to be higher and tended to occur later but lower more quickly. Dry matter accumulated more quickly in the early stage but became slower after heading. The final dry matters were smaller with sowing date postponed. Increased slightly crop growth rate before heading but decreased after heading. Considering the yield result, the suitable sowing date in low altitude area is around the first 10 days in April, in middle area 5 days later, and in high area the second ten days by (Guanghui *et al.,* 2012).

Seeded rice sown on 20th June proved to be the perfect for gaining maximum number of productive (panicle bearing) tillers, number of kernels per panicle. Among the crop production tools, proper time and method of sowing are the prerequisites that allow the crop to complete its life phase timely and successfully under a specific Agro-ecology (Bashir, *et al.,* 2010).

Evaluation of physiological of some hybrid rice varieties in different sowing dates. H1, H2, GZ 6522 and GZ 6903 hybrid rice were used. Six different sowing dates April 10th, April 20th, May 1st, May 10th, May 20th and June 1st seed were sown; and seedlings of 26 days old were transplanted at20cm spacing. Results showed that early time of sowing (April 20th) was topmost to other times of sowing for MT, PI, HD, number of tillers /M2, (plant height and root length) at PI and HD stage, chlorophyll content, number of days up to PI and HD, leaf area index, sink capacity, spikelets-leaf area ratio, Sterility percentage was the lowest in sowing 20th April. 1st of June, sowing gave the lowest with all traits under study. H1 hybrid rice variety superior other varieties for all characters studied except for number of days to PI and HD (Abou-Khali, 2009).

Early date of sowing is the best time of sowing for important properties such as maximum tillering, panicle initiation, chlorophyll content, leaf area index, sink capacity, panicle length, number of panicles $m^{-2}$, and grain yield (Khalifa, 2009).

Momin *et al.,* (2009) observed that plant height, tillers number, and dry matter of varieties varied significantly due to variation of transplanting dates. The short plants, less tillers, and low dry matter observed in early planted (22 July) crop and characters increased successive with the advances of planting date until 7-22 September and again declined thereafter irrespective of growth stages up to 60 DAT.

Safdar *et al.* (2008) observed that plant height of different genotype of fine rice was affected significantly when assessed through the interaction of varieties and transplanting dates. Fine grain rice genotype 99521 showed the maximum plant height (195 cm) in 16th June transplanting date, which was significantly different from all other treatment’s combinations. Minimum plant height was recorded in Super basmati when transplanted on 16th may. Means of varieties across 6 transplanting dates showed that maximum number of grains per panicle (138.5) was recorded from genotype 99513 which was statistically similar with genotype 99512 producing 131.7 grains per panicle. On the other hand, maximum grains from single panicle (119.3), irrespective of varieties, were counted from fine rice genotypes transplanting on 16th July which remained statistically at par with that transplanted on 1st July.

In rainfed lowland rice flowering occurs within optimum time if sowing was conducted from May onwards up to the first week of August. However, delayed sowing can be up to the first week of August for rainfed lowland cultivars if there is any crop loss due to flooding at the beginning of the cropping (Sarkar and Reddy, 2006).

It was experimented that mildly photoperiod-sensitive cultivars had a lower likelihood of encountering low temperature against with photoperiodinsensitive cultivars. The benefits of photoperiod sensitivity include reduced water use with greater sowing flexibility as growth duration is shortened when sowing is late (Farrell *et al.*, 2006).

Around mid-July was the perfect for earlier planting of high yielding varieties of rice. Late planting might have illuminated the crop to relatively more unfavorable condition in terms of water stagnation at the phase of tillering and due to low temperature pulled down the yield at the reproductive phase compared to earlier planting reported by Gohain and Saikia (1996).

For transplantation of high yielding cultivars best time between July 15 and August 15 for transplant *Aman* rice in Bangladesh. However, early transplanting provides better result than late transplanting (Hedayetullah *et al.*, 1994).

If a little early photosensitive variety is transplanted, their vegetative growth promoted which showed more height of plant and leafy growth. Due to highest plant height, such varieties lodge badly when transplanted early, as a result, reduced drastically in grain yield. On the other hand, when delayed transplanting it reduced grain development which results in produced more quantity of under developed grains and ultimately severe lower in yield (Kainth and Mehra, 1985).

Due to minimum temperature vegetative stage of rice may be longer in November planting of BR3 when the temperature was cool, the vegetative phase was extended by 50 days and the relative tillering rate reached its peak at 40 to 50 days after transplanting. In contrast with planting in July when the temperature was high, the relative tillering rate picked up the maximum rate within 15 to 25 days after transplanting. In maximum cases, tillering value reduce because of low temperature. So, adequate planting date and the use of photoperiod-sensitive cultivars can be convenient in a region in avoiding low temperature reduce during reproductive improvement obtained by Vergara and Chang, (1985).

Indica rice is more affected by time of transplanting than that of other type of rice variety for vegetative growth attributes (Langfield and Basinski, 1960). Time of transplanting has inherent effect on the responses of different cultivars of thermo-sensitive and photo in nature (Takahashi *et al.*, 1967).

### 2.1.2 Yield parameters

Seeded rice sown on 20th June proved to be the perfect for gaining maximum grain yield and net return. 20th June sowing also gave maximum number of productive (panicle bearing) tillers, number of kernels per panicle, 1000-grain weight and benefit-cost ratio found (Bashir, 2010).

Prabhakar and Reddy, (2010) observed the effect of dates of sowing and found that the 7th August transplanted crop was significantly shorter when compared to all other. The sowing of the nursery on 29th June has resulted in to significantly higher number of tillers when compared to sowing on 13 July. Among the dates of sowing the 29th June sown crop retained more LAI at 120 days after sowing. The biomass production was higher with 30th July sown crop when compared to the 13th August sown crop and was at par with rest of the sowing dates. The difference between the highest and lowest dry matter production was 317.2 $gm^{-2}$.

Islam *et al.* (2008) reported that direct wet-seeded rice produced 10% higher grain yield than transplanted rice and 31 December seeded rice produced the highest grain yield. Rice planted on 1 December significantly reduced the grains per panicle and January planted rice significantly reduced the panicle per unit area. Different yield and yield parameters like number of tillers per hill, grains per panicle, 1000 grain weight and sterility were significantly affected by transplanting time. Two genotypes were grown at 30/240C day/night temperature in a greenhouse, in both genotypes one-hour exposure to 33.70C at anthesis caused sterility. In IR64, about 7% spikelet fertility was reduced by per degree increase of temperature (Jagadish *et al.*, 2007).

Spikelet sterility of rice results from low temperatures during panicle development. However, this temperature alone cannot fully explain the fluctuations in sterility observed in the field, since the susceptibility of rice plants to low temperature often changes according to its physiological status during sensitive stages. Low water temperature (below 200C) during vegetative growth stage of rice plant significantly increased the sterility. On the other hand, low air temperature during vegetative growth also significantly increased the sterility, but this effect was diminished by warm water temperature even at low air temperature. There was a close and negative correlation between sterility and water temperature during vegetative growth (Shimono *et al.*, 2007).

Yield and quality of aromatic rice were topmost when exposed to a low temperature (day mean temperature $23^{0}$C). Yield, filled grain rate, and number of filled grains per panicle reduced significantly under the highest temperature (day mean temperature $30^{0}$C). The highest temperature also increased the chalkiness score, and reduced milled rice, milling quality of head rice, amylose content, alkali value, eating and aroma scores, and gel consistency in rice (Xu *et al.*, 2006).

Yield and spikelet sterility of rice in temperate Kashmir was affected by transplanting dates and nutrient condition. Spikelet sterility was higher in rice transplanted on 30 June as difference with that on 15 June due to reduced growth phases and minimum temperature during reproductive phase. Further, levels of N increasing under delayed transplanted conditions spikelet sterility increased and grain yield of rice reduced (Singh *et al.*, 2005).

Linscombe *et al.* (2004) reported that planting date had a major effect on grain yield. Grain yield at one location in southwest Louisiana was highest (8600 kg $ha^{-1}$) when rice was planted in late March, and grain yield (6500 kg $ha^{-1}$) decreased linearly as planting was delayed until early June.

Lower sterility was recorded in rice varieties 98901 (5.25%) and Super Basmati (5.08%) and maximum (13.08%) in PK 5261-1-2-1. Minimum sterility was observed in rice transplanted on July 21 followed by July 1, July 11 and July 31 by Akram *et al.* (2004).

Maximum grain yield was found due to accumulation effect of longer panicle, highest number of grains per panicle and 1000 grain weights (Salam *et al.*, 2004). Same findings were also reported by Rahman, (2003).

Biological yield of rice had the highest direct effect on grain yield followed by harvest index and 1000 grain weight. In 15 July transplanting of rice highest grain yield was obtained by Surek *et al.* (1998).

Panwar *et al.* (1989) noticed that spikelet number was the main component character affecting the rice yield. Number of panicles per hill and number of spikelets per panicle had negative direct effects on grain yield (Padmavathi *et al.*, 1996).
Yield attributes like panicle per plant, grains per panicle and 1000 grain weight increase yield in modern varieties (Saha Ray *et al.*, 1993).

These results suggest that temperatures before panicle initiation change the susceptibility of a rice plant to low temperatures during panicle development which results in spikelet’s sterility. Grain size in rice is considered to be the most stable character little difference in single grain weight or grain size would further increase the grain yield potential of rice. Evidence suggests that grain yield increase in can be achieved through promotion of one or more than one of the yield components of rice by Matsushima, (1957).

### 2.1.3 Growth and yield parameters

Khatun *et al.* (2020) concluded that maximum number of filled spikelet observed in Binadhan-17 (164.89/ panicle) and that was significantly different from other varieties. Percent of sterile spikelet was highest in BRRI dhan39 (12.9%) and that was statistically similar with Binadhan-16 (11.96%) and BRRI dhan33 (12.36%).

Hamid *et al.* (2016) reported that seedling age at transplanting, method and date of transplanting are important factors contributing plant growth and grain yield.

Effect of different sowing dates on paddy yield and yield components of direct seeded rice (*Oryza sativa*) variety Nerica.4. The different sowing dates revealed significant effect on all the studied growth and yield characters. The results showed early sowing dates produce a high grain yield more than later ones, delaying sowing date from 15th July decrease the grain yield (t/ha), this may be attributed to the decrease of 1000 grain weight, number of filled grains/panicle and increasing of the percent of unfilled grains/panicle. The grain yield (t/ha) was positively and highly correlated with number of filled grains/panicle and 1000 grain weight. The sowing dates 1st July and 15th July produced the maximum grain yield of (2.9 t/ha$^{-1}$) and (2.8 t/ha$^{-1}$), respectively.
It could be concluded that the period from the first of July to the mid of it can be considered as the optimum sowing date for direct seeding of the upland rice (variety Nerica.4) at Sudan and under White Nile State condition observed by Osman *et al.* (2015).

Effect of seed rates under different of sowing dates (20th April, 1st May and 10th May) on some rice varieties. Three rice varieties Sakha 101, Sakha 103, Sakha 104 were tested. Three seed rates were used (48, 95 and 144 kg /ha). Under three different sowing dates 20th April, 1st May and 10th May with seedling age were transplanted 25 days from sowing by 20×20 cm planting spacing. The results found that maximum tillering, panicle initiation, heading dates, leaf area index, chlorophyll content, 1000-grain weight, panicles length, number of panicles per hill and grain yield (Ton/ha) were increase by increased seed rates up to 143 kg seed $ha^{-1}$. Earlier sowing time (20th April) date of sowing gave had the highest value of all studied characters in Sakha 101 variety and this rice variety surpassed other varieties to all attributes under study. While 30th May date of sowing with Sakha 103 inbred rice gave the lowest value of all traits under study by Khalifa *et al.* (2014).

Climate change an effect on agriculture is limited understanding of crop responses to extremely high temperatures. This uncertainty partly reflects the relative lack of observations of crop behavior in farmers' fields under extreme heat. Simulations with two commonly used process-based crop models indicate that existing models underestimate the effects of heat on senescence. As the onset of senescence is an important limit to grain filling, and therefore grain yields, crop models probably underestimate yield losses for +2˚C by as much as 50% for some sowing dates. These results imply that warming presents an even greater challenge to wheat than implied by previous modelling studies, and that the effectiveness of adaptations will depend on how well they reduce crop sensitivity to very hot days (Lobell *et al.,* 2012).

Farmers typically start sowing their *Aman* seedling nurseries in mid-June, using long duration varieties such as BR11 and BRRI dhan49 (135–140 d), and transplant once there has been sufficient rain to enable them to puddle the soil, and harvest in early to late of November. The *Aman* crop is grown predominantly on rainfall, with supplementary irrigation during dry spells and after the rainy season ends, if needed. The monsoon rains usually start in the third week of June and end in mid-September, but this varies greatly, and when the rains start late, this results in transplanting of seedlings older than the optimum age, reduced yield, and delayed harvest (Amin and Haque, 2009).

20 July and 5 August gave the highest tillers hill$^{-1}$ of hybrid rice. Planting date (20 July, 5 August and 20 August) and N level (50.100 and 150 kg/ha) on rice (hybrid Proagery 6201) in Mddliya Pradesh. The number of tillers maximum up to 60 days after transplanting (DAT) and declined thereafter by Pandey *et al.* (2001).

Bindra *et al.* (2000) conducted an experiment in Malan. Himachal Pradesh. India, during the rainy seasons of 1996 and 1997 to determine the effect of N rates (0. 30. 60 and 90 kg/ha) and transplanting dates (7 and 14 July) on scented rice cv. Kasturi. There was a considerable reduction in yield contributing characters like panicle length with delay in transplanting from 7 July. Crops transplanted on 7 July record 2.72% panicle length respectively, then those transplanted on 14 July.

Effect of transplanting date on yield and yield attributes in 4 rice cultivars, a field experiment was lay out at the Iran Rice Research Institute in Amol in 1998. Treatments comprised: four genotypes Tarom. Nemat. Shel (7325 line) and Fajr (7328 line) and their transplanting dates with 10 days intervals from 13 March to 1 June 2000. Grain yield, biomass, harvest index, tiller number, grain number per ear, ear fertilized percentage and 1000-seed weight at different transplanting dates were obtained the delay in transplanting date decreased tiller number car fertilized percentage, grain number per ear. In 1000-seed weight and biomass grain yield and harvest index, but the different transplanting dates did not show any significant differences. Nemat had higher tiller number and 1000-seed weight compared to the other cultivars. Among the yield attributes, tiller number per plant. 1000-seed weight and grain number per ear had a positive and significant correlation with yield obtained by (Pirdashty *et al.*, 2000).

The optimum time of planting (5. 15 and 25 July) for four rice hybrids. Cirain yield of rice decreased progressively with delay in transplanting. The crops transplanted on 5 July and 15 July were comparable. Grain yield decrease with delayed transplanting was accompanied by fewer panicles and filled grains per panicle and lower 1000-grain weight. Grain yield was reduced by 9% from 5.14 ton/ha on 5 July to 4.69 ton/ha on 25 July reported by Muthukrishnan *et al.* (2000).

In a field trial in *Boro* season of 1996 in India. 55-day old seedlings of 5 short duration (C'alturel. IR50. Govind, China ad Jagilu) and 3 medium duration (Joymati. Mala and Mahsuri) rice cultivars were planted on 20 January or 4 or 19 February 1996. Among the short duration cultivars. Govind gave the best results, followed by China, while among medium duration cultivars Mahsuri was the best followed costly by Joymati. Planting on 20 January produced the highest yield in all the cultivars except Mala, which showed better performance with planting on 4 February (Chowdhury and Guha, 2000).

The optimum planting date for two advanced mutants of rice along with two check varieties in *Aman* season in 1997. The mutants were BINA 115 and BINA 163 and the check varieties were Binasail and BR22. There were three planting dates starting from July, with an interval of 30 days. The plant characters like number of tillers hill$^{-1}$ showed significant variation among the dates of planting obtained by Islam *et al.* (1999).

Hari *et al.* (1997) carried out a field experiment in 1993-94 at Haryana with 4 rice cultivars and found that seedling transplanted on 25 June produced highest number of productive tillers than those on 15 June. 5 or 25 July transplanted rice.

BRRI (1995) an experiment was conducted by to find out the optimum planting time of *Boro* rice which were planted at 15-day interval from 25 December to 12 March and found that all lines tested produced satisfactory yield up to 9 February and. after that, yield decreased drastically and field duration of the tested lines decreased with the advancement of planting dates. BR14 gave the highest (5.44 ton/ ha) and the lowest (2.24 ton/ha) yield when planted on 9

January and 12 March, respectively and required 117 and 92 days from planting to harvesting, respectively.

BRRI (1995) reported that four promising lines and the check BR14 were planted at 15-day intervals starting from 20 December up to 5 February at Gazipur using 40 days old seedlings for all the planting. Among the tested lines. RWBC-6-5 yielded the highest (5.75 ton/ha) from 5 January planting followed by BRR1-3 (5.08 ton/ha). Grain yields and maturity of all the lines and varieties decreased considerably after 20 January planting.

Seedling transplanting require at least 4 for recovery in the *Boro* rice season when transplanted in mid-January and direct-seeded rice might have an advantage of growth duration rather than yield in the *Boro* season compared to transplanted one. It is reported that when BR14 was broadcast directly to the field produced 5.66 ton/ha, while gave 6.59 ton/ha when it was transplanted and their field durations were 90 and 97 days, respectively reported by BRRI, (1995).

BRRI (1994) conducted an experiment by with 40-day old seedlings of sixteen promising lines, including one check variety BR26 were evaluated in *Boro* season. Seedlings were transplanted between 25 December 1993 to 12 March 1994. Results showed that BR4824-17-2-3 yielded significantly highest. The significantly highest yield was found when planted on 25 December and 9 January followed by 25 January planting. After 25 January planting the grain yield declined significantly. Gazipur in 1989-90 with 4 rice *vis*. Namely BR11, BR22, BR23 and Nazirsail which sown at various time. Among the cv. BR22 gave the highest seed yield from most of the sowing dates in both years.

Seed yield of BR11 and BR23 were similar up to first September when yield of BR11 decreased sharply with the September sowing BR22 and Nazirsail similar yields. It was concluded that BR11 and BR23 were suitable for the late sowing (Ali *et al.*, 1993)

BRRI (1993) conducted an experiment to find out the optimum planting time of 14 advanced lines in *Boro* season. Forty-day old *Boro* seedlings were transplanted between 25 December and 12 March in the *Boro* season at 15 days intervals. Among the tested promising lines/varieties. BR4828-2-21 yielded highest (5.18 ton/ha) when planted on 25 December. On the other hand, BR4828-50-12 yielded highest (5.18 t/ha) when planted on 9 January. The yield of all the promising lines varieties decreased progressively with the advancement of planting dates beyond 9 January.

BR22 and BR23 that transplanting 30-day old seedlings of both the varieties of 1 August to 7 October at 15-day interval up to 15 September and then at 7-day intervals, both the varieties gave the highest yield BR22 (4.52 ton/ha) and BR23 (3.97 ton/ha) when planted on 1 August. After that the yield was decreased gradually reported by Ali *et al.* (1993).

# CHAPTER III

# MATERIALS AND METHODS

The experiment was conducted at the experimental field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from June to November 2019 to evaluate the growth and yield performance of ten *Aman* rice varieties in Bangladesh.

The details of the materials and methods have been presented below:

## 3.1 Description of the experimental site

### 3.1.1 Location

The present piece of research work was conducted in the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka. The location of the site is $23^0$ 74′N latitude and $88^0$ 35′ longitude with an elevation of 8.2 meter from sea level. The geographical location of the experimental site was under the subtropical climate, characterized by three distinct seasons, winter season from November to February and the pre-monsoon period or hot season from March to April and monsoon period from May to October. Details of the meteorological data of air temperature, relative humidity, rainfall and sunshine hour during the period of the experiment was collected from the Weather Station of Bangladesh, Sher-e Bangla Nagar, Dhaka and has been presented in Appendix 1.

### 3.1.2 Soil & Climate

The soil belongs to "The Modhupur Tract", AEZ – 28 (FAO, 1988). Top soil was silty clay in texture, olive-gray with common fine to medium distinct dark yellowish-brown mottles. Soil pH was 5.6 and has organic carbon 0.45%. The experimental area was flat having available irrigation and drainage system and above flood level. The selected plot was medium high land. The details have been presented in Appendix I. The geographical location of the experimental site was under the subtropical climate, characterized by three distinct seasons, winter season from November to February and the pre-monsoon period or hot season from March to April and monsoon period from May to October. Details of the meteorological data of air temperature, relative humidity, rainfall and sunshine hour during the period of the experiment was collected from the Weather Station of Bangladesh, Sher-e-Bangla Nagar, Dhaka and has been presented in Appendix 1.

### 3.1.3 Design and layout

The experimental plots were laid out in randomized complete block design (RCBD). The field was divided into three blocks; representing three replications. Row to row and plant to plant distances were 25cm and 20cm respectively. Four (04) genotypes were distributed to each plot of 4 m × 2.5 m size within each block randomly.

### 3.1.4 Planting Materials

The experimental materials of the study comprised of 10 T. *Aman* rice varieties. The seeds were collected from BRRI, Gazipur, Bangladesh.

### 3.1.5 Treatment of the experiment

The experiment consisted of one factor:

Factor A: Different varieties of T. *Aman* rice

i. $V_1$ = BRRI dhan 80
ii. $V_2$ = BRRI dhan 79
iii. $V_3$ = BRRI dhan 70
iv. $V_4$ = BRRI dhan 56
v. $V_5$ = BRRI dhan 54
vi. $V_6$ = BRRI dhan 53
vii. $V_7$ = BRRI dhan 52
viii. $V_8$ = BRRI dhan 51
ix. $V_9$ = BRRI dhan 41and
x. $V_{10}$ = BRRI dhan 40

## 3.2Preparation of the experiment

### 3.2.1 Germination of seeds

Seeds of all collected rice genotypes soaked separately for 48 hours in clothes bag. Soaked seeds were picked out from water and wrapped with straw and gunny bag to increase the temperature fin facilitating germination.

### 3.2.2 Preparation of seedbed and raising seedling

The irrigated land was prepared thoroughly by 3 to 4 times ploughing and cross ploughing followed by laddering to attain a good puddle. Weeds and stubbles were removed. Thirty live separate strips were made and sprouted seeds were sown on each strip in $2^{nd}$July of 2019. Seedbed was irrigated with regular interval to maintain moisture.

### 3.2.3 Preparation of the main field

The experimental plot was at a lower elevation with high water holding capacity. The land was prepared thoroughly by 3-4 Limes ploughing and cross ploughing followed by laddering after application of cow dung to attain a good puddle. Weeds and stubbles were removed and land was finally prepared by the addition of basal dose of fertilizers.

### 3.2.4 Fertilizers and manure application

At the time of first ploughing, cow-dung was applied at the rate of 10 t $ha^{-1}$.

The fertilizers N, P, K, S and Zn in the form of urea, TSP, MP, Gypsum and ZnSO4, respectively were applied. The following doses were applied for the cultivation of the test variety.

Cow-dung = 10 t $ha^{-1}$

Urea = 120 kg $ha^{-1}$

TSP = 80 kg $ha^{-1}$

MP = 80 kg $ha^{-1}$

Gypsum = 20 kg $ha^{-1}$

$ZnSO_4$ = 5 kg $ha^{-1}$

Source: BRRI, 2013 (Adunik Dhaner Chash), Joydevpur, Gazipur.

The entire amount of TSP, MP, Gypsum and Zinc sulphate were applied during the final preparation. Urea was applied in two equal installments at tillering and panicle initiation stage.

### 3.2.5 Uprooting of seedlings

The nursery bed was made wet by application of water one day before uprooting of the seedlings. The seedlings were uprooted on $2^{nd}$August 2019, without causing much mechanical injury to the roots.

### 3.2.6 Transplanting of seedlings in the field

On the scheduled dates as per experiment the rice seedlings were transplanted in lines each having a line to line distance of 30 cm and plant to plant distance 25 cm in the well-prepared plots. A 25, 35- and 45-days old seedling were uprooted and transplanted on the will puddle plots on 2nd August 2019.

## 3.3 After care

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

### 3.3.1 Irrigation and drainage

Flood irrigation was provided to maintain a constant level of standing water up to 6 cm in the early stages to enhance tillering and 10-12 cm in the later stage to discourage late tillering. The field was finally dried out at 15 days before harvesting.

### 3.3.2 Gap filling

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

### 3.3.3 Weeding

Weeding was done to keep the plots free from weeds, which ultimately ensured better growth and development. The newly emerged weeds were uprooted carefully at tillering stage and at panicle initiation stage by mechanical means.

### 3.3.4 Top dressing

After basal dose, the remaining doses of urea were top-dressed in 2 equal installments and were applied on both sides of seedlings rows in the soil.

### 3.3.5 Plant protection

Furadan 57 EC was applied at the time of final land preparation and later on other insecticides were applied as and when necessary.

## 3.4 Harvesting, threshing and cleaning

The rice was harvested depending upon the maturity of 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 during 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 t $ha^{-1}$.

## 3.5 Data recording

### 3.5.1 Plant height

The height of plant was recorded in centimeter (cm) at the time of 50, 65 and 80 DAT (Days after transplanting) and at harvest. Data were recorded as the average of 10 plants selected at random from the inner rows of each plot. The height was measured from the ground level to the tip of the tiller.

### 3.5.2 Tillers hill$^{-1}$

The number of tillers hill$^{-1}$ was recorded at the time of 50, 65 and 80 DAT (Days after transplanting) and at harvest. Data were recorded as the average of 10 hills selected at random from the inner rows of each plot.

### 3.5.3 Productive tillers hill$^{-1}$

The total number of productive tiller hill$^{-1}$ was counted as the number of panicles bearing tiller hill$^{-1}$. Data on productive tiller hill$^{-1}$ were counted from 10 selected hills at harvest and average value was recorded.

### 3.5.4 Non-Productive tillers hill$^{-1}$

The total number of non-effective tillers hill$^{-1}$ was counted as the number of non-panicles bearing tillers plant$^{-1}$. Data on non-productive tiller hill$^{-1}$ were counted from 10 selected hills at harvest and average value was recorded.

### 3.5.5 Length of panicle

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

### 3.5.6 Days to maturity

Days to maturity were recorded by counting the number of days required to mature in each plot. Maturity date was estimated by keen observation of plants and started at first maturity and followed to at 50%, 80% and 100% maturity and when the plant became brownish in color than the rice plant attained its maturity.

### 3.5.7 Filled grains hill$^{-1}$

The total number of filled grains was collected from randomly selected 10 plants of a plot on the basis of grain in the spikelet and then average number of filled grains hill$^{-1}$ was recorded.

### 3.5.8 Unfilled grains hill$^{-1}$

The total number of unfilled grains was collected from randomly from selected 10 plants of a plot on the basis of unfilled grain in the spikelet and then average number of unfilled grains hill$^{-1}$ was recorded.

### 3.5.9 Weight of 1000 seeds

One thousand seeds were counted randomly from the total cleaned harvested seeds of each individual plot and then weighed in grams and recorded.

### 3.5.10 Grain yield

Grains obtained from each unit plot were sun-dried and weighed carefully. The dry weight of grains of central 1 $m^2$ area and five sample plants were added to the respective grain yield/$m^2$ in kg $ha^{-1}$.

### 3.5.11 Straw yield

Stover yield obtained from each unit plot were sun-dried and weighed carefully. The dry weight of straw of central 1 $m^2$ area and five sample plants were added to the respective straw yield $m^2$ and finally converted to kg $ha^{-1}$.

### 3.5.12 Harvest index

Harvest index was calculated from the grain and straw yield of rice for each plot and expressed in percentage. Harvest index was calculated using the following formula:

HI = (Seed yield × 100)/ Biological yield Here,

Biological yield = Seed yield + Straw yield

### 3.5.13 Yield

Grains obtained from each unit plot were sun-dried and weighed carefully. The dry weight of grains of central 1 $m^2$ area and five sample plants were added to the respective grain yield/$m^2$ and converted to t $ha^{-1}$.

## 3.6 Analysis of data

The data obtained for different characters were statistically analyzed by “MSTAT-C” program to find out the significance of the difference levels of loose seeds collected from three seeds store. The mean values of all the characters were evaluated and analysis of variance was performing by the “F” (variance ratio) test. The significance of the difference among the treatment combinations means was estimated by the least significant difference (LSD) at 5% level of probability (Gomez and Gomez, 1984).

# CHAPTER IV

# RESULTS AND DISSCUTION

The results of the study were presented by evaluating the growth and yield performance of ten *Aman* rice varieties of BRRI. The details of the results and discussion have been presented below:

### 4.1 Plant height

All other growth parameters of any crop, plant height is one of the important parameters as it determines or modifies yield contributing characteristics and finally shapes the grain yield (Reddy and Redd, 1997). Due to the genetic makeup among the varieties, variation might be occurring in plant height. Plant height among all varieties increased progressively, and differed significantly, reaching a maximum at harvest (Table 1).

**Table 1**. Plant height of modern *Aman* rice varieties at different days after transplanting

| **Varieties** | **Plant height (cm) at** | | | |
|---|---|---|---|---|
| | 50 DAT | 65 DAT | 80 DAT | Harvest |
| BRRI dhan 80 | 68.50 ab | 104.26 a | 108.53 ab | 111.40 b |
| BRRI dhan 79 | 75.26 a | 104.36 a | 116.20 a | 122.93 a |
| BRRI dhan 70 | 77.32 a | 110.05 a | 117.75 a | 123.70 a |
| BRRI dhan 56 | 64.80 bc | 73.25 cd | 93.20 c | 92.13 d |
| BRRI dhan 54 | 71.25 ab | 91.13 b | 103.86 b | 108.67 bc |
| BRRI dhan 53 | 62.74 c | 84.20 bc | 95.41 bc | 97.60 c |
| BRRI dhan 52 | 58.59 cd | 69.30 d | 84.10 d | 91.33 d |
| BRRI dhan 51 | 61.83 c | 76.86 c | 91.20 c | 114.87 ab |
| BRRI dhan 41 | 51.13 d | 65.26 de | 76.06 e | 81.13 e |
| BRRI dhan 40 | 49.01 d | 62.20 e | 79.53 de | 86.10 de |
| LSD (0.01) | 0.01 | 0.01 | 0.01 | 0.01 |
| CV (%) | 8.19 | 7.82 | 4.73 | 4.33 |

At the growth stage 50 DAT, 65 DAT and at 80 DAT the variety BRRI dhan

70 produced the highest plant height (77.32 cm, 110.05 cm and 117.75 cm respectively), whereas the variety BRRI dhan 79 produced statistically similar in plant height. On the other hand, at 50 DAT and at 65 DAT, the shortest plant height (49.01 cm and 62.20 cm) was observed in the variety BRRI dhan 40 and 80 DAT and at harvest the variety BRRI dhan 41 produced the shortest plant height (76.06 cm and 81.13 cm respectively). This result was in consistent to those of Khatun (2001) and Das *et al*. (2012) who observed variable plant height among the rice varieties.

## 4.2 Tillers hill$^{-1}$

Tiller numbers per plant in most of the treatments improved exponentially up to harvest (Table 2). The maximum number of tillers hill$^{-1}$ (46.33) was recorded in the variety BRRI dhan 70 followed by BRRI dhan 70 (31.26). The minimum number of tillers (18.23) was observed in the variety BRRI dhan 52 which was statistically significant with other varieties.

**Table 2.** Number of tillers hill$^{-1}$ of local *Boro* rice varieties at different days after transplanting

| **Varieties** | **Number of tillers hill$^{-1}$ at** | | | |
|---|---|---|---|---|
| | 50 DAT | 65 DAT | 80 DAT | Harvest |
| BRRI dhan 80 | 22.20 ab | 25.66 b | 29.66 bc | 33.00 b |
| BRRI dhan 79 | 23.93 a | 21.87 bc | 31.26 b | 29.80 bc |
| BRRI dhan 70 | 24.48 a | 36.63 a | 46.33 a | 45.60 a |
| BRRI dhan 56 | 17.00 b | 19.86 bc | 20.40 cde | 22.07 de |
| BRRI dhan 54 | 19.66 b | 23.86 bc | 24.73 b-e | 29.60 bc |
| BRRI dhan 53 | 18.46 bc | 24.26 bc | 23.40 b-e | 24.47 cde |
| BRRI dhan 52 | 20.36 ab | 20.53 bc | 18.23 e | 20.40 e |
| BRRI dhan 51 | 15.00 c | 26.26 b | 27.26 b-e | 29.13 bc |
| BRRI dhan 41 | 19.20 b | 27.00 b | 28.20 bcd | 29.93 bc |
| BRRI dhan 40 | 12.66 d | 16.60 c | 19.13 de | 19.80 e |
| LSD (0.01) | 0.01 | 0.01 | 0.01 | 0.01 |
| CV (%) | 21.25 | 13.43 | 14.48 | 9.22 |

In a column Mean values having similar letters are significantly similar and those having dissimilar letters differ significantly as per 0.01level of significance, CV=Co efficient of variation

According to Khakwani *et al*. (2006) and Paraye and Kandalkar (1994) who reported that plant height is significantly influenced by sowing dates. Similar result was found from the report of Kainth and Mehra (1985); Safdar *et al.* (2013).

### 4.3 Flag leaf chlorophyll content

Flag leaf chlorophyll a and b content from spectrophotometer data was collected from 50, 65 and 80 DAT which is one of the most important yield contributing character to the selection of better yielding *Aman* verity. At 50 DAT the highest data was found from BRRI dhan79 as 2.52 and the lowest from BRRI dhan52 (1.95).

**Table 3**: Effect of variety on flag leaf chlorophyll content in *Aman* season

| **Varieties** | **Flag leaf chlorophyll (mg $g^{-1}$) content at** | | |
|---|---|---|---|
| | 50 DAT | 65 DAT | 80 DAT |
| BRRI dhan 80 | 2.24 ab | 2.30 | 2.39 |
| BRRI dhan 79 | 2.52 a | 2.40 | 2.56 |
| BRRI dhan 70 | 2.07 b | 1.98 | 2.75 |
| BRRI dhan 56 | 2.28 ab | 2.27 | 2.45 |
| BRRI dhan 54 | 2.31 ab | 2.31 | 2.37 |
| BRRI dhan 53 | 2.12 b | 2.02 | 2.18 |
| BRRI dhan 52 | 1.95 c | 1.91 | 2.24 |
| BRRI dhan 51 | 2.43 a | 2.39 | 2.15 |
| BRRI dhan 41 | 2.16 b | 2.23 | 2.27 |
| BRRI dhan 40 | 1.97 c | 2.11 | 2.24 |
| LSD (0.01) | 4.12 | NS | NS |
| CV (%) | 9.38 | 9.20 | 8.78 |

In a column Mean values having similar letters are significantly similar and those having dissimilar letters differ significantly as per 0.01level of significance, NS= Non significance CV=Co-efficient of variation

For 65 DAT the highest data was found from BRRI dhan79 as 2.40and the lowest from BRRI dhan52 as 1.91. The chlorophyll measurement at 80 DAT indicates the highest amount of flag leaf chlorophyll content was from BRRI dhan70 (2.75) and the lowest from the verity BRRI dhan51 (2.15) (Table 3).

### 4.4 Leaf area index

Leaf area index showed statistically significant variation due to different rice variety at 15, 30, 45, 60 and 75 days after transplanting (DAT) (Table 5). The highest leaf area index at 15, 30, 45, 60 and 75 DAT (0.41, 1.75, 3.89, 5.94 and 6.94, respectively) were recorded from BRRI dhan54 which were statistically similar (0.40, 1.66, 3.55, 5.66 and 6.59, respectively) to BRRI dhan32, whereas the lowest leaf area index (0.35, 1.48, 2.99, 4.18 and 4.80, respectively) was recorded from BRRI dhan70 (Table 8). Jisan *et al.* (2014) reported that BRRI dhan54 produced the highest leaf area index, while the lowest values of these parameters were produced by BRRI dhan70. Similar results also reported by Amin *et al.* (2006), Son *et al.* (1998) and Shaloie *et al.* (2014) from their earlier study.

**Table 4.** Leaf area index at different days after transplanting for different rice varieties in *Aman* season

| Rice Varieties | Leaf area index | | | | |
|---|---|---|---|---|---|
| | **30 DAT** | **40 DAT** | **50 DAT** | **60 DAT** | **70 DAT** |
| BRRI dhan 80 | 0.80 ab | 1.66 ab | 3.55 b | 5.66 ab | 6.59 ab |
| BRRI dhan 79 | 0.79 ab | 1.61 abc | 3.49 b | 5.29 bc | 6.13 bc |
| BRRI dhan 70 | 0.75 b | 1.48 c | 2.99 d | 4.18 d | 4.80 d |
| BRRI dhan 56 | 0.77 ab | 1.50 bc | 3.09 d | 4.00 d | 4.62 d |
| BRRI dhan 54 | 0.81 a | 1.75 a | 3.89 a | 5.94 a | 6.94 a |
| BRRI dhan 53 | 0.77 ab | 1.61 abc | 3.46 bc | 5.25 bc | 6.09 bc |
| BRRI dhan 52 | 0.77 ab | 1.58 bc | 3.21 cd | 5.22 bc | 6.04 bc |
| BRRI dhan 51 | 0.75 b | 1.56 bc | 3.27 bcd | 4.98 c | 5.74 c |
| BRRI dhan 41 | 0.69c | 1.47c | 3.01d | 3.94d | 4.25e |
| BRRI dhan 40 | 0.67c | 1.50bg | 3.26bcd | 4.20d | 4.60d |
| LSD(0.05) | 0.047 | 0.147 | 0.259 | 0.426 | 0.542 |
| CV(%) | 6.57 | 6.32 | 5.24 | 5.74 | 6.29 |

In a column mean values having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.01 level of significance.
CV=Coefficient of variance;

## 4.5 Effective tillers hill$^{-1}$

Variety had significant effect on effective tillers hill$^{-1}$ (Table 3). The highest number of effective tillers hill$^{-1}$ (43.76) was produced by BRRI dhan 70. The lowest number of effective tiller hill$^{-1}$ (17.53) was observed in BRRI dhan 40 which was preceded statistically similar by BRRI dhan 52 (18.00).

Jisan *et al.* (2014) reported that, variation in number of tillers hill$^{-1}$ might be due to varietal characters. Similar result was also reported by Ramasamy *et al.* (1987) who specified that number of tillers hill$^{-1}$ differed due to varietal variation.

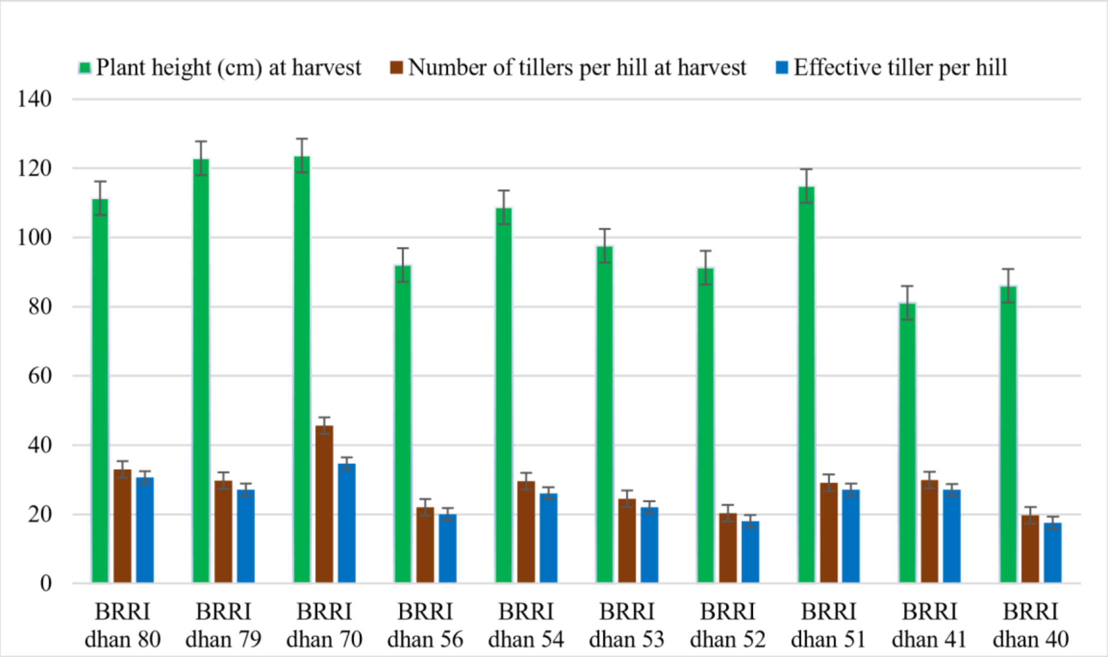



**Figure 1:** Effect of variety on Plant height, No. tiller hill$^{-1}$ at harvest and effective tiller hill$^{-1}$ in *Aman* season

## 4.6 Panicle length

Panicle length and plant height might have increased grain yield of rice indirectly by increasing the number of spikelets per panicle and panicle length, respectively

(Behera, 1998). The highest panicle length (22.26 cm) was recorded in the variety BRRI dhan 79 which was followed by the variety BRRI dhan 54. The lowest panicle length (15.22 cm) was found with the variety BRRI dhan 40 which was preceded by BRRI dhan 53, BRRI dhan 52 and BRRI dhan 41 (Table 3).

Maximum grain yield was found due to growth effect of longer panicle Salam *et al*. (2004). Same findings were also reported by Rahman (2003). This result is also consistent with findings of Sarkar (2014) who reported that panicle length significantly varied among varieties.

**Table 5**. Yield and yield contributing characters of different indigenous Aman rice varieties

| Varieties | Effective tiller hill$^{-1}$ | Panicle length (cm) | Grains panicle$^{-1}$ |
|---|---|---|---|
| BRRI dhan 80 | 30.73 b | 18.58 bc | 103.77 b |
| BRRI dhan 79 | 27.13 bc | 22.26 a | 113.17 ab |
| BRRI dhan 70 | 34.76 a | 20.22 ab | 133.81 a |
| BRRI dhan 56 | 20.00 cd | 18.82 bc | 96.57 bc |
| BRRI dhan 54 | 26.13 bc | 21.54 a | 88.17 c |
| BRRI dhan 53 | 22.00 c | 18.35 c | 74.01 cd |
| BRRI dhan 52 | 18.00 d | 17.71 c | 45.34 e |
| BRRI dhan 51 | 27.13 bc | 19.11 bc | 52.81 e |
| BRRI dhan 41 | 27.06 bc | 17.64 c | 62.81d |
| BRRI dhan 40 | 17.53 d | 15.22 d | 47.69 e |
| LSD (0.01) | 0.01 | 0.01 | 0.01 |
| CV (%) | 10.54 | 3.98 | 14.59 |

In a column Mean values having similar letters are significantly similar and those having dissimilar letters differ significantly as per 0.01level of significance, CV=Co efficient of variation

## 4.7 Grains panicle$^{-1}$

The number of grains panicle-$^{1}$ was the highest (133.81) with the variety BRRI dhan 70 which was statistically alike with BRRI dhan 79. The lowest number of grains panicle$^{-1}$ (45.34) was recorded with the variety BRRI dhan 52 which was statistically similar with BRRI dhan 51 and BRRI dhan 40 (Table 3).

Kiani and Nematzadeh (2012) concluded that filled grains/panicle correlated significantly with grain yield. Sarkar (2014) reported that number of filled grains/panicle influenced expressively due to variety. The results were also supported by Singh and Gangwer (1989) who opined that varietal differences regarding the number of filled grains panicle$^{-1}$ might be due to their differences in genetic constituents.

### 4.8 Filled grains panicle$^{-1}$

These results revealed that number of grains panicle$^{-1}$ was highest (111.25) with the variety BRRI dhan 70 that was statistically identical with BRRI dhan 79. The lowest number of filled grains panicle$^{-1}$ (40.56) was recorded in the variety BRRI dhan 52 which was statistically similar to BRRI dhan 40 (Table 5).

**Table 6.** Yield and yield contributing characters of different indigenous *Aman* rice varieties

| Varieties | Filled grains panicle$^{-1}$ | Unfilled grains pancle$^{-1}$ | 1000-grain weight (g) |
|---|---|---|---|
| BRRI dhan 80 | 74.96 bc | 7.20 b | 26.23 a |
| BRRI dhan 79 | 98.45 ab | 7.10 b | 25.74 a |
| BRRI dhan 70 | 111.25 a | 9.20 a | 26.45 a |
| BRRI dhan 56 | 83.29 bc | 8.80 a | 21.86 bc |
| BRRI dhan 54 | 46.51de | 5.15 d | 24.80 ab |
| BRRI dhan 53 | 61.36 cde | 6.35 c | 18.88 d |
| BRRI dhan 52 | 40.56 e | 8.90 a | 20.92 c |
| BRRI dhan 51 | 66.69 cd | 9.00 a | 24.34 ab |
| BRRI dhan 41 | 49.17 de | 6.50 c | 22.02 bc |
| BRRI dhan 40 | 41.64 e | 5.40 d | 24.34 ab |
| LSD (0.01) | 0.01 | 0.01 | 0.01 |
| CV (%) | 14.24 | 4.19 | 5.53 |

In a column Mean values having similar letters are significantly similar and those having dissimilar letters differ significantly as per 0.01level of significance, CV=Co efficient of variation

Bashir *et al*. (2010) and Shah and Bhurer (2005) who reported that a greater number of filled grains per panicle was visualized in the early seeding and declined gradually in the successive seeding dates.

### 4.9 Unfilled grains panicle$^{-1}$

Statistically significant variation was recorded due to different rice variety in terms of unfilled grains panicle$^{-1}$ (Table 5). The maximum number of unfilled grains panicle$^{-1}$ (9.20) was recorded from BRRI dhan 70 which was statistically similar (9.00, 8.90 and 8.80) to BRRI dhan 51, BRRI dhan 52 and BRRI dhan 56 and closely followed (7.10) by BRRI dhan 79, whereas the minimum number of unfilled grains panicle$^{-1}$ (5.15) was recorded from BRRI dhan 54 which was statistically similar (5.40) to BRRI dhan40 and closely followed by BRRI dhan53 (6.35) and BRRI dhan80 (7.20) (Table 5).

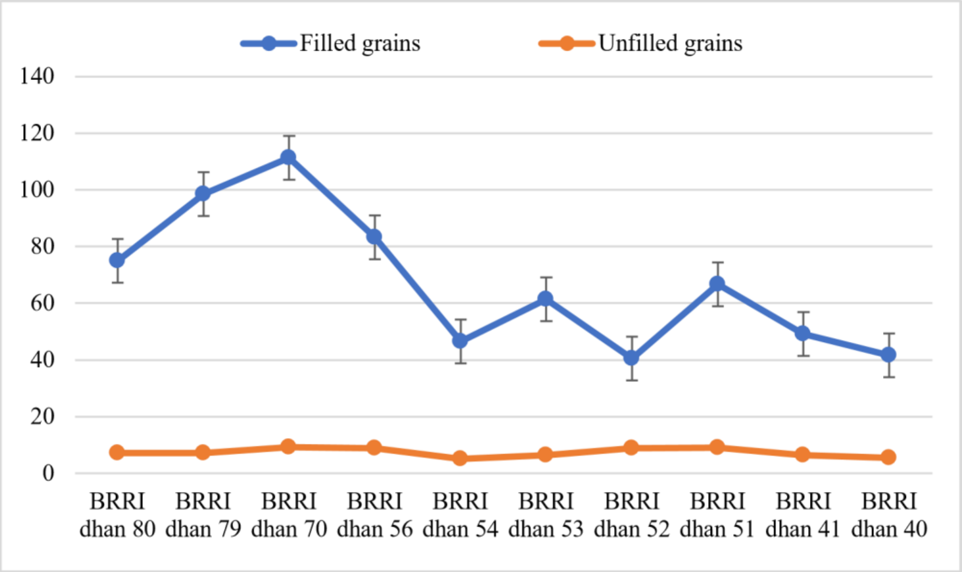



**Figure 2:** Effect of *Aman* rice varieties on filled grain and unfilled grain panicle$^{-1}$

### 4.10 1000 -grain weight.

Thousand grain weights are also an important yield contributing trait. Among the tested varieties the highest 1000-grain weight (26.45 g) was produced by BRRI dhan 70 which might be due to its larger grain size and that was statistically similar to BRRI dhan 79 and BRRI dhan 80. The lowest 1000-grain weight (18.88 g) was found in BRRI dhan 53 (Table 5).

Roy *et al.* (2014) studied on 12 rice varieties and found difference in thousand weights of grains due to morphological and varietal variation. Mondal *et al.* (2005) stated that 1000-grain weight differed significantly among the 17 *Aman* cultivars studied.

### 4.11 Grain yield

Among the ten varieties/cultivar studied BRRI dhan 54 yielded (5.01 t/ha) which statistically similar with BRRI dhan 70 (Table 7). BRRI dhan 41 had the minimum yield (3.78 t/ha) which was significantly lowest than rest of the varieties/cultivars.

**Table 7:** Yield and harvest index for different rice varieties in *Aman* season

| Varieties | Grain yield (t $ha^{-1}$) | Straw yield (t $ha^{-1)}$ | Biological yield (t $ha^{-1}$) | Harvest index (%) |
|---|---|---|---|---|
| BRRI dhan 80 | 4.26 b | 7.76 ab | 7.41 cd | 50.04 |
| BRRI dhan 79 | 4.52 b | 7.64 abc | 6.54 de | 51.23 |
| BRRI dhan 70 | 4.93 a | 6.53 e | 7.51 bc | 55.66 |
| BRRI dhan 56 | 4.22 b | 6.85 de | 7.46 bc | 57.55 |
| BRRI dhan 54 | 5.01 a | 7.89 a | 6.42 f | 56.71 |
| BRRI dhan 53 | 4.78 ab | 7.45 a-d | 9.43 a | 53.05 |
| BRRI dhan 52 | 4.12 bc | 7.20 b-e | 7.37 cd | 49.81 |
| BRRI dhan 51 | 3.92 c | 6.93 cde | 7.43 cd | 48.37 |
| BRRI dhan 41 | 3.78 d | 6.57e | 7.04 d | 56.16 |
| BRRI dhan 40 | 4.01 bc | 7.21a-d | 8.74 b | 54.57 |
| LSD (0.01) | 0.01 | 0.63 | NS | NS |
| CV (%) | 4.23 | 6.19 | 17.38 | 8.32 |

In a column Mean values having similar letters are significantly similar and those having dissimilar letters differ significantly as per 0.01level of significance, NS= Non significance CV=Co-efficient of variation

More number of grains per panicle, a smaller number of non-effective tillers and higher root length of BRRI dhan 54 may have resulted in higher yield. Poor tillering, a smaller number of grains per panicle, lodging tendency and more straw yield may be the reasons for such lower yield in BRRI dhan 41. Varietal variances of grain yield were reported by Biswas *et al.* (1998). The genotypes, which produced higher number of effective tillers per hill and higher number of grains per panicle also showed higher grain yield in rice (Dutta *et al.*, 2002). Yield differences due to varieties were recorded by Islam *et al.* (2014) who observed variable grain yield among varieties.

### 4.12 Straw yield

Statistically significant variation was recorded due to different rice variety in terms of straw yield (Table 6). The highest straw yield (7.89 t $ha^{-1}$) were recorded from BRRI dhan 54 which were statistically similar (7.76, 7.64 and 7.45 t $ha^{-1}$) to BRRI dhan80, BRRI dhan79 and BRRI dhan53 closely followed (7.20 t $ha^{-1}$) by BRRI dhan52, whereas the lowest straw yield (6.53 t $ha^{-1}$) was recorded from BRRI dhan70 which was statistically similar (6.85 t $ha^{-1}$) to BRRIdhan56.

### 4.13 Biological yield

Biological yield did not vary significantly among the varieties (Table 6). However, numerically the highest biological yield (9.43 t $ha^{-1}$) was obtained from the variety BRRI dhan 53. The lowest biological yield (6.42 t $ha^{-1}$) was found in the BRRI dhan 54. These results are in agreement with the results of Sohel *et al.* (2009).

### 4.14 Harvest index

Varieties did not follow any regular trend in case of harvest index and did not vary significantly (Table 6). However, numerically the highest harvest index (57.55%) was recorded from the variety BRRI dhan 56 and that of the lowest (48.37%) was recorded in BRRI dhan 51.

Kusutani *et al.* (2000) highlighted the contribution of high harvest index to yields. High yield is determined by physiological process leading to a high net accumulation of photosynthates and their partitioning (Miah *et al.*, 1990). Jisan *et al.* (2014) and Tyeb *et al.* (2013) reported that variety has significant influence on harvest index.

# CHAPTER V

# SUMMARY AND CONCLUSION

An experiment was conducted at the Experimental Field of Agricultural Botany Department, Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh, during June to November, 2019 to find out the growth and yield performance of ten *Aman* rice varieties of BRRI at the Agricultural Botany experimental field of Sher-e Bangla Agricultural University (SAU). The selected varieties were BRRI dhan 80, BRRI dhan 79, BRRI dhan 70, BRRI dhan 56, BRRI dhan 54, BRRI dhan 53, BRRI dhan 52, BRRI dhan 51, BRRI dhan 41 and BRRI dhan 40. And seedling of plant transplanting 50 DAT (Days after transplanting), 65 DAT and 80 DAT. The summary of the results and discussion have been presented below:

Plant height of the variety was recorded at 50, 65 and 80 DAT (Days after transplanting). At the growth stage 50 DAT, 65 DAT and at 80 DAT the variety BRRI dhan 70 produced the highest plant height (77.32 cm, 110.05 cm and 117.75 cm respectively), which statistically similar the variety BRRI dhan 79 produced in plant height. At 65 and 85 DAT BRRI dhan 40 and BRRI dhan 41 were produced shortest plant height likely 62.20 cm and 76.06 cm respectively.

Maximum number of tillers hill$^{-1}$ (46.33) was recorded in the variety BRRI dhan 70 followed by BRRI dhan 79 (31.26). The minimum number of tillers (18.23) was observed in the variety BRRI dhan 52 which was statistically significant with other varieties. Number of effective tillers hill$^{-1}$ was produced highest (43.76) by BRRI dhan 70. The lowest number of effective tiller hill$^{-1}$ (17.53) was observed in BRRI dhan 40 which was preceded statistically similar by BRRI dhan 52.

The highest panicle length (22.26 cm) was recorded in the variety BRRI dhan 79 which was followed by the variety BRRI dhan 54. The lowest panicle length (15.22 cm) was found with the variety BRRI dhan 40 which was preceded by BRRI dhan 53, BRRI dhan 52 and BRRI dhan 41. The number of grains panicle-

$^{1}$ was the highest (133.81) with the variety BRRI dhan 70 which was statistically alike with BRRI dhan 79. The lowest number of grains panicle$^{-1}$ (45.34) was recorded with the variety BRRI dhan 52 which was statistically similar with BRRI dhan 51 and BRRI dhan 40. And number of grains panicle$^{-1}$ was highest (111.25) with the variety BRRI dhan 70 that was statistically identical with BRRI dhan 79. The lowest number of filled grains panicle$^{-1}$ (40.56) was recorded in the variety BRRI dhan 52 which was statistically similar to BRRI dhan 40

Among the all tested varieties the highest 1000-grain weight (26.45 g) was produced by BRRI dhan 70 which might be due to its larger grain size and that was statistically similar to BRRI dhan 79 and BRRI dhan 80. The lowest 1000grain weight (18.88 g) was found in BRRI dhan 53. BRRI dhan 54 yielded (5.01 t/ha) which statistically similar with BRRI dhan 70. BRRI dhan 41 had the minimum yield (3.78 t/ha) which was significantly lowest than rest of the varieties/cultivars. Among the ten varieties/cultivar studied BRRI dhan 54 yielded (5.01 t/ha) which statistically similar with BRRI dhan 70. BRRI dhan 41 had the minimum yield (3.78 t/ha) which was significantly lowest than rest of the varieties/cultivars.

Leaf area index showed statistically significant variation due to different rice varieties at 15, 30, 45, 60 and 75 days after transplanting (DAT). The highest leaf area index at 15, 30, 45, 60 and 75 DAT (0.41, 1.75, 3.89, 5.94 and 6.94, respectively) were recorded from BRRI dhan54 which were statistically similar (0.40, 1.66, 3.55, 5.66 and 6.59, respectively) to BRRI dhan32, whereas the lowest leaf area index (0.35, 1.48, 2.99, 4.18 and 4.80, respectively) was recorded from BRRI dhan70.

Flag leaf chlorophyll a and b content from spectrophotometer data was collected from 50, 65 and 80 DAT which is one of the most important yield contributing character to the selection of better yielding *Aman* verity. At 50 DAT the highest data was found from BRRI dhan79 as 2.52 and the lowest from BRRI dhan52 (1.95). For 65 DAT the highest data was found from BRRI dhan79 as 2.40and the lowest from BRRI dhan52 as 1.91. The chlorophyll measurement at 80 DAT indicates the highest amount of flag leaf chlorophyll content was from BRRI dhan70 (2.75) and the lowest from the variety BRRI dhan51 (2.15).

No significantly vary among the varieties on biological yield. However, numerically the highest biological yield (9.43 t $ha^{-1}$) was obtained from the variety BRRI dhan 53. The lowest biological yield (6.42 t $ha^{-1}$) was found in the BRRI dhan 54. Varieties did not follow any regular trend in case of harvest index and did not vary significantly (Table 3.b). However, numerically the highest harvest index (57.55%) was recorded from the variety BRRI dhan 56 and that of the lowest (48.37%) was recorded in BRRI dhan 51.

Considering the stated findings, it may be concluded that yield and yield contributing parameters and quality are positively correlated with the *Aman* rice variety. Considering the situation of the present experiment, further studies in the following areas may be suggested:

1. BRRI dhan70 should be chosen among the test *Aman* rice varieties for getting higher grain yield.
2. This experiment should be carried out in different Agro-ecological zones (AEZ) of Bangladesh for confirmation of the results.

# REFERENCES

Abou-Khali, A, A, B. (2009). Evaluation of some hybrid rice varieties under different sowing time. *African J. Plant. Sci.*,**3**(4): 53-58.

Akram, H. M., Ali, A., Nadeem, M. A., Iqbal, M. S. (2007). Yield and Yield components of rice varieties as affected by transplanting dates. *J. Agril. Res.*, **45**(2): 105 -111.

Ali, M.G.; Mannan. M.A.; Haider, K.P. and Siddique, S.B. (1993). Effect of planting dates on the growth and yield of modern transplanted *Aman* rice. *Ann. Bangladesh Agric.*, **3**(2): 103-108.

Asia and pacific commission on agricultural statistics (2016). Agriculture Market Information System (AMIS) in Bangladesh. Twenty sixth session on Asia and Pacific Commission Agriculture Statistics, 15-19 February,2016, Thimphu,Bhutan . Retrieved from http://www.fao.org/fileadmin/templates/ess/documents/apcas26/presentations/APCAS-16-5.2.5_-_Bangladesh_-_AMIS_in_Bangladesh.pdf

BBS (Bangladesh Bureau of Statistics) (2019). Statistical pocket book of Bangladesh. Mins. Planning. Govt. Peoples Repub. Bangladesh.: 67-73.

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

BBS (2015). Yearbook of Agricultural Statistics-2015. 27th Series, Planning Division, Ministry of Planning, Dhaka, Bangladesh. pp. 17-65.

Behera, A. K. (1998). Response of scented rice (*Oryza sativa*) to nitrogen under transplanted condition; *Indian J. Agron*., **43**(1):64–67.

Bashir, M. U., Akbar, N., Iqbal, A. and Zaman, H. (2010). Effect of different sowing dates on yield and yield components of direct seeded coarse rice (*Oryza sativa* L.). *Pakistan J. Agri. Sci.*, **47**(4): 361-365.

Bindra, A. D., Kalia, B. D. and Kumar, S. (2000). Effect of graded levels of nitrogen and dates of transplanting on growth, yield and yield attributes of scented rice. *Adv. Agril. Res., India.* 13: 209-212.

Biswas, J. K., Hossain, M. A., Sarkar, B. C., Hassan, M. and Haque, M. Z. (1998). Yield performance of several rice varieties seeded directly as late *Aman* crops. *Bangladesh J. Life Sci.*, 10: 47–52.

BRRI (Bangladesh Rice Research Institute). (1992). Annual report for 1990. BRRI. Pub. No. 102. Joydevpur, Gazipur, Bangladesh. pp. 8-11.

BRRI (Bangladesh Rice Research Institute). (1993). Annual report for 1993. BRRI. Pub. No. 115. Joydevpur, Gazipur, Bangladesh. pp. 5-7.

BRRI (Bangladesh Rice Research Institute). (1994). Annual report for 1994. BRRI. Pub. No. 123. Joydevpur, Gazipur, Bangladesh. pp. 7-10.

BRRI (Bangladesh Rice Research Institute). (1995). Annual report lor 1989. BRRI. Pub. No. 98. Joydevpur, Gazipur, Bangladesh. pp. 58-59.

BRRI (Bangladesh Rice Research Institute). (1995). Annual report for 1993. BRRI. Pub. No. 113. Joydevpur, Gazipur, Bangladesh. pp. 182-220.

BRRI (Bangladesh Rice Research Institute). (1995). Annual report for 1992. BRRI. Pub. No. 71. Joydevpur. Gazipur, Bangladesh. pp. 14-16.

BRRI (Bangladesh Rice Research Institute). (2018). Annual Report for Jan. 2016- Jan. 2017. BRRI, Joydevpur. Bangladesh Pub. No. 135. pp. 42-43.

BRKB (2016). Rice production problem, 5th edition. p.70. Retrieved 13 January 2017Fromhttp://knowledgebank-brri.org/Publications/Riceproduction-problem/booklet-rice-production-problem.pdf.

DAE (Department of Agricultural Extension) (2016). Annual Report of Additional Director Office, DAE, Banarupa, Rangamati, Bangladesh. pp. 4-7.

Das, B, Mannan MA, Das PK. Performance study of three high yielding varieties ofBangladesh and one exotic rice variety. B.Sc. Thesis. Agrotechnology Discipline, Khulna University, Khulna. 2012; pp.19-27.

Dutta, R. K., Baset, M. A. and Khanam, S. (2002). Plant architecture and growth characteristics of fine grain and aromatic rice and their relation with grain yield. Intl. Rice Comm. Newslett., 51: 51–56.

FAO (Food and Agriculture Organization) (1988). Production year book, Food and Agricultural Organization of the United Nations, Rome, Italy. No.46.

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

Farrell, T. C., Fukai S., and Williams, R. L. (2006). Minimizing cold damage during reproductive development among temperate rice genotypes. I. Avoiding low temperature with the use of appropriate sowing time and photoperiod-sensitive varieties. CSIRO Publishing. Collingwood. Australia.

Faruk, M. O., Rahman, M. A. and Hassan, M. A. (2009). Effect of seedling age and number of seedlings per hill on the yield and yield contributing characters of BRRI dhan 33. *Int. J. Sustain. Crop Prod*., 4: 58-61.

Gohain, T. and L. Saikia. (1996). Effect of date of transplanting on growth and yield of rainfed low rice (*Oryza sativa*). *Indian J. Agron*., 41: 488-490.

Gomez, K. A, Gomez A. A. (1984). Statistical procedure for agricultural research. International Rice Research Institute. John Wiley and Sons, New York, 139-240.

Guanghui, X., Baolin, S., Lei, S., Anyou, T. (2012). Effects of Sowing Date on Dry Matter Production of Hybrid Rice. *J. China Agril. University*. 5: 5-9.

Hedayetullah, S., Sen, S. and Nair, K. R. (1994). A Statistical Note of Agriculture Workers. No. 20. Influence of dates of planting and spacing on some winter varieties of rice. *Indian J. Agril. Sci*., 14:148-159.

Hasanuzzaman, M., Nahar, K., Roy, T. S., Rahman, M. L., Hossain, M. Z. and Ahmed, J.U. (2009). Tiller dynamics and dry matter production of transplanted rice asaffected by plant spacing and number of seedlings per hill. *Academic J.Plant Sci.,* 2: 162-168.

Hari. O.M.: Katyal. S.K. and Dhinan. S O. (1997). Effect on times of transplanting and rice hybrids on growth and yield. *Indian J. Agron.,* **42**(2): 262-264.

Islam, M. S., Paul, S. K. and Sarkar, M. A. R. (2014). Varietal performance of modern transplant *Aman* rice subjected to level of nitrogen application. *Bangladesh J. Agril. Univ*., **12**(1): 55-60. https:// doi.org/ 10.3329/ j bau. v12i1. 21239.

Islam, M. F., Sarkar, M. A. R., Abedin, M. Z., Razzaque M. A. and Parveen, S. (2008). Effects of date of planting using drum seeder on growth and yield of *Boro* rice. *Bangladesh J. Agril. Res*., 33: 19-29.

Islam. M. R., Rahman, M. H., Awal, M. A. and Hossain, S. M. G. (1999). Effect of date of transplanting of yield of two advanced mutants of rice in *Aman* season. *Bangladesh J. Nuclear Agric*., 15: 34-40.

Islam, M. A. and Ahmed, J. U. (1981). Effect of age of seedlings on the yield of transplant *Aman* cultivars. *Bangladesh J. Agril. Sci*., **8**(2): 175-179.

Jahan, M. S., Kumamaru, T., Hamid, A. and Satoh, H. (2003). Diversity of grain quality characters in Bangladesh rice germplasm. Khulna University Studies., 5: 71-77.

Jisan, M. T., Paul, S. K. and Salim, M. (2014). Yield performance of some transplant *Aman* rice varieties as influenced by different levels of nitrogen. *Bangladesh J. Agril. Univ.*, **12(**2): 321–324. https://doi.org/10.3329/jbau.v12i2.28691.

Khatun, R. Effect of variety and nitrogen on the performance of fine rice. M. Sc. Thesis, Department of Agronomy, Bangladesh Agricultural University, Mymensingh, Bangladesh. 2001, pp 93.

Khatun, S. M., Alam M. M., Khalil, M. I., Roknuzzaman M. and Imam M.M. (2020). Growth and yield performance of six *Aman* rice varieties of Bangladesh. *Asian J. Agril. Res.*, **12** (2): 1-7.

Kiani, G. and Nematzadeh, G. (2012). Correlation and path coefficient studies in $F_2$ populations of rice. Notulae Scientia Biological. **4**(2): 124-127.

Khakwani, A. A., Zubair, M., Mansoor, M., Naveed, K., Shah, I. H., Wahab, A. Ilyas, M. and Ahmed, I. (2006). Agronomic and morphological parameters of rice crop as affected by date of transplanting. *J. Agron.*, **5**(2):248-250.

Kainth, G. S. and Mehra, P. L. (1985). Rice Production: Potentials and Constraints. Inter India Publication. New Delhi, 110015.

Khalifa, A. A. A., ELkhoby, W. and Okasha, E. M. (2014). Effect of sowing dates and seed rates on some rice cultivars. *African J. Agril. Res.*, **9**(2):196-201.

Kueneman,F.A. (2006). Improved rice production in a changing environment: From concept to practice. *Intl. Rice Comm. Newsl*., 55: 1-20.

Kusutani, A., Tovata, M., Asanuma, K. and Cui, J. (2000). Studies on the varietal differences of harvest index and morphological characteristics of rice. *Japanese J. Crop Sci*., 69: 359-364. https://doi.org/10.1626/jcs.69.359.

Langfield, E. C. B. and Basinski, J. J. (1960). The effect of time of planting on the behavior of rice varieties in northern Australia. *Tropical Agric. Thrim*., 37: 383-392.

Linscombe, S. D., Jordan, D. L., Burns A. B. and Viator, R. P. (2004). Rice response to planting date differs at two locations in Louisiana. *Crop Management Doi.,* 10: 1094.

Lobell, D. B. Sibley, A and Ortiz- monasterio, J. V. (2012). Extreme heat effects on wheat senescence in India. Nature Climate Change. 2 :186– 189.

Mahmud, J. A., Haque, M. M. and Hasanuzzaman, M. (2013). Growth, dry matter production and yield performance of transplanted *Aman* rice varieties influenced by seedling densities per hill. *International J. Sustainable Agril*., **5**(1): 16-24.

Mahmud, J. A., Haque, M. M. and Shamsuzzaman, A. M. M. (2012). Performance of modern inbred and some selected hybrid rice varieties in *Aman* season. *J. Expt. Bio. sci*., **3**(2): 45–50.

Matsushima, S. (1957). Analysis of developmental factors determining yield and yield prediction in low land rice. Bull. *Natl. Inst. Agril. Sci. Series,* 5: 1-271.

Mejia, DL. (2006). Using whole grain to promote small and medium enterprises (SMEs). *Intl. Rice Comm. Newsl*., 55:128-139.

Momin, S. I. and Husain, M. (2009). Technology development and dissemination to augment rice production in Bangladesh. *In: 'The Guardian'*. pp. 33-35.

Mondal, M. M. A., Islam, A. F. M. S. and Siddique, M. A. (2005). Performance of 17 modern transplant *Aman* cultivars in the north region of Bangladesh. *Bangladesh J. Crop. Sci.,* 16: 23-29.

Muthukrishnan. P. Ponnuswamy, K,, Santhi, P. and Subramanian, M. (2000). Effect of transplanting time on the performance of rice hybrids in Cauvcry delta zone. *Madras J. Agril.,* **87**(7-9): 506-507.

Osman, K. A., Ahmed, M. M., Yasir, M. A., Elsheikh A., Idris, E. (2015). Influence of different sowing dates on growth and yield of direct seeded rice (*Oryza sativa* L.) in semi-arid zone (Sudan). *Intl. J. Agril. Res.,* **6**(6):38-48.

Oteng-Darko, P., Kyei-Baffour, N. and Ofori, E. (2013). Yield of rice as affected by transplanting dates and plant spacing under climate change simulations. *Wudpecker J. Agril. Res.,* 2: 55-63.

Pandey, N.; Verma, A. K. and Tripathis, R. S. (2001). Effect of planting time and nitrogen on tillering pattern, dry matter accumulation and grain yield of hybrid rice (*Oryza sativa*). *Indian J. Agril. Sci.,* **71**(5): 337-338.

Paraye, P. M. and Kandalkar, V. S. (1994). Effect of seedling age on longduration, rain fed varieties of rice under delayed transplanting. *Indian J. Agric. Sci.,* **64**(3):187-188.

Pattar. P. S.; Reddy, B. G. M. and Kuchanur. P. (2001). Yield and parameters of rice influenced by date of planting and age of seedlings. *Indian J. Agril. Sci*., **71**(8): 521-522.

Pirdashty. H., Sarvestani, Z. T., Nasir, M. and Ullah, V. (2000). Effect of transplanting date on yield and yield components of some rice cultivars Seed and Plant. **16**(2): 146-158.

Rahman, M. A. (2003). Effect of levels of USG and depth of placement on the growth and yield of transplant *Aman* rice. M.S. Thesis, Dept. Agron, Bangladesh Agril. Univ. Mymensingh. pp. 100.

Ramasany S, Chandrasekaran B, Sankaran S. Effect of spacing and seedlings hill-1on rice yield. International Rice Research Newsletter, IRRI, Philippines, 1987; **12(**4): 49.

Rasool, F., Habib, R. and Bhat, M. I. (2012). Evaluation of plant spacing and seedlings per hill on rice (*Oryza sativa* L.) productivity under temperate conditions. *Pak. J.Agri. Sci*., **49**(2): 169-172.

Reddy, TY, Redd GH. Principle of Agronomy. Kalyani Publication, New Delhi, India.1997; p. 515.

Roy, S. K., Ali, M. Y., Jahan, M. S., Saha, U. K., Ahmad-Hamdan, M. S, Hassan, M. M. and Alam, M. M. (2014). Evaluation of growth and yield attributing characteristics of indigenous *Boro* rice varieties. *J. Life Sci.,* 11: 122-126.

Safdar, M. E., Noorka, I. R., Tanveer, A., Tariq, S. A. and Rauf, S. (2013). Growth and yield of advanced breeding lines of medium grain rice as influenced by different transplanting date. *J. Animal & Plant Sci.,* **23**(1): 227-231.

Safdar, M. E., Ali, A. Muhammad, S., Sarwar, G. and Awan, T. H. (2008). Effect of transplanting dates on paddy yield of fine grain rice genotypes. *Pakistan J. Bot.,* **40**(6): 2403-2411.

Saito, K. and Futakuchi, K. (2009). Performance of diverse upland rice cultivars in lowland high soil fertility conditions in West Africa. Field Crops Res., 111, 243-250. https://doi.org/10.1016/j.fcr.2008.12.011

Salam, M. A., Ali, F., Anwar, M. P. and Bhuiyan, M. S. U. (2004). Effect of level of nitrogen and date of transplanting on the yield and yield attributes of transplanted *Aman* rice under SRI method. *Bangladesh J. Agril. Univ*., 2: 31-36.

Sarkar, S. C. (2014). Performance of five selected hybrid rice varieties in *Aman* season. M.S. Thesis, Dept of Agricultural Botany, Sher-e-Bangla Agril, Univ., Dhaka. pp. 25-26, 44-46. Retrieved fromhttp://archive. saulibrary.edu. bd:8080/ bitstream/ handle/ 123456789/ 342/ Bot SAU201401_12-08-02835.pdf?sequence=1

Sarkar, R. K and Reddy, J. N. (2006). Response of lowland rice (*Oryza sativa*) cultivars to different sowing dates during rainy season. Indian Council of Agricultural Research. New Delhi, India.

Saha Ray, P. K., Nahar, K., Ahmed, H. U., Miah, N. M. and Islam, M. A. (1993). Genetic variability and character association in irrigated rice Bangladesh *J. Plant Breed. Genet.,* 6: 69-74.

Shah, L. M. and Bhurer, K. P. (2005). Response of wet seeded rice varieties to sowing dates. *Nepal J. Agric. Res.,* 6:35-38.

Shahjahan, M. (2007). Modern rice in Asia: Role in food security and poverty alleviation. Financial Express.htm. vol. no. regd.no. Da. 1589.

Shams, B. S. (2002). Effect of elevated temperature on the growth and yield parameters of modern *Boro* rice varieties. M. S. Thesis, Dept. of Crop Bot., Bangladesh Agric. Univ., Mymensingh. pp 1-2

Shimono, H., Okada, M., Kanda, E. and Arakawa, I. (2007). Low temperatureinduced sterility in rice: evidence for the effects of temperature before panicle initiation. Elsevier. Amsterdam. Netherlands.

Singh, S. K. and Modgal, Y. P. (2005). Effect of nitrogen, copper and magnesium fertilization on yield and nutrition of rice. *Pakistan J. Sci. Ind. Res.*, **45**(2): 102-107.

Singh, S, Gangwer, B. (1989). Comparative studies on production potentials in transitional tall and improved rice cultivars. Journal of Andaman Science Association, **5** (1): 81-82.

Sohel, M. A. T., Siddique, M. A. B., Asaduzzaman, M., Alam, M. N. and Karim, M. M. (2009). Varietal performance of transplant *Aman* rice under different hill densities. *Bangladesh J. Agril. Res*., **34**(1): 33-39.

Surek, H., Korkut, Z. K. and Bilgin, O. (1998). Correlation and path analysis for yield and yield components in rice in an 8-parent half diallel set of crosses. *Oryza*, 35: 15- 18.

Takahashi, J.K., P.K. Chnomai, C. Veugsa and P. Kransaerindh. (1967). Increasing the yields of photosensitive varieties by modifying their cultural practices. IRC. Newsl., 16: 39-44.

Tyeb, A., Paul, S. K. and Samad, M. A. (2013). Performance of variety and spacing on the yield and yield contributing characters of transplant *Aman* rice. *J. Agrof. Environ***., 7** (1): 57-60.

Ullah, M. M., Malek, M. A., Karim, M. M. and Ali, M. S. (2012). A Report on Jhum Research on CHT. Hill Agricultural Research Station, Bangladesh Agricultural Research Institute, Khagrachari Hill District. pp. 3-20. Retrieved on 16 December 2016 from http://www. khdcbd.org/ khagracori/assets/uploads/files/A_Report_on_Jhum_Research_in_CHT. pdf (Accessed on-16.12.16).

Vergera, B. S. and Chang, T. T. (1985). The flowering response of the rice plant to photoperiod: a review of the literature. Los Banos: International Rice Research Institute. p. 61.

Wani S.A, Qayoom S, Bhat M.A, Sheikh A.A, Bhat T.A, Hussain, S. (2017) Effect of varying sowing dates and nitrogen levels on growth and physiology of scented rice. *Oryza*, **54**(1):97-106.

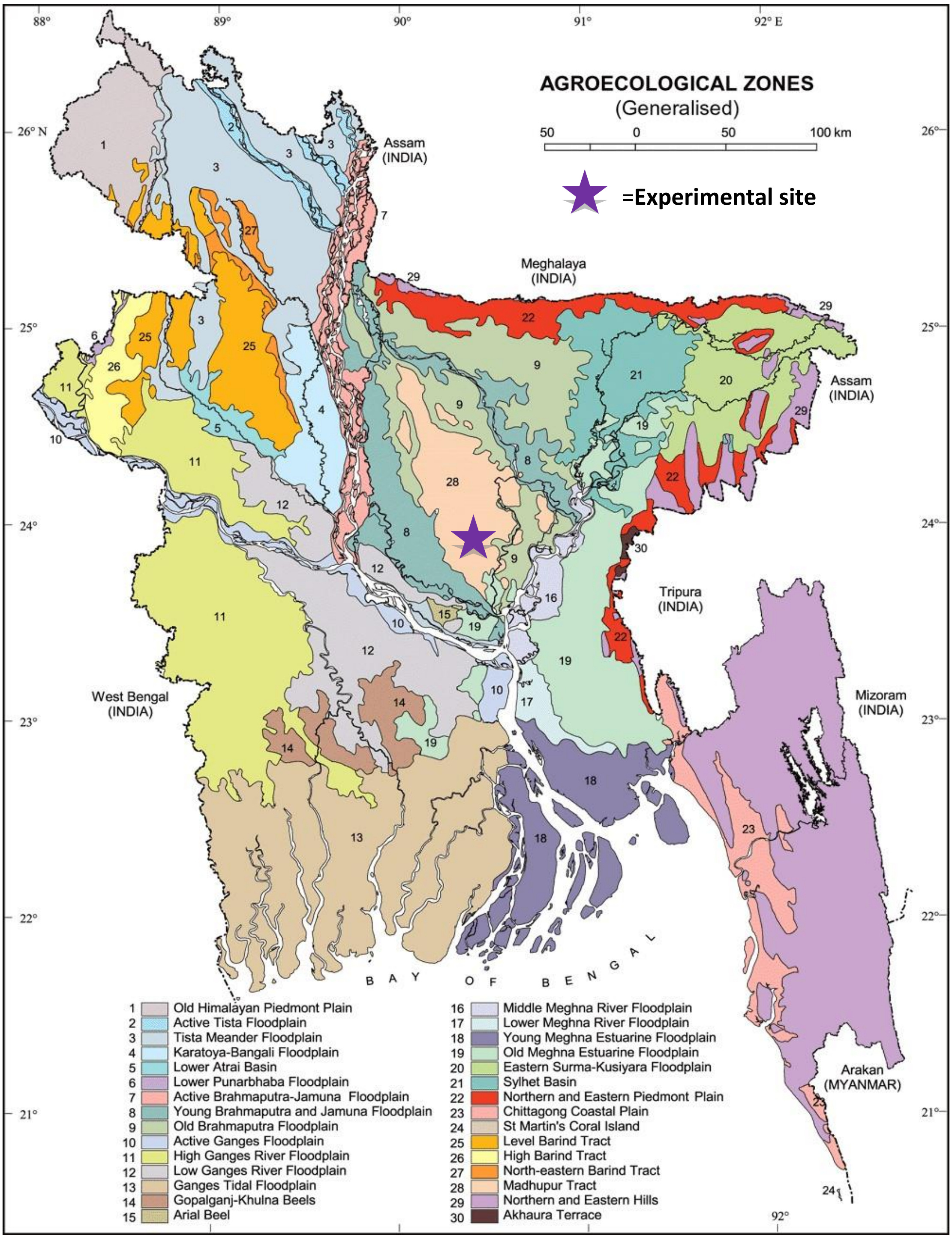
Yusuf, HKM. (1997). In: Report of the sustainable Food security Mission in Bangladesh (FAO, Rome), Dhaka.

Zhong-yang, H., Yi, Y., Hong-cheng, Z., Yan, X., Xiao-cheng, X., Qi-gen, D., Ke, X., Hai-yan., W. (2012). Effect of Sowing Date on Characteristics of Photosynthesis and Dry Matter Production of Direct Seeding Rice. *Scientia Agricultura Sinica*, 18: 49-54.

Xu, Z. J., Zhong, X. L., Wei, W., Ru, T. X., Hao, R. Y. and Lin, L. Z. (2006). Effect of temperature on yield and quality of aromatic rice. South China Agricultural University. Guangzhou, China.

## APPENDICES

## Appendix I. Map showing the experimental site under study




**Appendix II.** Characteristics of soil of experimental field

A. Morphological characteristics of the experimental field

| Morphological features | Characteristics |
|---|---|
| Location | Sher-e-Bangla Agricultural University Agronomy research field, Dhaka |
| AEZ | AEZ-28, Modhupur Tract |
| General Soil Type | Shallow Red Brown Terrace Soil |
| Land type | High land |
| Soil series | Tejgaon |
| Topography | Fairly leveled |

B. The initial physical and chemical characteristics of soil of the experimental site (0 - 15 cm depth)

| Physical characteristics | |
|---|---|
| Constituents | Percent |
| Sand | 26 |
| Silt | 45 |
| Clay | 29 |
| Textural class | Silty clay |
| Chemical characteristics | |
| Soil characters | Value |
| pH | 5.6 |
| Organic carbon (%) | 0.45 |
| Organic matter (%) | 0.78 |
| Total nitrogen (%) | 0.03 |
| Available P (ppm) | 20.54 |
| Exchangeable K (me/100 g soil) | 0.10 |

**Appendix III.** Monthly meteorological information during the period from June 2019 to November, 2019

| Year | Month | Air temperature ($^0$C) | | Relative humidity (%) | Total rainfall (mm) |
|---|---|---|---|---|---|
| | | Maximum | Minimum | | |
| 2018 | November | 28.10 | 11.83 | 58.18 | 47 |
| | December | 25.00 | 9.46 | 69.53 | 00 |
| 2019 | January | 25.2 | 12.8 | 69 | 00 |
| | February | 27.3 | 16.9 | 66 | 39 |
| | March | 31.7 | 19.2 | 57 | 23 |
| | April | 33.50 | 25.90 | 64.50 | 119 |

Source : Meteorological Centre, Agargaon, Dhaka (Climate Division)

**Appendix IV.** Analysis of variance of the data of plant height

| Source of variation | Degree of freedom | Mean square of plant height | | |
|---|---|---|---|---|
| | | 50 DAT | 65 DAT | 80 DAT |
| Replication | 2 | 0.27 | 0.002 | 0.073 |
| Variety | 9 | 432.95 | 526.87 | 688.29 |
| Total | 11 | | | |

**Appendix V.** Analysis of variance of the data of total tillers per hill

| Source of variation | Degree of freedom | Mean square of tiller per hill | | |
|---|---|---|---|---|
| | | 50 DAT | 65 DAT | 80 DAT |
| Replication | 2 | 0.361 | 3.08 | 4.52 |
| Variety | 9 | 44.77 | 45.58 | 38.62 |
| Total | 11 | | | |

**Appendix VI.** Analysis of variance of the data of effective tillers per hill, panicle length and grains per panicle

| Source of variation | Degree of freedom | Mean square of | | |
|---|---|---|---|---|
| | | Effective tiller per hill | Panicle length | Grains per panicle |
| Replication | 2 | 0.3611 | 0.08333 | 0.0078 |

| | | | | |
|---|---|---|---|---|
| Variety | 9 | 46.51 | 0.101 | 26.65 |
| Total | 11 | | | |

**Appendix VII**. Analysis of variance of the data of weight of 1000 seeds, harvest index and yield (ton/ha)

| Source of variation | Degree of freedom | Mean square of | | |
|---|---|---|---|---|
| | | Weight of 1000 seeds | Harvest index | Yield (ton/ha.) |
| Replication | 2 | 0.077 | 0.0054 | 0.00062 |
| Variety | 9 | 189.52 | 51.56 | 2.37 |
| Total | 11 | | | |