Growth and Yield Performance of BINA Released Six Promising Aman Rice Varieties of Bangladesh

Md. Robiul Islam Akondo1*, Md. Belal Hossain1, Sayed Eshtiaq Akter1 and Md. Morshedul Islam1

1Bangladesh Institute of Nuclear Agriculture (BINA), Sub-Station, Gopalganj, Bangladesh.

Authors’ contributions

This work was carried out in collaboration among all authors. Author MRIA designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors MBH and SEA managed the analyses of the study. Author MMI managed the literature searches. All authors read and approved the final manuscript.

ABSTRACT

The experiment was conducted with six rice varieties to determine their growth and yield performance. The experiment was laid out in a randomized complete block design (RCBD) with three replications. All the growth and yield contributing attributes varied significantly among the six rice varieties. The results revealed that maximum No. of filled spikelets/panicle observed in Binadhan-16 (108.43) and that was statistically similar with Binadhan-17 (100.10). Minimum number of filled spikelets/panicle observed in Binadhan-11 (60.60) and that was statistically similar with Binadhan-15 (63.87). Maximum 1000-seed weight was observed in Binadhan-16 (25.67 g) that was statistically similar with Binadhan-20 (25.33 g). The minimum 1000-seed weight was observed in Binadhan-15 (22.33 g) that was statistically similar with Binadhan-17 (23.00 g). Maximum number of non effective tiller was observed in Binadhan-15 (11.53) and minimum number in Binadhan-17 (2.30) that was statistically similar with Binadhan-16 (2.94). Highest grain yield was obtained from Binadhan-16 (6.57 t ha−1) that was significantly different from other varieties. Lowest grain yield observed in Binadhan-15 (5.39 t ha−1) that was statistically similar to Binadhan-7 (5.54 t ha−1). The highest straw yield (6.80 t ha−1) is produced by Binadhan-16. The lowest (5.89 t ha−1) straw yield was produced by Binadhan-7.
1. INTRODUCTION

Bangladesh is an agricultural country where rice is the number one crop. In Bangladesh high yielding rice varieties have been introduced through BRRI, BINA, IRRI and different seed companies [1]. Aman is one of the main crops in Bangladesh. It is the second largest rice crop in the country in respect to the volume of production while Boro remains the top. It is notable that the area coverage of Aman is the largest as a single crop and Boro remains the second. The production of Aman depends on the weather condition of the country and farmers usually cultivate Aman in their land. Rice grows in more than a hundred countries with a total area of about 160 million hectares, producing more than 700 million tons every year [2]. More than three billion people in the world are taking rice as their main food [3]. Rice (Oryza sativa L.), belongs to the family Gramineae, is the most important food in tropical and subtropical regions [4]. Bangladesh ranks 4th in both area and production and 6th in the production of per hectare yield of rice [5]. In Bangladesh 11.52 million hectares of land is used for rice with annual production of 34.72 million tons [6]. Whereas 5.62 million hectares of land is used for Aman Rice with annual production of 14.05 million tons [6]. Rice is grown in Bangladesh in three distinct growing seasons namely Aus, Aman and Boro. Rice covers the area of 5.66 million hectares with a production of 13.3 million tons [7]. According to [8] in Bangladesh, the average yield of rice is about 2.92 t ha⁻¹ which is very low compared to other rice growing countries of the world, like China (6.30 t ha⁻¹), Japan (6.60 t ha⁻¹) and Korea (6.30 t ha⁻¹). The population of Bangladesh is increasing at an alarming rate and the cultivable land is decreasing due to urbanization and industrialization. The nation is still adding about 2.3 million people in every year to its total of 150 million [9]. Thus, the population will swell progressively to 223 million by the year 2030 which will demand additional 48 million tons of food grains [10]. Population growth required a continuous increase in rice production in Bangladesh and the highest priority has been given to produce more rice [11]. Rice production has to be increased at least 60% by 2020 to meet up food requirement of the increasing population [12]. Rice yields are either stagnating/declining in post green revolution era mainly due to different factors related to crop production [13]. The reasons for low productivity of rice includes various factors like erratic rainfall, drought, weed, insect pest diseases, unavailability of quality seeds, non adoption of recommended production and plant protection technology but the major reason attributed to prevalence of local varieties instead of high yielding rice varieties [14]. High yielding varieties typically yield 10 to 20% more than conventional varieties on similar soil due to the heterotic effect [15,16]. High yielding varieties have higher yields but lower milling quality than conventional rice varieties [17]. The growth process of rice plants under a given agro-climatic condition differs due to specific rice variety [18]. Compared with conventional cultivars, the high yielding varieties have larger panicles, heavier seeds, resulting in an average rice grain yield increase of 7.27% [19]. 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 [20]. 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 [21]. So far among modern Aman rice varieties BINA has developed 10 [22] and that of BRRI developed 62 [23]. This research work was designed for comparative study on growth and yield of different Aman rice varieties.

2. MATERIALS AND METHODS

2.1 Experiment Material

A field experiment was conducted during Kharif-II (Aman) season of 2019 at BINA Sub-station, Gopalganj. Six rice varieties (i.e., Binadhan-7, Binadhan-11, Binadhan-15, Binadhan-16, Binadhan-17 and Binadhan-20) were used in this experiment. The varieties are collected from Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh.

2.2 Design of Experiment

The experiment was conducted in randomized complete block design (RCBD) with three replications at farm of BINA sub-station, Gopalganj during 2019-2020. Seeds were sown on 29 August and transplanted on 18 september, 2019 in BINA sub-station, Gopalganj. Unit plot size was 12 m² (4×3 m) with 20 cm row to row...
spacing and 15 cm from plant to plant within rows.

2.3 Experimental Management

The experimental plot was uniformly fertilized with Urea, TSP, MoP, Gypsum, Zinc sulphate @ 130, 50, 80, 45 and 2.5 kg/ha respectively. The total amount of TSP, MoP, Gypsum Zinc sulphate and one third of urea was applied as basal dose. The rest of the urea was top dressed at two equal split doses at 30 and 50 DAT (Days after Transplanting). Hand weeding was done to control weeds with the help of khurpi after 30 DAT and 50 DAT. Irrigation was applied as per requirement.

2.4 Data Collection Parameters

Data was taken on morphological yield contributing characters such as plant height, number of effective tiller/hill, number of non effective tiller/hill, total number of tiller/hill, panicle length, grain/panicle, filled spikelets/panicle, unfilled spikelets/panicle (avg. of 5 randomly selected representative plants), 1000 seed weight (from each experimental plot 1000 seed counted and weighted), grain yield (was taken after proper drying of seeds, At first seed yield was taken from all the experimental unit area and converted into ton ha⁻¹), straw yield (was taken after proper drying). All the data were collected from each plot at maturity.

2.5 Data Analysis

The data were compiled and tabulated in proper form for statistical analysis. Analysis of variance was done following the experimental design with the help of the computer package Statistix 10. Later the means were separated through Least Significance Difference (LSD) test at 5% level of significance was used to compare mean differences among the treatments [24].

3. RESULTS AND DISCUSSION

3.1 Plant Height

Highest plant height was observed in Binadhan-20 (103.07 cm) and Binadhan-15 (95.00 cm). Binadhan-7, Binadhan-16 and Binadhan-17 produced statistically similar height (Table 01). Binadhan-11 (85.13 cm) had the lowest plant height compared to the other varieties and cultivars. Mainly varietal variation is responsible for difference in plant height of the cultivar/varieties. [25] showed variable plant height due to varietal differences.

3.2 Panicle Length

Longest panicle length (23.07 cm) was found in Binadhan-7, which was statistically identical to Binadhan-15 (22.93 cm). Panicle length (21.27 cm) was found in Binadhan-11 which was statistically identical to Binadhan-16 (21.53 cm). The Shortest length was observed in Binadhan-17 (20.80 cm). (Table 1). [25] stated that panicle length significantly varied among varieties.

3.3 Number of Grain/Panicle

Highest number of grain/panicle (142.13 cm) was found in Binadhan-16, which was statistically identical to Binadhan-17 (135.47 cm). The number of grain/panicle (117.73 cm) was found in Binadhan-20 and (109.40 cm) in Binadhan-7. The lowest number of panicle length was observed in Binadhan-11 (94.87 cm) which was statistically identical to Binadhan-15 (97.47 cm) (Table 1). Panicle length significantly varied among varieties [25].

3.4 Number of Filled Spikelets/Panicle

Binadhan-16 had significantly maximum number of filled spikelets/panicle (108.43) which was statistically identical to Binadhan-17 (100.10 cm) (Table 1). Binadhan-20 (85.90) and Binadhan-7 (80.40) gave statistically identical result. Minimum number of filled spikelets/panicle (60.60) was observed in Binadhan-11 which was statistically identical to Binadhan-15 (63.87 cm). Variation in grain filling may have occurred due to genetic, environmental or cultural management practices adopted. [26] observed that yield was affected by the filled grains/panicle. [27] observed that filled grains/panicle correlated significantly with grain yield. [28] reported that the number of spikelets per panicle in indigenous rice is generally lower. [25] reported that number of filled grains/panicle influenced significantly due to variety.

3.5 Number of Unfilled Spikelets/Panicle

There were significant differences amongst varieties and cultivars in number of unfilled spikelets/panicle (Table 1). Binadhan-17 showed the highest number of unfilled spikelets/panicles (35.37) which was statistically identical to Binadhan-11 (34.27), Binadhan-16 (33.70) and
Binadhan-15 (33.60). Binadhan-7 had the lowest number of unfilled spikelets/panicles (29.00). Cultural management and environmental conditions are responsible for grain/panicle.

3.6 1000 Grain Weight (g)

Highest 1000 grain weight was recorded in Binadhan-16 (25.67 g) which was statistically identical to Binadhan-20 (25.33) and lowest was in Binadhan-7 (23.67 g) which was statistically identical to Binadhan-11 (Table 1). Highest 1000 grain weight of Binadhan-16 was may be due to long and fine grain and lowest weight of Binadhan-7 and Binadhan-11 may be due to small sized grain, round shape and aromatic. [28] studied on 12 rice varieties and found difference in thousand weight of grains due to morphological and varietal variation. [29] stated that 1000-grain weight differed significantly among the 17 Aman cultivars studied.

3.7 Harvest Index (HI) (%)

Binadhan-16 had significantly highest HI (96.71%) which was statistically identical to Binadhan-20 (95.48%) and Binadhan-15 (88.28%) gave lowest harvest index. [29] reported the contribution of high harvest index to yields. [30,31,32] stated that variety has significant influence on harvest index.

Number of grain/panicle showed significant correlation with No. of filled spikelets/panicle and yield at 1% level of significance. Also showed significant correlation with No. effective tiller/hill at 5% level of significance. Both No. of unfilled spikelets/panicle and 1000 grain wt (g) had non-significant correlation. No. of filled spikelets/panicle showed significant correlation with No. effective tiller/hill at 5% level of significance and significant correlation with yield at 1% level of significance. Other yield contributing characters had non-significant correlation with No. of filled spikelets/panicle. Number of unfilled spikelets/panicle showed non-significant correlation with all yield contributing characters (Table 2). 1000 grain wt (g) showed significant correlation with yield at 5% level of significance and had non-significant correlation with No. effective tiller/hill. No. effective tiller/hill showed non-significant correlation with yield.

Significantly higher total number of tillers per hill (Fig. 1) was produced by Binadhan-7 (40.00) and the lowest number of total tillers per hill in Binadhan-17 (29.60). Number of non-effective tillers per hill was lowest in Binadhan-16 (2.30) which was statistically same to the Binadhan-15 (2.95). Number of non-effective tillers per hill was highest in Binadhan-11 (11.53) which was statistically same to the Binadhan-7 (10.67) and Binadhan-15 (9.91). On the other hand, highest number of effective tillers per hill was produced by Binadhan-16 (35.39) which was statistically different to the other varieties. The lowest number of effective tillers per hill was produced by Binadhan-11 (24.00). [31] concluded that, variation in number of tillers per hill might be due to varietal characters.

![Fig. 1. No. of effective, non effective and total tiller per hill of six rice varieties](image-url)
Table 1. Growth and yield contributing characters of six rice varieties

| Variety     | Plant height (cm) | Panicle length (cm) | No. of grain/panicle | No. of filled spikelets/panicle | No. of unfilled spikelets/panicle | 1000 grain wt (g) | HI (Harvest index) (%) | No. of effective tiller/hill | No. of non effective tiller/hill | total no. of tiller/hill | Grain yield(t/ha) | Straw yield(t/ha) |
|-------------|-------------------|---------------------|----------------------|-------------------------------|----------------------------------|-------------------|------------------------|----------------------------|-------------------------------|-----------------------|----------------|------------------|
| Binadhan-7  | 90.20bc           | 23.07a              | 109.40c              | 80.40b                        | 29.00b                           | 23.67ab          | 94.27ab                | 32.33                      | 10.67                         | 43.00                 | 5.55           | 5.88             |
| Binadhan-11 | 85.13c            | 21.27b              | 94.87d               | 60.60c                        | 34.27a                           | 23.67ab          | 92.73ab                | 24.00                      | 11.53                         | 35.53                 | 5.78           | 6.23             |
| Binadhan-15 | 95.00ab           | 22.93a              | 97.47d               | 63.87c                        | 33.60a                           | 22.33b           | 88.28b                 | 27.63                      | 9.91                          | 37.53                 | 5.39           | 6.12             |
| Binadhan-16 | 90.73bc           | 21.53bc             | 142.13a              | 108.43a                       | 33.70a                           | 25.67a           | 96.71a                 | 35.39                      | 2.95                          | 38.33                 | 6.57           | 6.79             |
| Binadhan-17 | 90.40bc           | 20.80c              | 135.47a              | 100.10a                       | 35.37a                           | 23.00b           | 94.70ab                | 27.30                      | 2.30                          | 29.60                 | 6.06           | 6.40             |
| Binadhan-20 | 103.07a           | 22.20ab             | 117.73b              | 85.90b                        | 31.83ab                          | 25.33a           | 95.48a                 | 27.67                      | 5.00                          | 32.67                 | 5.92           | 6.20             |
| LSD(5%)     | 9.33              | 2.86                | 8.30                 | 10.86                         | 3.99                             | 2.29             | 6.96                   | 2.67                       | 2.38                          | 1.85                  | 0.49           | 0.38             |
| CV(%)       | 5.55              | 2.86                | 3.93                 | 7.18                          | 6.66                             | 5.26             | 4.09                   | 5.05                       | 18.53                         | 2.81                  | 4.55           | 3.35             |

(LSD=Least Significant Difference, CV=Co-efficient of variation)

Table 2. Correlation between different yield contributing characters of six rice varieties

|                      | No. of grain/panicle | No. of filled spikelets/panicle | No. of unfilled spikelets/panicle | 1000 grain wt (g) | No. effective tiller/hill | Yield |
|----------------------|----------------------|---------------------------------|----------------------------------|-------------------|---------------------------|-------|
| No. of grain/panicle | 1.0000               |                                 |                                  |                   |                           |       |
| No. of filled spikelets/panicle | 0.9870**             | 1.0000                          |                                  |                   |                           |       |
| No. of unfilled spikelets/panicle | 0.1068NS             | 0.0541NS                        | 1.0000                          |                   |                           |       |
| 1000 grain wt (g)    | 0.4095NS             | 0.4566NS                        | 0.2934NS                        | 1.0000            |                           |       |
| No. effective tiller/hill | 0.5239*              | 0.5943*                         | 0.4222NS                        | 0.4371NS          | 1.0000                    |       |
| Yield                | 0.7755**             | 0.7473**                        | 0.1957NS                        | 0.4910*           | 0.3607NS                  | 1.0000|

NS=Non Significant; *-Significant at 5% level; **- Significant at 1% level
Fig. 2. Grain and straw yield of six rice varieties

The highest straw yield (6.80 t ha\(^{-1}\)) is produced by Binadhan-16 (Fig. 2). The lowest (5.89 t ha\(^{-1}\)) straw yield was produced by Binadhan-7.

Maximum grain yield observed in Binadhan-16 (6.57 ha\(^{-1}\)) that was significantly different from the other varieties. Minimum grain yield observed in Binadhan-15 (5.39 ha\(^{-1}\)) that was statistically similar to Binadhan-17 (5.55 t ha\(^{-1}\)).

Maximum absolute growth rate, total dry matter, filled spikelet per panicle and also maximum 1000 seed weight collectively contributed to higher grain yield in Binadhan-16 compared to other varieties. Varietal differences of grain yield were reported by [33]. 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. Yield differences due to varieties were recorded by [34] who observed variable grain yield among varieties.

4. CONCLUSION

In conclusion, from the data pertaining to the different varieties, it may be indicated that not only maximum growth rate and maximum tiller number indicates good yield but also less inactive tiller, maximum filled grain, maximum 1000 grain weight collectively contribute to maximum yield in Binadhan-16 and alter that contribute to minimum grain yield in Binadhan-15. Considering above facts necessary steps should be undertaken to reduce the crop production in the other variety.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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