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Article

Performances of short growing photo-insensitive rice varieties to evade cyclonic hazard in the coastal region during Aman season

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Abstract: An experiment was conducted at a farmer's field in Bakergonj Upazilla of Barisal district from July 2014 to October 2014 to study the adaptive performance of six aman rice varieties. The varieties included in the study were BRRI dhan62, BINA dhan7, BINA dhan8, BINA dhan10, BINA dhan11, and Maloti (local). The experiment was laid out in a randomized complete block design with three replications. Variety Maloti produced highest plant height (126cm) and BRRI dhan62 produced least plant height (93cm). Variety BINA dhan7 and BINA dhan11 produced highest LAI, total dry matter (g plant^{-1}). Yield of different rice varieties varied significantly. Variety BINA dhan11 gave the highest yield (5.033 t ha^{-1}) which was statistically at par with that of BINA dhan7 (5.00 t ha^{-1}) and BINA dhan8 (4.50 t ha^{-1}), BINA dhan10 (3.933t ha^{-1}), BRRI dhan62 (4.167t ha$^{-1)}$. The highest grain yields of these varieties were obtained to the highest number of bearing tillers m^{-2}. The lowest grain yield (3.50 t ha^{-1}) and straw yield (4.840 t ha^{-1}) were found in Maloti. The shortest period for first flowering (66 days) was observed in BRRI dhan62. Among the varieties, the longest maturity stage (139 days) was observed in local *var*. Maloti. While the shortest period was observed in BRRI dhan62 (94.5 days). So, the experiment concluded that BINA dhan11 was the highest performing short duration variety followed by BINA dhan7, while BRRI dhan62 and, BINAdhan8, BINAdhan10 performed better among the short duration varieties respectively during aman season to evade cyclonic effect and for cultivating boro rice in Bakergonj Upazilla of Barisal district.

Keywords: performances; photo-insensitive rice varieties; cyclonic hazard; coastal region

1. Introduction

The southern coastal region holds an environment different from other parts of Bangladesh. About 78 thousand hectares of land is inundated by tidal water at different levels. The crop production is restricted due to salinity during dry season. Sweet water availability during dry season is very limited in the coastal area. Farmers are habituated to cultivate their land by tidal water. Most dominant cropping pattern, single transplanted aman alone occupied 35% land of net cropped area. Very negligible portion, less than 1% of net cropped areas occupied by five minor cropping patterns consisting wheat, mustard and potato. These crops do not perform well in the coastal region due to shorter (30-40 days) winter period compared to that of north-west region (3-4 months). The turnaround time after transplanted aman harvest in the coastal saline environment is very short to catch Rabi crop (Karim, 1990). Moreover, rapid tillage operation in many cases is not possible because of late November shower. In the Rabi season, about 50% of the cropped area remains fallow under single transplanted aman and Fallow – B. Aus/ transplanted aus – transplanted aman cropping patterns. In this period a vast portion of this fallow area is used as an unplanned grazing land of buffaloes and sheep. The southern region is relatively more flat and is also inundated by tidal flooding twice a day. Cropping pattern is determined largely by the time of onset of monsoon; early monsoon encourages to grow aus during the kharif-I season otherwise the entire region becomes a single cropped area with transplanted aman rice only. People living this area reluctant to grow crops in rabi season due to scarcity of water. They generally cultivate transplanted aman which is sown in early July to September and harvested in late December to early January. Rabi season starts from mid October. During this time land is occupied by local transplanted aman which make unsuitable for cultivation. So to make this huge land into double or triple cropped area it is necessary to introduce short duration rice varieties as a result farmers could cultivate rabi crops after harvesting transplanted aman. Productivity of Aman rice is particularly low in most of these coastal areas because of excessive flooding (either partial or complete) and less adoption of suitable high yielding varieties (HYV) of rice. Farmers rely on traditional rice varieties that are tall, do not respond to inputs and have low yields of 2-2.5 t/ha (Mondal *et al.*, 2004). Natural disaster occurs almost every year in Bangladesh due to climate change. Crop agriculture is often constrained by different hazards and disasters such as floods, droughts, soil and water salinity, cyclones and storm surges (MoEF, 2009). It is very common phenomenon in coastal regions of this country. Bangladesh is subject to devastating cyclones, originating over the Bay of Bengal, in the periods of April to May and October to November. Often accompanied by surging waves, these storms can cause great damage and loss of life. One of the reasons why it hits Bangladesh coast often is the conical shape of the Bay of Bengal. Over the last 50 years, 15 severe cyclones with wind speed ranging from 140 to 225 km/hr have hit the coastal area of Bangladesh of which 7 hit in pre-monsoon and rest in the post-monsoon season (FAO/GIEWS Global Watch, 2007). Cyclone cause huge damage to production of traditional crops. The 1970 Bhola cyclone was a devastating cyclone that struck on November 12, 1970 (Islam, 2006). It was the deadliest tropical cyclone ever recorded, and one of the deadliest natural disasters in modern times. More than 2,50,000 people lost their lives in the storm, primarily as a result of the storm surge that flooded much of the low-lying islands of the Ganges Delta. The cyclone which struck Bangladesh on the night of 29-30 April 1991 was particularly severe causing widespread damage, killing 138882 people (Bern, *et al.* 1993). In 2007, Bangladesh suffered a natural disaster like the cyclone SIDR of November 15, an unusually powerful storm that triggered giant waves up to 30ft (7m) high and killed more than 10000 people in the south western coastal belt of Bangladesh covering the districts of Bagerhat, Barisal, Patuakhali, Pirojpur, Khulna and Satkhira. More than 1.6 million acres of cropland was reportedly damaged. The main crop damaged was rice that was under cultivation during this Aman season (United Nation 2007).

2. Materials and Methods

2.1. Site description

2.1.1. Geographical location

Geographically, the experimental area is located at $22^0 55'$ N latitude and $90^0 33'$ E longitudes. The area is covered with Gangetic Tidal Floodplains. The area lies at 0.9 to 2.1 meter above mean sea level. The experimental field belongs to the Agro–ecological zone of AEZ–13 (UNDP, 1988; FAO, 1988). The region of the study was slightly affected by salinity where the total coverage of this region is 17066 km^2 with a total land volume of 1706600 ha (when Barisal, Jhalakathi, Pirojpur, Patuakhali, and Barguna are included) and the western coastal zone surrounded by the Sundarbans (mangrove forest).

2.1.2. Soil

The soil of the experimental field was silty clay loam having pH value of 6.8 due to salinity. The characteristics of the experimental soil have been examined by the Soil Resource Development Institute (SRDI), Regional

Laboratory, Barisal. The organic matter content found 0.93% in most cases. Deficiency of nitrogen is acute and widespread. Status of exchangeable Potasium is almost satisfactory.

2.1.3. Climate and weather

The experimental area is situated in the sub–tropical climatic zone and characterized by heavy rainfall during the months of July to October (Kharif Season) and scanty rainfall during the rest period of the year.

2.2. Experimental materials

The experiment treatments consisted with single factors i.e. variety as planting materials.
The following 6 rice varieties were included as experimental treatment.

i. BINA dhan7
ii. BINA dhan8
iii. BINA dhan10
iv. BINA dhan11
v. BRRI dhan62
vi. Maloti (local rice)

2.3. Experimental design and layout

The experiment was laid out in a randomized complete block design (RCBD) with three replications. The total numbers of unit plots were 18. The size of each unit plot was 10 m^2 (4 m × 2.5m). The spaces between blocks and plots were 1m and 1m, respectively.

2.4. Seed selection

Healthy seeds of, BINA dhan7, BINA dhan8, BINA dhan10 and BINA dhan11 were collected from Bangladesh Institute of Nuclear Agriculture (BINA). BRRI dhan62 was collected from Bangladesh Rice Research Institute (BRRI), Joydebpur, Gazipur.

2.5. Priming of seed

Healthy and vigorous seeds were selected for priming. Before sowing the seeds were primed following hydro priming technique by soaking in water for 24 hours at room temperature and then incubated for 30 hours at 35^0C. The primed seeds were then sown in the seed bed.

2.6. Preparation of seedling nursery

A common procedure was followed in raising seedlings in the seedbed. The seedbed was prepared by puddling with repeated ploughing followed by laddering. Weeds were removed and irrigation was gently provided to the bed as and when necessary. No fertilizer was used in the nursery bed.

2.7. Seed sowing

After sprouting, the seeds were sown in the previously prepared wet seed bed on 5 July 2014.

2.8. Land preparation for transplanting

The tidal free land was opened on 29 July, 2014 and prepared by ploughing and cross ploughing with power tiller and country plough. Then the land was laddered with traditional tools. Thereafter, the land was ploughed and cross–ploughed and deep ploughing was obtained good tilth, which was necessary to get better yield of this crop. The plots were spaded one day before transplanting and the whole amount of fertilizers were incorporated thoroughly before planting according to fertilizer recommendation guide (BARC, 2005).

2.9. Uprooting of seedlings

The seedbeds were made wet by application of water on the previous day before uprooting the seedlings. The seedlings were uprooted carefully without causing dry injury to the roots. The uprooted seedlings were kept on soft mud under shade.

2.10. Transplanting of seedlings

On 30 July 2014, 25 day–old seedlings were transplanted in the tidal free puddled land keeping plant to plant distance 25 cm and row to row distance 25 cm. Gap filling was made up to 7 days after transplanting to maintain proper treatment and similar plant population density for every plot.

2.11. Uses of Fertilizer

The land was fertilized with cowdung, urea, triple super phosphate, muriate of potash, gypsum and zinc sulphate at the rate of 10 t, 200 kg, 150 kg, 125 kg, 50 kg and 8 kg ha^{-1}, respectively. The whole amount of cowdung, triple super phosphate, muriate of potash, gypsum and zinc sulphate were applied at the time of final land preparation. Urea was applied in 3 equal splits at 10, 20 and 40 days after planting (DAT).

2.12. Intercultural operations

Intercultural operations were done for maintaining the normal growth and development of the crop. Crops were infested with different weeds. Weeding was done twice by hand pulling on 12 August and 05 September. No irrigation was provided as crop was grown in rain fed condition.

2.13. Plant protection measure

The crop was infested by Stem borer and Rice bug. Stem borer was controlled by applying of Mortar at the rate of 12.5 ml $10L^{-1}$ of water on 25 August 2014 and 28 September 2014. Rice bug was controlled by applying Carate at the rate of 12.5 ml $10L^{-1}$ of water on 28 September 2014.

2.14. Sampling and data collection

Sampling was started from tillering and continued up to harvest at 10, 20, 30, 40, 50, 60, 70, 80 DAT and at harvest or 110 days after transplanting (DAT). At each sampling five random hills from each plot were uprooted avoiding border hills and washed them in running tap water. Then the plant samples were carried to the laboratory. Plant height; number of leaves $plant^{-1}$; number of total, effective and non–effective tillers $hill^{-1}$; Flag leaf length; Days of 50% flowering; Days of 80% maturity; leaf area (LA); leaf area index (LAI); total dry matter (TDM); Crop and relative growth rate (CGR and RGR); length of root; length of panicle; number of total, sterile and non–sterile spikelets $panicle^{-1}$; 1000–grain weight; grain, straw and biological yield and harvest index (HI) were recorded.

2.15. Harvest and post harvest operations

Harvest was done when 80–90% of the grains became golden in colour. Ten hills excluding border hills were randomly selected from each plot. Selected plants were cut at the ground level and were separately bundled and properly tagged for recording necessary data. Grain and straw yields were determined by harvesting one square meter area which was prefixed at the center of each plot. The harvested crops were then threshed and cleaned. Grain and straw weights were recorded after proper sun drying.

2.16. Parameters studied

(i) Plant height (cm)
(ii) Number of total tillers $hill^{-1}$
(iii) Leaf area index
(iv) Total dry matter (g $plant^{-1}$)
(v) Crop growth rate (g m^{-2} day^{-1})
(vi) Relative growth rate (g m^{-2} day^{-1})
(vii) Length of panicle (cm)
(viii) Number of total spikelets $panicle^{-1}$
(ix) 1000 seed weight (g)
(x) Grain yield (t ha^{-1})
(xi) Straw yield (t ha^{-1})
(xii) Biological yield
(xiii) Harvest index

2.17. Measurement of morpho–physiological parameters

2.17.1. Plant height (cm)

Plant height was recorded from 5 randomly selected plants from each plot and was taken at different days after transplanting *viz*. 10, 20, 30, 40, 50, 60, 70, 80, 90 and 100 DAT and at harvest or 110 days after transplanting (DAT). The effective plant height was considered from ground level to the top of the leaf at vegetative phase and panicle less at harvest (110 DAT) stage. Plant height data was measured by a meter scale and recorded in cm.

2.17.2. Number of total tillers hill^{-1}

Number of total tillers hill^{-1} data was observed from 5 randomly selected plants from each plot at 10 days interval from 10 days after planting to 80 DAT *viz*. 10, 20, 30, 40, 50, 60, 70 and 80 DAT.

2.17.3. Leaf area index

The leaf area of one hill was measured by an automatic leaf area meter. Leaf area of the rest five hills were calculated from the leaf dry weight of respective hills multiplying with the ratio of the leaf area of measured hills and its dry weight. Then the leaf area was expressed as average of five. Finally leaf area index (LAI) was calculated as follows–

$$\text{LAI} = \frac{\text{LA}}{\text{P}}$$

Where, LA = leaf area (cm^2), P = ground area (25cm × 25 cm = 625 cm^2 plant^{-1})

2.17.4. Total dry matter (g plant^{-1})

The plant parts such as shoot including leaves and roots were detached and kept separately in oven at 80±2^{O} C for 72 hours. The oven dried samples were weighed for dry matter production. The total dry matter production was calculated at 10, 20, 30, 40, 50, 60, 70 and 80 DAT from the summation of shoots including leaves and roots (whole plant).

2.17.5. Crop growth rate (g m^{-2} day^{-1})

The CGR values of crops were calculated for the period of 10- 20, 20- 30, 30- 40, 40- 50, 50- 60, 60- 70, 70- 80 DAT). Rate of dry matter production per unit of time per unit of ground area was calculated with the following formula:

$$\text{CGR} = \frac{1}{A} . \frac{W_2 - W_1}{T_2 - T_1} \quad \text{g m}^{-2} \text{day}^{-1}$$

Where, W_1= Total dry matter production at previous sampling date
W_2= Total dry matter production at current sampling date
T_1= Date of previous sampling
T_2= Date of current sampling
GA= Ground area (m^2)

2.17.6. Relative growth rate (g g^{-1}day^{-1})

The relative growth rate (RGR) values at different growth stages 10- 20, 20- 30, 30- 40, 40- 50, 50- 60, 60- 70, 70- 80 DAT) were calculated using the following formula–

$$\text{RGR} = \frac{\text{LogeW}_2 - \text{LogeW}_1}{T_2 - T_1} \quad \text{g g}^{-1} \text{day}^{-1}$$

Where, W_1= Total dry matter production at previous sampling date
W_2= Total dry matter production at current sampling date
T_1= Date of previous sampling
T_2= Date of current sampling
Log_e= Natural logarithm

2.17.7. Length of panicle (cm)

Panicle length was measured from the basal node of the rachis to the apex of each panicle from the randomly selected 5 hills.

2.17.8. Number of total spikelets panicle^{-1}

Number of total spikelets panicle^{-1} were recorded by the following formula

Number of total spikelets panicle^{-1}= Number of sterile spikelets panicle^{-1} + number of non–sterile spikelets panicle^{-1}.

2.17.9. Days of 50% flowering

Days of 50% flowering was counted when 50% plant gives flowering in every variety by selecting 5 hills randomly.

2.17.10. Days of 80% maturity

Days of 80% maturity was counted when 80% spikelets of all the rice varieties become matured enough to harvest from randomly selected 5 hills.

2.17.11. 1000 seed weight (g)

One thousand cleaned dried seeds were counted randomly from each sample and weighed by using a digital electric balance at the stage the grain retained 12% moisture and the mean weight were expressed in gram.

2.17.12. Grain yield (t ha^{-1})

Grain yield was determined from the central 5 m^2 of the plot and expressed as t ha^{-1} on 12% moisture basis. Grain moisture content was measured by using a digital moisture tester.

2.17.13. Straw yield (t ha^{-1})

Straw yield was determined from the central 5 m^2 of each plot. After threshing, the sub–sample was oven dried to a constant weight and finally converted to t ha^{-1}.

2.17.14. Biological yield

Grain and straw yields are altogether regarded as biological yield. The biological yield was calculated with the following formula:

Biological yield= Grain yield (t ha^{-1}) + Straw yield (t ha^{-1})

2.17.15. Harvest index

It denotes the ratio of economic yield to biological yield and was calculated with the following formula (Gardner *et al*., 1985).

$$\text{Harvest index (\%)} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

Where, Economic yield= Grain yield and Biological yield= Grain yield+Straw yield

3. Results and Discussion

3.1. Plant height

In all the six aman rice varieties, plant heights were significantly affected by different days after planting (Table 1). Among six varieties, plant heights were higher in Maloti than that of BINA dhan7, BINAdhan-8, BINA dhan10, BINA dhan11, BRRI dhan62 respectively. From the Table1, it is evident that the plant height increased progressively with the advancement of time and growth stages. These results also indicated that the plant height of all six varieties varied significantly due to the differentiation in their genetic characters and also the variation in adaptability with the studied field condition. Such variation in plant heights of many varieties were also reported by Zubaer *et al*. (2007); Ashrafuzzaman *et al*. (2009); Uddin *et al*. (2010); Hossain *et al*. (2005) and many other researchers at home and abroad.

Table 1. Effect of variety on plant height of some short growing Transplanted aman at different DAT.

Variety		Plant height (cm) at different days after transplanting (DAT)								
	Seedling	10	20	30	40	50	60	70	80	Harvest
BINA dhan7	35.1c	40.2c	45.2c	50.3c	66.6c	80.3c	101.0c	106.0bc	106.0cd	101.0bc
BINA dhan8	45.2b	50.1b	55.2 b	60.2b	71.0b	84.3bc	111.0 b	111.3b	111.3bc	109.0b
BINA dhan10	42.7 b	48.1b	56.2b	62.1b	72.6b	80.3c	95.3c	115.3 b	115.0b	100.3bc
BINA dhan11	44.1b	49.2b	57.5b	61.1b	71.3b	82.3c	99.7c	112.0b	112.3bc	106.0b
BRRI dhan62	42.2b	47.3 b	53.3b	60.2b	72.6b	88.3ab	98.7c	100.3c	100.3d	93.00c
MALOTI (local dhan)	50.2a	55.3a	66.1a	71.1a	82.3a	91.3a	121.3a	126.3a	130.7a	126.0a
CV (%)	3.93	5.07	3.94	3.57	3.16	3.26	4.33	4.45	3.31	4.65

3.2. Leaf area index

Significant variation was observed in Leaf area index of different varieties (Figure 1). During the vegetative stage the LAI was slow, increased sharply until attaining a maximum at 80 DAT approximately in all varieties. Significantly the highest LAI was observed in BINA dhan7 (3.90) followed by BINA dhan11 (3.77) and the lowest in Maloti (1.91) at 80 DAT.

The variation in LAIs might be attributed to variation in number of leaves, leaf expansion and leaf senescence with age. The maximum LAI was obtained in BINA dhan7 (3.90) possibly because of their higher number of leaves, maximum leaf expansion (i.e. leaf length and breadth) and minimum leaf senescence. The result obtained from the present study is consistent with the result of Zubaer *et al*. (2007). The findings of Alam *et al*. (2003) were also similar with the present study who also found significant variation in leaf area among the transplant aman rice.

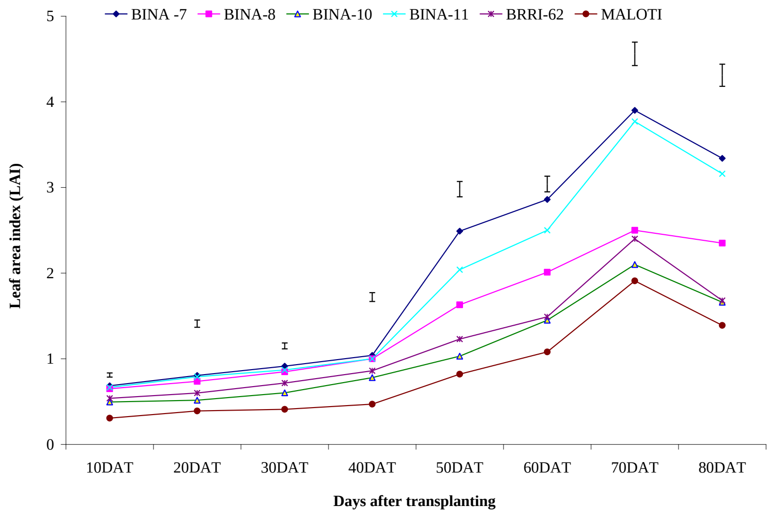

Figure 1.Variation in LAI of different rice varieties at different DAT during aman season.

3.3. Total dry matter (g plant^{-1})

Total dry matter (TDM) m^{-2}as assessed in periodic intervals, were statistically significant at most growth stages (Table 2). The highest (1210g) and lowest (864.0g) TDM m^{-2} were found in BINA dhan7 and Maloti respectively (Table 2). BINA dhan8, BINA dhan11 produced same result statistically with BINA dhan7.While BINA dhan10 and BRRI dhan62 produced intermediate total dry matter. The variation in TDM was found to be the inherent genetic makeup of the studied varieties and also the variation in weight of leaves, shoot, root and other parts of the plants. So, the enhancement of TDM was directly related to the height of stem or plant, leaves and roots in this study. The findings of the present study were also similar to Mannan *et al*. (2012) who reported that the higher productive variety Chinigura produced the highest amount of TDM while least amount of DM was in Kataribhog due to genetic variation and also the variation in weight of plant parts. Similarly, Islam (2011) showed higher total dry matter plant^{-1} in local line KD5 18–150 under temperature stress. Baset Mia and Shamsuddin (2011) also found significant variation in TDM by local and modern rice cultivars. Zubaer *et al*. (2007) also reported that BINA dhan 4 performed better in producing total dry matter than the other two genotypes.

Table 2. Total dry matter (TDM) g m^{-2} production in some short growing transplanted aman varieties during aman season.

Variety	Total dry matter (TDM) g m^{-2} at Different Days After transplanting (DAT)							
	10	**20**	**30**	**40**	**50**	**60**	**70**	**80**
BINA dhan7	80.5a	180.4a	280.5a	401.3a	611.5a	976.5a	1135.0a	1210.0a
BINA dhan8	66.7bc	111.1bc	153.7b	301.4bc	533.3b	775.4b	973.3b	1125.0a
BINA dhan10	62.4d	104.6cd	145.6b	280.5bc	501.8c	666.6c	957.3b	997.4b
BINA dhan11	68.3b	117.5b	160.5b	321.5b	601.9a	788.7b	981.4b	1165.0a
BRRI dhan62	65.6c	106.7cd	150.3b	283.7bc	520.5b	685.1c	970.1b	1002.0b
MALOTI (local)	60.4d	101.5d	141.2b	270.7c	482.4d	560.4d	792.5c	864.0c
CV (%)	2.01	3.36	6.96	6.86	1.74	5.53	4.18	4.45

3.4. Crop growth rate (g m^{-2} day^{-1})

Crop Growth Rate(CGR) from early initial stages rapidly increased followed by a lag period between 50-60DAT 2nd increase between 60-70 DAT and a sharp decrease at the approach of reproductive development in most of the varieties except BINA dhan7 and BINA dhan8(Figure 2). The varieties BINA dhan7 and BINA dhan8 had the continual increase in CGR until about 60-70 DAT and after reaching their peaks they declined with the transition of reproductive development i.e. between 60-80DAT. The CGR a measure of the ability of the performance of a crop, in the tested varieties at the experimental site indicates that BINA dhan7 and BINA dhan8 had the superiority in their ability to be well adapted under the agro- climatic condition of Bakergonj while the other varieties had some limitations to the fluctuations of the prevailing environmental conditions where the crop was grown. Significant variation regarding RGR were also obtained by Roy *et al.* (2014) due to varieties where the highest CGR was observed in BRRI dhan 48 and lowest in BRRI dhan42 among four rice varieties due to genetic variation which are also agreed to the findings of Nicknejad Jahan *et al*. (2009).

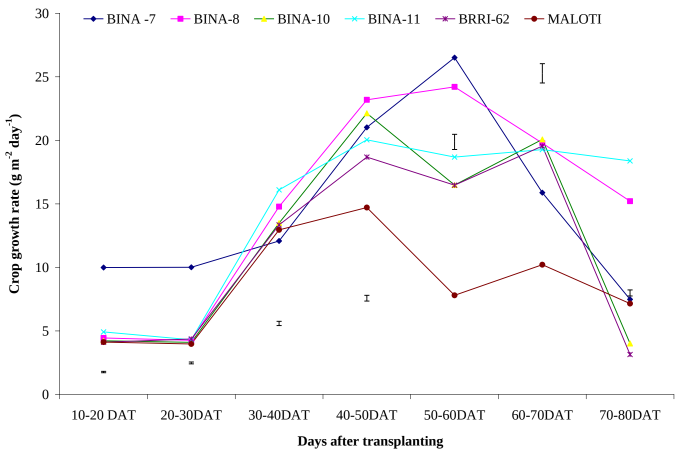

Figure 2. Variation in (CGR) (g m^{-2}day^{-1}) of different Rice varieties at different DAT during aman season.

3.5. Relative growth rate (g g^{-1} day^{-1})

The variation of RGR (mg g^{-1}d^{-1}) in different test varieties is presented in Figure 3. The shapes of the variation of RGR curves were in continual decreasing rate in BINA dhan7, BINA dhan8, BINA dhan10, BINA dhan11and BRRI dhan62. But in case of Maloti it increases from 30-70 DAT then decreases gradually. Significant variation regarding RGR were also obtained by Roy *et al.* (2014) due to varieties where the highest RGR was observed in BRRI dhan48 and lowest in BRRI dhan42 among four rice varieties due to genetic variation which are also agreed to the findings of Nicknejad and Jahan *et al*. (2009).

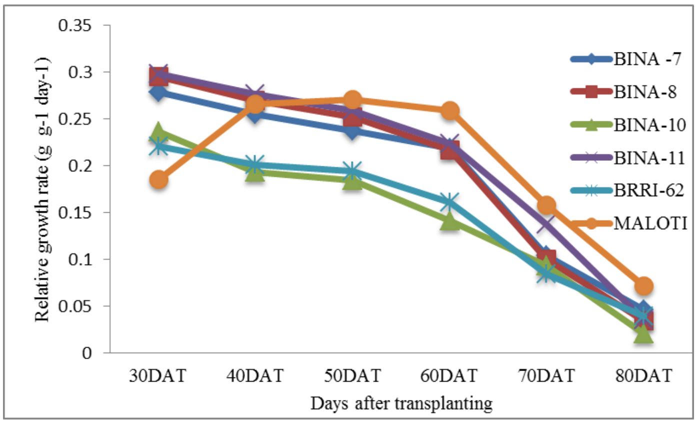

Figure 3. Variation in (RGR) (g g^{-1}day^{-1}) of different rice varieties at different DAT during aman season.

3.6. Number of tillers hill^{-1}

The developments of tillers hill^{-1}in rice due to varieties have been presented in Table 3. The number of tillers hill^{-1} varied significantly among varieties (Table 3). The maximum number of tillers was produced from the variety BINA dhan7 33.67 while BINA dhan8 had 31.93, BINA dhan10 had 30.23, BINA dhan11 had 31.33, BRRI dhan62 had 32.00 and Maloti had 26.0 tillers at harvest. This result showed that BINA dhan7 produced maximum tillers hill^{-1} than Maloti which might be due to the genetic makeup of those varieties and also the variation in adaptability with the studied area. Tiller(s) number hill^{-1} is an important yield contributing character in rice. Mondal *et al*. (2005) found significant differences in number of tillers hill^{-1} in 17 rice varieties. Differences in the production of total tillers hill^{-1} might be due to genetic variation, physiological functions and growth characters of the varieties under study. Similar trend were also found by Sohel *et al*. (2009) who reported that all the yield and yield contributing character differed significantly due to varietal difference.

3.7. Days to 50% flowering

Days to 50% flowering significantly differed amongst the varieties in this study (Table 3). Days to 50% flowering recorded maximum (111) in Maloti than BRRI dhan62 (66) BINA dhan7 (71), BINA dhan8 (81) and BINA dhan10 (78). Variety Maloti takes maximum days in 50% flowering and variety BRRI dhan62 takes least time to give 50% flowering. Variation in days to 50% flowering is found due to inheritable character of those varieties. Besides, differences in characteristics of the studied varieties were also occurred for the variation in duration of flowering and heading. The above results of variability in Days to 50% flowering are also in full agreement with many workers (Hossain *et al.*, 2005; Yang *et al.*, 2001).

Table 3. Yield and yield attributes of different short growing T. aman varieties during aman season.

Variety	**No. of total tillers hill^{-1}**	**Days of 50 % flowering**	**Days of 80 % maturity**	**Panicle length (cm)**	**Grain/Panicle (no.)**	**Non filled Grain/Panicle (no.)**
BINA dhan -7	33.7a	71.0cd	100.5bc	28.3ab	132.3b	18.0a
BINA dhan -8	31.9ab	81.0b	108.5b	30.0a	116.7c	16.7ab
BINA dhan -10	30.2b	78.0bc	106.3b	22.3d	82.7e	13.7b
BINA dhan -11	31.3b	76.0bc	106.1b	25.3c	142.3a	17.7a
BRRI dhan -62	32.0ab	66.0d	94.5c	25.0c	75.3e	9.3c
MALOTI (local dhan)	30.7b	111.0a	139.3a	27.7b	99.7d	19.7a
CV (%)	3.2	5.0	4.2	3.5	4.0	11.6

3.8. Days to 80% maturity

Significant variation was found amongst the varieties in this study (Table 3). Highest no. of days to 80% maturity was observed in Maloti (139 days) while minimum no. of days to 80% maturity was observed in BRRI dhan62 (94 days). Less variation is found in BINA dhan8 (108), BINA dhan10 (106), BINA dhan11 (106) in days to 80% maturity. BINA dhan7 requires second lowest (100) days to 80% maturity. This variation in days to 80% maturity was occurred due to genetic makeup of those varieties. The findings of the present study were also similar to Mannan *et al*. (2012) who reported that the higher productive variety Chinigura needs minimum no. of days to 80% maturity while maximum was in Kataribhog due to genetic variation.

3.9. Length of panicle

Panicle length of the studied varieties varied significantly where BINA dhan8 had longest panicle 30.00 cm than BINA dhan10 (22.33 cm). BINA dhan7 had 28.33, BINA dhan11 produced 25.33cm, BRRI dhan62 25.0cm and Maloti 27.67cm panicles (Table 3). So, the above result showed that there was significant variaton among the varieties due to its genetic variation. This result is in agreement with the findings of Baset Mia and Shamsuddin (2011) who reported that panicle length significantly varied due to varieties. Bakul *et al*. (2009) also reported that higher yield in rice can be achieved from longer panicle length. Jeng *et al*. (2009) and many other scientists reported the similar results in their studies.

3.10. Number of total spikelets panicle^{-1}

Analysis of variance data on total spikelets panicle^{-1} was significantly influenced by the effect of varieties (Table 3). Among six varieties, BINA dhan11 had maximum (142.3) and BRRI dhan62 (66.00) produced minimum no. of total spikelets panicle^{-1}.While BINA dhan7 produced 132.3, BINAdhan8 116.7, BINA dhan10

82.67 and Maloti 99.67 no. of spikelets panicle$^{-1.}$ The variation in total grains panicle^{-1} was found due to the variation in effective, non effective and total tiller production. Similar results were found by Hossain *et al*. (2014) who reported that the both hybrid rice varieties Heera2 (119.8) and Aloron (111.8) produced the highest spikelets panicle^{-1} than that of BRRI dhan48 (105.5). Hossain *et al*. (2014) also found similar results due to genetic makeup. Uddin *et al*. (2011) also found that the modern variety BRRI dhan44 performed better than local varieties due to genetic makeup of the varieties and these findings were identical to the study of Hossain *et al*. (2005).

3.11. Thousand–grains weight

Thousand grains weight represents grain size and ultimately is related to grain yield. The effect of rice varieties on 1000–grains weight was significant (Table 4). Genotype BINA dhan8 produced the highest weight of 1000–grain (22.60g) due to heavier grain than BRRI dhan62 (18.08 g) BINA dhan7 produced 21.00 g, BINA dhan10 produced 19.60 g, BINA dhan11 produced 18.83 g and Maloti produced 20.0 g thousand grain weight. Alam *et al*. (2012) reported that 1000–grains weight differed significantly among the cultivars studied where BR11 produced the highest 1000–grain weight (23.79g) and BRRI dhan33 produced the lowest (21.69g) which might be due to the genetic variation. Similar result was also obtained by Jeng *et al*. (2009).

3.12. Grain yield

There were significant differences among the varieties in respect of grain yield (Table 4). Among six varieties, BINA dhan11 produced the highest grain yield (5.03 t ha^{-1}) compared to the lowest in Maloti (3.5t ha^{-1}) .While BINA dhan7 produced 5.00 t ha^{-1}, BINA dhan8 produced 4.5t ha^{-1}, BINA dhan10 produced 3.93t ha^{-1}, BRRI dhan62 produced 4.16t ha^{-1}.Besides, higher yield BINA dhan11 also had the tallest plant, production of more effective and total tillers, filled and total grains panicle^{-1} and highest weight of 1000–grain as well as larger sizes of grains. Uddin *et al*. (2010), Pruneddu and Spanu (2001) and many workers reported that the varieties which produced higher number of effective tillers hill^{-1} and higher number of filled grains panicle^{-1} also gave higher grain yield ha^{-1}. Similar results were also reported by Mondal *et al.* (2005) in rice. It was further observed that the genotype DU–527 had remarkable superiority to growth, yield attributes and grain yield over the other varieties due to their genetic differences among the varieties. Similarly, Sohel *et al*. (2009) reported that these variations in yield might be due to genetic makeup of the varieties.

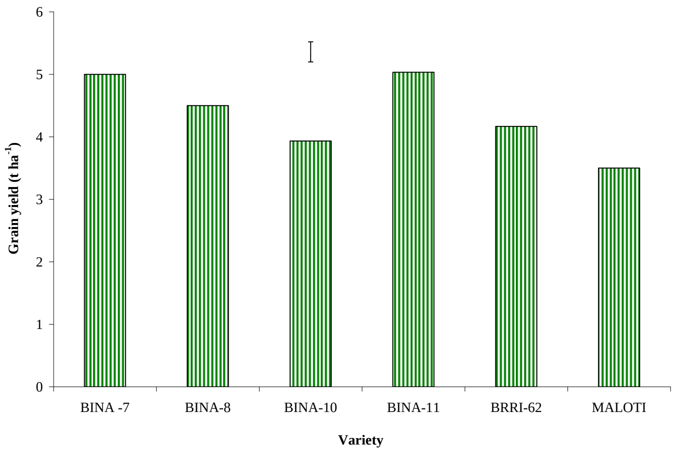

Figure 4. Variation in grain yield (t/ha) of different short growing aman varieties.

3.13. Straw yield

Statistical analysis of variance data showed significant differences among six varieties in respect of straw yield (Table 4). The variety BINA dhan11 produced highest straw yield (7.48t ha^{-1}) and least in Maloti (4.84t ha^{-1}). While BINA dhan7 produced 5.00t ha^{-1}, BINA dhan8 produced 5.95t ha^{-1}, BINA dhan10 5.53t ha^{-1} and BRRI dhan62 produced 5.56t ha^{-1} straw yields. These result revealed that the variation in straw yield was due to shorter plant height and fewer no. of leaves plant^{-1}. Uddin *et al*. (2011) reported that the BRRI dhan44 produced significantly higher straw yield (5.28t ha^{-1}) against the lowest by Lalchicon (2.94t ha^{-1}). This might be due to varietal differences.

3.14. Biological yield (t ha^{-1})

A significant variation was found among the varieties in respect of biological yield (Table 4). Among six varieties, biological yield had higher in BINA dhan11 (12.52t ha^{-1}) and lowest in Maloti (8.40t ha^{-1}). While BINA dhan7 produced 11.64t ha^{-1}, BINA dhan8 10.45t ha^{-1}, BINA dhan10 9.487t ha^{-1} and BRRI dhan62 produced 9.733t ha^{-1} biological yield. This variation on biological yield was found due to the genetic variation which was supported by Uddin *et al*. (2011) who reported that the BRRI dhan–44 produced higher biological yield than Lalchicon. Besides, the variation in biological yield was also found due to the variation in grain and straw yield.

3.15. Harvest index (%)

Harvest index (HI) represent comparative yield performance between grain and straw yield. The data on harvest index was significantly influenced by the varieties (Table 4). The variety BINA dhan8 recorded the highest harvest index (43.06%) and lowest harvest in BINA dhan11 (39.92%). While BINA dhan7 produced 42.96%, BINA dhan10 41.45%, BRRI dhan62 42.81% and Maloti produced 41.96% HI. These results revealed that HIs differed significantly due to the genetic differences of the studied varieties their differential adaptability and also the variation of grain and straw yield as well as biological yield. These findings were also similar to that of the study of Uddin *et al*. (2011) who reported that the harvest index differed significantly among the varieties due to its genetic variability.

Table 4. Yield and yield attributes of different short growing transplanted aman varieties during aman season.

Variety	1000 grain wt.(g)	Grain Yield (t/h)	Straw Yield (t/h)	Biological Yield (t/ha)	Harvest Index (%) (Oven dry basis)
BINA dhan7	21.00 b	5.00a	6.63b	11.64a	42.96a
BIN dhan8	22.60a	4.50b	5.95c	10.45b	43.06a
BINA dhan10	19.60bc	3.93c	5.55c	9.48b	41.45ab
BINA dhan11	18.83cd	5.03a	7.48a	12.52a	39.92b
BRRI dhan62	18.08d	4.16bc	5.56c	9.73b	42.81a
MALOTI (local)	20.00bc	3.500d	4.84d	8.34c	41.96a
CV (%)	3.82	5.06	4.25	5.87	2.07

4. Conclusions

The present study reveals that, the performances of BINA dhan7, BINA dhan11, and BRRI dhan62 have the high yielding capacity and are of short duration. Therefore, it could be recommended that farmers can cultivate the BINA dhan7, BINA dhan11, and BRRI dhan62 during aman season to evade cyclonic effect and pave the way for cultivating boro rice and other rabi crops in this mono cropped area.

Conflict of interest

None to declare.

References

Alam MM and MK Mondal, 2003. Comparative water requirement and management practices for hybrid and inbred rice cultivation in Bangladesh. Bangladesh J. Agrl. Sci, 30: 345-351.

Alam MS, MA Baki, MS Sultana, KJ Ali and MS Islam, 2012. Effect of variety, spacing and number of seedlings per hill on the yield potentials of transplant aman rice. Int. J. Agr. & Agri. R., 2: 10–15.

Ashrafuzzaman M, MR Islam, MR Ismail, SM Shahidullah and MM Hanafi, 2009. Evaluation of six aromatic rice varieties for yield and yield contributing characters. Int. J. Agric. Biol., 11: 616–620.

Bakul MRA, MS Akter, MN Islam, MMAA Chowdhury and MHA Amin, 2009. Water stress effect on morphological characters and yield attributes in some mutants T–aman rice lines. Bangladesh Res. Pub. J., 3: 934–944.

BARC (Bangladesh Agriculture Research Council). 2005, Fertilizer Recommended Guide (BARC, 2005), Bangladesh Agriculture Research Council, Farm gate, Dhaka, Bangladesh.

Baset Mia MA and ZH Shamsuddin, 2011. Physio–morphological appraisal of aromatic fine rice (*Oryza sativa* L.) in relation to yield potential. Intl. J. Bot., 7: 223–229.

Bern C, J Sniezek, Mathbor, GM Siddiqi, MS Ronsmans, C Chowdhury, AM Choudhury, AE Islam, K Bennish, and E Noji , 1993. Risk factors for mortality in the Bangladesh cyclone of 1991, Bulletin of the World Health Organization, 71, pp.73-78.

FAO/GIEWS Global Watch (last updated 21 December 2007). Livelihood of over 8.9 million people adversely affected by Cyclone Sidr in Bangladesh.

Hossain MF, MSU Bhuiya and M Ahmed, 2005. Morphological and agronomic attributes of some local and modern aromatic rice varieties of Bangladesh. Asian J. Plant Sci., 4: 664–666.

Hossaina MM, F Sultana and AHMA Rahmana, 2014. A comparative screening of hybrid, modern varieties and local rice cultivar for brown leaf spot disease susceptibility and yield performance. Archives of Phytopathology and Plant Protection, 47:795–802 (online available at: http://dx.doi.org/10.1080 /03235408.2013.822753)

Islam T, 2006. Integrated Approach to Cyclone Wind Analysis and disaster planning for the Benladesh coast, Ph.D. Dissertation, Texas Tech University, December.

Islam MT, 2011. Effect of temperature on photosynthesis, yield attributes and yield of aromatic rice genotypes. Int. J. Sustain. Crop Prod., 6: 14–16.

Jeng TL, TH Tseng, CS Wang, CL Chen and JM Sung, 2009. Yield and grain uniformity in contrasting rice genotypes suitable for different growth environments. Field Crops Res., 99: 59–66.

Karim, Z, SG Hussain and M Ahmed, 1990. Salinity problems and crop intensification in the coastal regions of Bangladesh. Soils publication No. 33. BARC,p.17.

Mannan MA, MSU Bhuiya, MIM Akhan and MM Rana, 2012. Influence of date of planting on the growth and yield of locally popular traditional aromatic rice varieties in boro season. J. Sci. Found., 10: 20–28.

MOEF (Ministry of Environment and Forest, G.o.t.P.s.R.o.B., National Adaptation Programme of Action. Final Report. 2009, UNFCCC.

Mondal MMA., AFM Islam and MA Siddique, 2005. Performance of 17 modern transplant aman cultivar in the northern region of Bangladesh. Bangladesh J. Crop Sci., 16: 23–29.

Nicknejad Y, R Zarghami, M Nasiri, H Pirdashti, DB Tari and H Fallah, 2009. Investigation of physiological indices of different rice (*Oryza sativa* L.) varieties in relation to source and sink limitation. Asian J. Plant Sci., 8: 385–389.

Pruneddu G and A Spanu, 2001. Varietal comparison of rice in Sardinia. Dipartimentodi Science Agroomiche Genetica vegetable Agraria, Universita degli, Italy Informatore–Agraria., 57:47–49.

Roy TS, MAI Pulo, MA Hussain and S Khatun, 2014. Effect of varieties and row spacing on the growth and yield of AUS rice. Bangladesh Res. Pub. J., 10: 138–144.

Sohel MAT, MAB Siddique, M Asaduzzaman , MN Alam and MM Karim, 2009. Varietal performance of transplant aman rice under differnt hill densities. Bangladesh J. Agril. Res., 34: 33–39.

Uddin MJ, MM Hasan, S Ahmed and MM Hasan, 2010. Effect of spacing on morpho–physilogical response of different T. aman rice cultivars under coastal high land ecosystem. Indian Journal of Agriculture Research, 44: 251–258.

Uddin MJ, S Ahmed, M Harun–or–Rashid, MA Hasan and M Asaduzzaman, 2011.Effect of spacing on the yield and yield attributes of transplanted aman rice cultivars in medium lowland ecosystem of Bangladesh. Journal of Agriculture Research, 49: 465–476.

UN (United Nation), 2007. Cyclone Sidr United Nations Rapid Initial Assessment Report, With a Focus on 9 Worst Affected Districts, 22 November.

UNDP, 1988. Land Resources Appraisal of Bangladesh for Agricultural Development. Report 2. Agroecological Regions of Bangladesh. United Nations Development Programme and Food and Agriculture Organization. pp. 212–221.

Yang F, XL Wang, Ma JY and FL Ling, 2001. A comparative analysis of yield component factors of the two rice varieties of JND3 and JND13. J. Jilin Agril. Univ., 23: 21–24.

Zubaer MA, AKMMB Chowdhury, MZ Islam, T Ahmed and MA Hasan, 2007. Effects of water stress on growth and yield attributes of Aman rice genotypes. Int. J. Sustain. Crop Prod., 2: 25-30.