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EVALUATION OF SOME TRADITIONAL RICE (*Oryza sativa* L.) CULTIVARS FOR THE EARLINESS, YIELD AND OTHER AGRONOMIC TRAITS IN SOUTHERN BANGLADESH

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A B S T R A C T

Global warming and climate change are predicted to have a major impact on rice production, necessitating both adaption and mitigation strategies. Among the agricultural crops, rice is highly vulnerable to climatic extremes such as drought, unseasonal rains, flooding, and high temperature stress. However, there is a dearth of short duration varieties which will fit well into the reduced growing period brought about by the changing climatic and rainfall pattern. With this point of view, a study was conducted at the research field of Bangladesh Agricultural Development Corporation (BADC) situated at Subarnachar sub-district under Noakhali district of Chittagong division in Bangladesh during July-November 2018 to sort out some cultivars for their earliness, adaptability, yield and other agronomic traits. Total 11 Kanihati cultivars *viz.,* Kanihati 1, Kanihati 2, Kanihati 3, Kanihati 4, Kanihati 6, Kanihati 7, Kanihati 8, Kanihati 9, Kanihati 10, Kanihati 11 and Kanihati 12 were tested against the standard check BRRI dhan52. Test materials were arranged in a randomized complete block design with three replications in three blocks. Result reveals that Kanihati 9, Kanihati 7, and Kanihati 3 were qualified for further screening and evaluation processes for few more years as they were 20 days earlier having the yield potentials of statistically similar with BRRI dhan52.

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INTRODUCTION

In Bangladesh, rice (*Oryza sativa* L.) is life. It is the staple food of the country's 160 million people, providing more than two-thirds of dietary calories and more than half the protein intake. It is the main plank of food security, a driver of economic policy, a determinant of national objectives, and a pillar of social stability. Among the three rice growing seasons in Bangladesh, approximately 55% of total annual rice is produce in Boro season (November to March) followed by 38% and 7% in Aman (July-October) and Aus season (April-June), respectively (BBS, 2017).

Rice production in Bangladesh is largely rain fed and with increased frequencies of weather extremes, use of short maturity varieties should be emphasized and promoted. Growing short duration varieties of rice has other advantages like fitting other crops in between. It has been reported that, adoption of short duration rice varieties is one of the strategies to mitigate emission of methane and nitrous oxide which are greenhouse gases. Since rice crop is said to be one of the major contributing factors to global warming, growing short duration varieties is one way of reducing such emissions. Short duration varieties would also reduce exposure of crops to pests such as wild animals thereby reducing probability of crop damage due to shortened cropping period. Thus, more emphasis must be given on the development and release of short maturity varieties. This way, research on evaluation of short duration varieties will go a long way in contributing to the national crop production as well as in reducing the factors affecting the global climate change.

According to Pandey et al. (2010), the short maturity crops were one of the most important criteria for crop intensification programs. The target of earliness in varieties is for the avoidance of unfavourable conditions and provides window of opportunities (IRRI, 1994). Thus, in the wake of looming crisis of global warming and food security issues, development of short maturing crops should receive priority and focus. Considering the above discussed facts, we were aimed to explore some local short duration potential lines for Aman rice. That is why, in this study eleven local Kanihati lines were evaluated to test their performance having the shorter life cycle against standard check BRRI dhan52.

MATERIALS AND METHODS

Experimental site and season

The experiment was conducted at the research field of the Bangladesh Agricultural Development Corporation (BADC) situated at Subarnachar sub-district under Noakhali district of Chittagong division in Bangladesh during July-November 2018. Geographically site was situated at 22.36°N and 91.12°E position with an altitude of two meter above the sea level (Figure 1).

Edaphic and climatic condition

The experiment site is situated on the Young Meghna Estuarine Floodplain of predominantly dark grey non-calcareous alluvium soils under the Subarnachar series (Brammer, 1996). It was a medium-high land under Coastal Saline Tract with the characteristics that has been presented in Table 1.

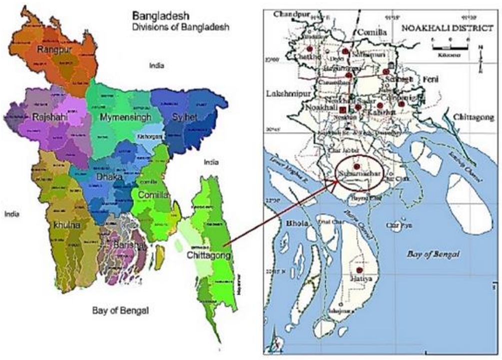

Figure 1. Map of Bangladesh showing the experimental site at Subarnachar, Noakhali, Bangladesh.

Table 1. Soil properties at 0-15 cm depth of the experimental field

Sand (%)	20
Silt (%)	65
Clay (%)	36
Textural class	Silty Clay Loam
p^H	6.30
Organic matter (%)	1.81
Total nitrogen (%)	0.11
Available sulfur (ppm)	1.58
Available phosphorus (ppm)	2.00
Exchangeable potassium (ppm)	0.35

During the study period, July was the warmest month when the highest maximum and minimum temperature (33.7 and 26.5℃, respectively) had recorded with about 84% relative humidity (Figure 2). Temperature declined gradually from September to November when November was the coolest month (maximum 30.7℃ and minimum 19.8℃). Enough rainwater was available during the transplanting and early rice growth due to the highest rainfall in July (730 mm). Rainfall started to be declined with the month onward and reached nil in November. More cloudy sky prevailed during June and started to be clearer towards November and the November had the clearest sky having the highest sunshine hours.

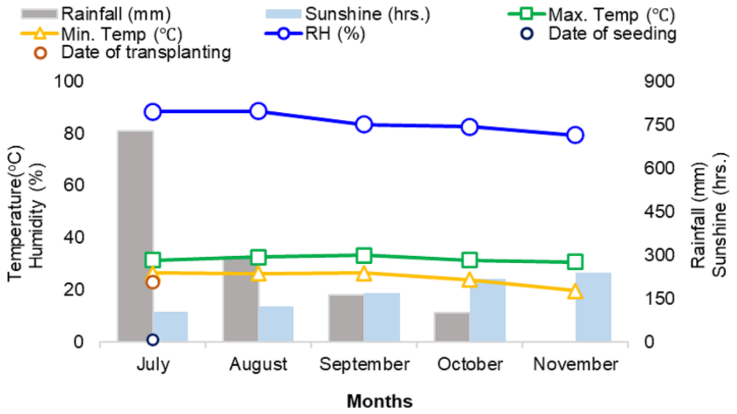

Figure 2. Monthly average temperature and relative humidity, and total rainfall and sunshine hours at Subarnachar, Noakhali, Bangladesh.

Tests materials

The test materials used for the experiment included 11 cultivars of traditional Kanihati rice *viz.*, Kanihati 1, Kanihati 2, Kanihati 3, Kanihati 4, Kanihati 6, Kanihati 7, Kanihati 8, Kanihati 9, Kanihati 10, Kanihati 11, Kanihati 12. They were collected from BADC Farm, Itakhola, Habigonj, Bangladesh. The cultivars were tested against the standard check BRRI dhan52 for their earliness, adaptability, yield and other agronomic traits.

Seed sowing, seedlings transplanting and field layout

Seed was sown in the nursery on 01 July 2018 on well prepared seedbed made by puddling with repeated ploughing followed by laddering. The main field was prepared by a two-wheel tractor. The land was prepared by four ploughings and cross ploughings then sun-drying for two days, followed by inundation and laddering. The seedlings of 21 days aged were transplanted on 20 July 2018, allocating three seedlings $hill^{-1}$ at a spacing of 25 cm ×15 cm. Each plot of 10 m × 4 m size was arranged in a RCBD design replicated three times.

Cultural operations

The land was fertilized with phosphorus, potassium, sulfur, and zinc @ 25, 40, 15, and 2.0 kg ha^{-1} as triple superphosphate, muriate of potash, gypsum, and zinc sulfate, respectively at final ploughing. Nitrogen was applied @ 80 kg ha^{-1} as urea in three equal splits at 25, 45, and 60 DAT. The weedicide, Butachlor was used to control weeds such as grasses and sedges, and it was applied with 1.5 kg active ingredient ha^{-1} at three DAT. In addition to chemical control of weeds, one hand weeding was done at 25 DAT, and irrigations were applied as and when required. Adequate plant protection measures were taken as per the recommendation of the BRRI (2017).

Harvesting and measurements

The crop was harvested at maturity (when 80% of grain became golden yellow) on different dates of respective cultivars, from 3 m × 1 m central area of each plot. The varieties were evaluated for earliness and their potential through measurement of basic agronomic traits. Thus, crop performance data gathered from the experiment included (1) days to 50% flowering as a measure for maturity duration, (2) plant height, (3) number of productive tillers, (4) length of panicle, (5) number of grains panicle^{-1}, (7) weight of 1000 grains and (8) grain yield. The weight of 1000 grains and grain yield was calculated at 14% moisture content using the following formula (USDA, 1979) and converted to t ha^{-1}.

$$\text{Adjusted yield} = \frac{100 - \text{harvested moisture (\%)}}{100 - \text{adjusted moisture (\%)}} \times \text{harvested yield}$$

Percent yield increase over control (YOC) was calculated using the following formula (Devasenpathy et al., 2008).

$$\text{YOC \%} = \frac{\text{YT - YC}}{\text{YC}} \times 100$$

Where, YT and YC are yield in the treatment and in the control, respectively

Data analysis

The data were compiled in Microsoft excel. All data were subjected to analysis of variance (ANOVA), and Duncans' Multiple Range Test compared means at P<0.05, using the statistical package program *STAR* (IRRI, 2014).

RESULTS AND DISCUSSIONS

Days to 50% flowering (DTF)

The test materials showed significant difference (p<0.05) in terms of days to flowering (Figure 3). They took time between 66 to 112 days to reach 50% flowering which is an important measure of maturity duration in rice. Kanihati 6 had the shortest DTF with 66 days while the check BRRI dhan52 had the longest DTF of 112 days. While Kanihati 8 and 10 reached flowering in 84 and 86 days which were 12-14 days earlier than other Kanihati cultivars.

DTF is the genetic potentiality of a cultivar (Chowhan et al., 2017) meaning the long duration cultivars take longer time to flower and vise-versa. Besides, the variation in the temperature also affect the flowering days. Temperature is a kind of stress for which varieties tolerant to such stress will be required. Plants subjected to stressful condition correspond to changes in the physiological order of growth performance and respond differently leading to a differing day to flower and maturity (Taiz and Zeiger, 2002). Some of the effects of the higher or cooler temperature on rice plant include leaf yellowing, stunted growth and delayed head formation (IRRI, 1974) and thus, must be selected for further testing for promotion.

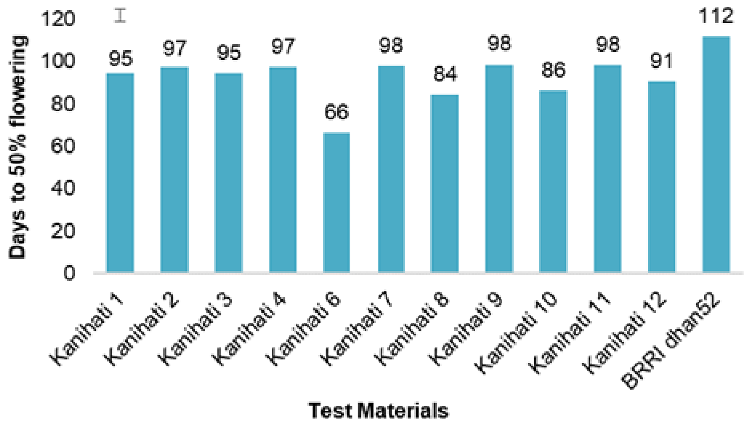

Figure 3. Earliness of test materials in terms of days to flowering.

Plant height

Plant height of the 11 Kanihati lines ranged between 86 to 108 cm (Figure 4). The Kanihati 4 was the tallest plant (108 cm) which was statistically identical with BRRI dhan52 (104 cm), while Kanihati 6 was the shortest plant of 86 cm. Rest of the cultivars were in the limit of 92-101 cm.

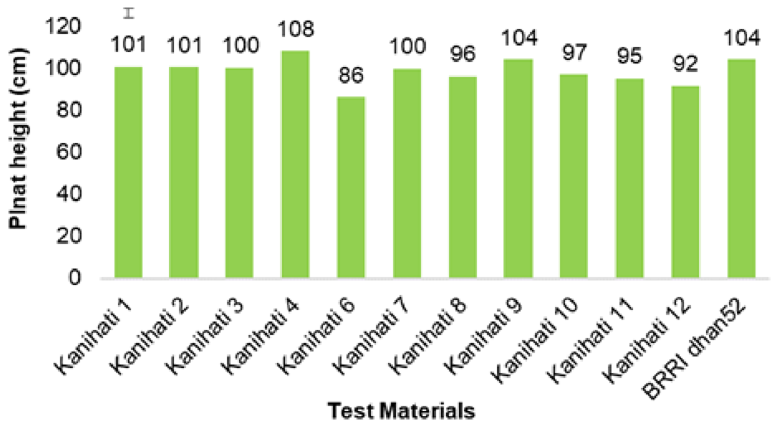

Figure 4. Mean plant height (cm) of test materials.

Plant height is an important agronomic characteristic considered in rice evaluation trials. Rice breeders and physiologists consider plant height as one of the most important criteria as the grain yield and plant heights are always correlated in the development of new plant types, or the ideotypes (Yang et al., 2007). Differences in plant height of the cultivar/varieties were mainly due to varietal variation. Roy et al. (2014) also recorded variable plant height due to varietal differences. This variation in plant height was probably due to the genetically make-up of the genotypes. Plant height is more important from the viewpoint of farmers' preference for variety adoption. Since farmers use rice straw as cattle feed, the farmers prefer those varieties which gives higher yield as well as more straw. The ideal plant height for the farmers should be above100 cm (Ghimiray et al., 2008). Further, Chhogyel et al. (2013) mentioned that an ideal plant height for would be a medium plant height of about 105-115 cm. In the current experiment, almost all the test had their heights of about 90-108 cm, making them ideal for farmers and qualifies for further testing, scrutiny and assessment.

Productive tillers

All the 11 tested lines were observed to have good tillering ability (Figure 5) at $p<0.05$. The crop stand was good and the average number of productive tillers $hill^{-1}$ in the experiment was 17 which is a standard number for higher yielding varieties. The productive tillers $hill^{-1}$ ranged between 13 to 21 with the lowest being recorded in Kanihati 6 with just 13. The check, BRRI dhan52 produced the highest number of productive tillers (21) which was identical to Kanthati 4 with about 20.

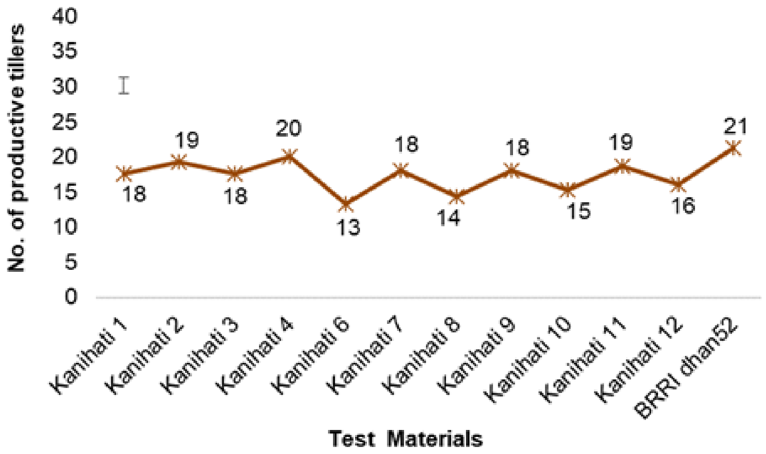

Figure 5. Comparison of number of productive tillers per hill among the test materials.

Number of productive tillers $hill^{-1}$ is an important yield component of rice crop which has direct relation with the grain yield. The number of productive tillers $hill^{-1}$, in the range of 13 to 21 in the current experiment showed that the cultivars had good yield potential. Yoshida (1981) mentioned that number of panicles bearing heads in rice is determined by the tillering ability of a variety. Thus, the tillering ability of these varieties was an additional prerequisite for narrowing down the selection for further testing. Number of panicles bearing tillers is regarded as one of the most important yield components in rice which determine the ultimate yield (Baloch et al., 2006).

Panicle length, grains $panicle^{-1}$ and weight of 1000-grains

The length of the panicle of the tested lines ranged between 23-28 cm (Figure 6) with an average of 26 cm. The longest panicle (28.5 cm) was recorded in Kanihati 4 followed by BRRI dhan52 (27.3 cm) which was statistically identical with Kanihati 2, Kanihati 9 and Kanihati 11. The shortest panicle (23.2 cm) was recorded in Kanihati 8 and was identical to Kanihati 6, Kanihati10 and Kanihati12.

The highest number of grains $panicle^{-1}$ (Figure 6) was recorded in BRRI dhan52 followed by Kanihati 3 and the lowest was recorded in Kanihati 8 and 6 followed by Kanihati 12, 9 and 7. Rest of the cultivars produced the identical grains of about 120 $panicle^{-1}$.

The highest weight of 1000 grains (Figure 6) was recorded in BRRI dhan52 (29 g) which was statistically identical with Kanihati 4 (28.7 g) and Kanihati 2 (28.6 g). The lowest weight was recorded (22.4 g) in Kanihati 6 followed by the rest of the cultivars.

Differences in panicle length (Miller et al., 1991), number of grains $panicle^{-1}$ (Shamsuddin et al., 1988) and weight of 1000 grains (Mondal et al., 2005) were mainly due to morphological and varietal variation and have influenced the differences among all the cultivars in the present study. Besides, the variation of solar radiation (sunshine hours) also has impact on translocation of photosynthates from the source to sink (Yoshida and Parao, 1976; Khush and Peng, 1996) that might have influenced the variation of the number of grains and their weight in the panicles of the test materials in this study.

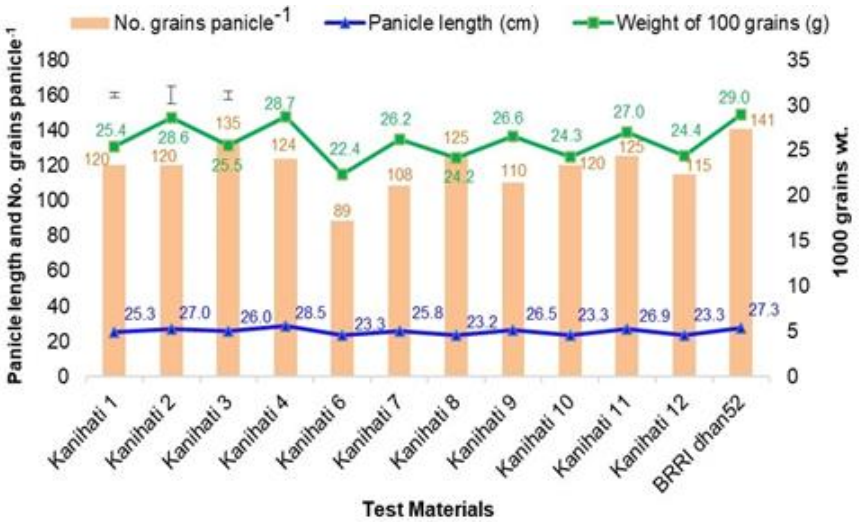

Figure 6. Comparison of length of panicle (cm), number of grains panicle^{-1} and weight of 1000 gains (g) among the test materials.

Days to maturity (DTM)

Days to maturity were significantly (P<0.05) different among the test entries of this present study (Figure 7). The BRRI dhan52 took the longest time (151 days) to mature in the field while Kanihati 6 took the shortest time (103 days) followed by the Kanihati 6 and 12. Kanihati 1, 3, 6 and 9 took the limit of our acceptable time (131-134 days). Rest cultivars needed about 141 days to mature.

The lifespan of cultivar is controlled by the genetic makeup (Awal et al., 2007; Ghosh et al., 2015). Cultural management, edaphic and climatic factors may also affect in the duration of maturity (Ahmed et al., 2015; Haque et al., 2016).

Moreover, four materials (Kanihati 9, 7, 3 and 1) performed well with maturity days of 131-134 days therefore were marked for further trait analysis over some more years. The DTM of these four varieties were shorter as compared to the BRRI dhan52 (check) based on other favourable characteristics, these cultivars will undergo further evaluations in the subsequent seasons.

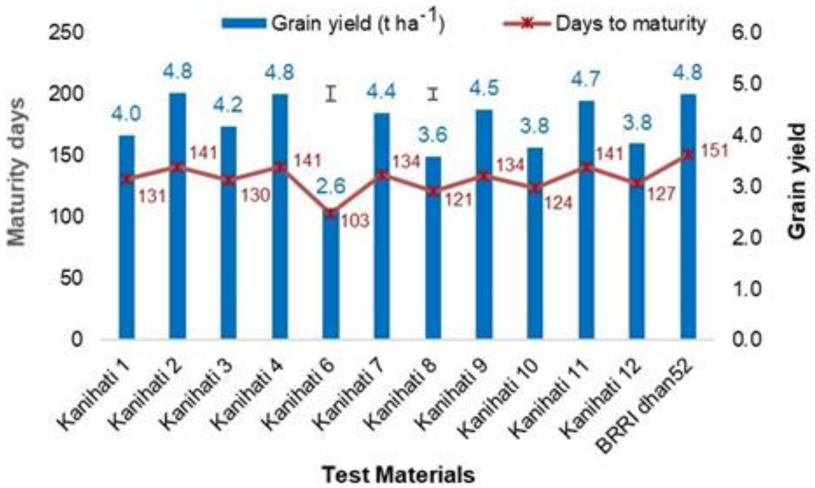

Figure 7. Comparison of days to maturity and grain yield (t ha^{-1}) among the test materials.

Grain yield

The grain yield was varied significantly ($P<0.05$) among the test entries (Figure 7). The highest yield was recorded in BRRI dhan52 (4.8 t ha^{-1}) which was statistically identical to Kanihati 2, 4 and 11 followed by Kanihati 9, 7, 3 and 1. Kanihati 6 produced the lowest yield (2.6 t ha^{-1}) followed by the rest of the cultivars. Poor tillering, a smaller number of grains $panicle^{-1}$ and lowest seed weight may be the reasons for such lowest yield in Kanihati 6. Varietal differences of grain yield were reported by Biswas et al. (1998). The genotypes, which produced higher number of effective tillers $hill^{-1}$ and higher number of grains per panicle with the robust grains also showed higher grain yield in rice (Dutta et al., 2002; Islam et al., 2014).

In crop variety development, higher or optimum grain yield is the ultimate objective of breeders, agronomists, crop physiologists and researchers. Rice yield should be the most important trait for a varietal evaluation and screening processes. This agrees with the IRRI's report on adoption of improved rice varieties in Asia (Wang et al., 2012). Crop varieties with ideal agronomic traits such as plant height, maturity duration, tillering ability, resistance to diseases and insect pests (not done in this study), should produce good levels of yield for promotion. Therefore, based the evaluation result, the three Kanihati cultivars (Kanihati 9, 7 and 3) were assessed to be the best performing ones. Thus, these four cultivars, based on preliminary evaluation showed potential for next levels research promotion. Grain yielding ability is one important varietal characteristic in rice (IRRI, 1965), and therefore, varieties with yield potential and other basic traits provide basis for large scale promotion. According to the rice breeding history (Hargrove and Coffman, 2006), a semi-dwarf higher yielding rice variety, IR 8 was a prototype for all the modern varieties grown today. Under best management, IR8 yielded 9.4 t ha^{-1} grain yields and was the first higher yielding rice variety that changed the world food situation. Therefore, the goal of breeding and varietal improvement work is to get varieties producing higher yield. The evaluations would be continued for few more years before actual promotion in the farmers' field.

CONCLUSION

In this study, Kanihati 9, Kanihati 7 and Kanihati 3 cultivars were assessed to have performed well. Based on the evaluation result, these cultivars have qualified for further screening and evaluation processes for few more years they have earliness of less than 140 days with preferred grain yield of greater than 4 t ha^{-1}.

COMPETING INTEREST

The authors declare no competing interests.

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