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Performance Study of Koshihikari Rice Variety and Its Economic Prospect in Comparison with Three Popular Rice Varieties of Bangladesh

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Authors' contributions

This work was carried out in collaboration among all authors. Author BD designed the study, managed the literature searches, performed data collection, survey, statistical analysis and data interpretation, research writing. Author MMH drafted the manuscript. Author MAM supervised the work. Author SM helped with data collection and edited the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

The research was conducted to observe the growth and yield performance of one exotic rice variety namely Koshihikari in comparison with other three popular high yielding rice varieties of Bangladesh and its economic prospect. The experiment was laid out in a Randomized Complete Block Design (RCBD) with five replications. Experimental site is located in the geographical location of 22º47´ N and 89º34´ E at the Dr. Purnendu Gain Field Laboratory of Agrotechnology Discipline, Khulna University, Bangladesh and the field was typical rice growing medium high land with clay-loam soil texture. Four rice varieties namely BRRI dhan28, BRRI dhan47 and BRRI dhan50 and Koshihikari rice variety of Japan were tested to compare the yield potential. At harvest, the tallest plant height was produced by BRRI dhan47 (93.19 cm) while the most dwarf plant by Koshihikari (78.30 cm) and

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the maximum number of tiller hill^{-1} (16) was produced by Koshihikari. BRRI dhan50 was produced the longest panicle (22.87 cm) and maximum number of grains panicle^{-1} (119) while the shortest panicle (14.93 cm) and minimum grains panicle^{-1} (60) was produced by Koshihikari variety. The highest 1000-grain weight (22.21 g) and grain yield (7.62 t ha^{-1}) were observed in BRRI dhan47 whereas the lowest 1000-grain weight (17.30 g) was observed in BRRI dhan50 and the minimum grain yield (5.6 t ha^{-1}) was found in Koshihikari variety. However, Koshihikari has some performance limitations, but it has brighter economic prospect than the other three popular rice varieties of Bangladesh because cultivating Koshihikari only in 0.1% mean rice cultivated land area in Boro season in Bangladesh and exporting at the price of only 10% of retailer price in world market may bring about BDT 1091 million export revenue that will be more than total revenue earned by Bangladesh by exporting rice at present.

Keywords: Exotic variety; tested; export revenue.

1. INTRODUCTION

Rice is the most vital food crop of the developing part of the Globe and that is the staple food of more than half of the world's population, for which about 90% of rice is grown by more than 200 million small rice farmers, who individually possess less than 1 hectare of land. This cereal is harvested from 159 million hectares annually, which has twice the value of production in the developing world as any other food crop and the value is more than US $150 billion per year. More than 1 billion people, one-fifth of world population depend on rice cultivation for their livelihood [1].

Bangladesh ranks third in area and fourth in production of world rice and over 90% of its population depend on rice for their daily diets [2]. Rice is cultivated in 10.29 million hectares of land and that is 80% of cropped area of Bangladesh that produces 25.18 million tons of rice [3]. The staple food rice, accounts for about 92% of the total food grains produced in Bangladesh and rice production employs almost 55-60% of our labor forces providing national food security [4].

The agro based economy of Bangladesh is predominated by intensive rice cultivation and the national average yield is 2.77 t ha^{-1} while the yields of other rice growing countries of Asia such as Taiwan, China, Indonesia and Japan are 4.60, 5.72, 4.38 and 5.97 t ha^{-1} respectively [5]. India and Vietnam are successful in producing modern semi-dwarf hybrid rice varieties as a viable alternative. Good hybrid rice has the potential of yielding 14-28% more than the best-inbred or pure line variety cultivated under similar agro-climatic conditions [6].

Koshihikari is a popular rice variety cultivated mainly in Japan as well as in Australia and the United States. It is super-premium short grain rice with unique characteristics such as firmness, consistency, aroma and a pleasant sweetness. Slightly off white, firm but creamy and low glycemic attributes make this rice suitable for making Sushi; the special food that is made from Koshihikari rice or general consumption. In time, this rice becomes popular in different parts of the globe. Koshi rice is cultivating successfully in California and Tennessee and even though it may not be grown as well in Japan, the American rice variety retains many of its attributes what make koshi rice such an exclusive product. Being grown locally, it is less expensive and more readily available than the Japanese koshi rice varieties [7].

Rice is paying a vital role in economy of Bangladesh and it has natural advantages like favorable climate, soil and cheap labor force as key factors for relatively higher production. Bangladesh can earn some extra foreign currency by producing and exporting rice that demanded in the world market besides feeding its population. Among the demanded rice in world market, Koshihikari is important one that may help Bangladesh to reduce its huge trade deficit. Therefore, the goal of this research is to observe the growth and yield performance of Koshihikari rice variety in Bangladeshi agro climatic condition, in comparison to other three popular high yielding rice varieties of Bangladesh and evaluation of economic prospect of Koshihikari in Bangladesh.

2. MATERIALS AND METHODS

The experiment was conducted at the Dr. Purnendu Gain Field Laboratory of Agrotechnology Discipline, Khulna University, Khulna, Bangladesh. The experimental site is located in the Agroecological Zone 13 of Bangladesh with the geographical location of 22º47´ N and 89º34´ E having subtropical climate characterized by moderate temperature and

heavy rain fall during the Kharif season (April to October) and low rainfall and low temperature during the Boro season (November to March). The experimental field was typical rice growing medium high land with clay-loam texture having p^H of 8. Soil samples were collected from 0-15 cm depth of the experimental field to examine the fertility status of the field according to the prescribed method. The experiment was conducted in Boro season and four rice varieties were tested, among them three high yielding rice varieties of Bangladesh namely BRRI dhan28, BRRI dhan47 and BRRI dhan50 and one exotic rice variety from Japan was Koshihikari. The experiment was laid out in a Randomized Complete Block Design (RCBD) with five replications. The selected field was firstly divided into five equal blocks and each block was further subdivided into four unit plots of 20 m^2 (5 m x 4 m) size. The distance between block to block was 1.0 m and plot to plot distance was 50 cm. A piece of medium high land was selected for seedbed preparation with 2 m length and 1.25 m width and space between the beds were 0.5 m. Seedbed was made ready by ploughing four times with power tiller followed by laddering. The bed was kept wet by irrigation as and when required. Before sowing in the seedbed, seeds were soaked for 24 hours for sprouting and care was taken to ensure no pests and diseases infestation. The experimental field was prepared 15 days before transplanting sufficiently enough to make the field ready for transplanting with application of basal doses of nutrients. N (118 kg ha^{-1}), P_2O_5 (63 kg ha^{-1}), K_2O (72 kg ha^{-1}), Ca (13 kg ha^{-1}) and Zn (3 kg ha^{-1}) were applied according to fertility status and Soil Resource Development Institute (SRDI), Bangladesh recommendation. The total P_2O_5, K_2O, Ca, Zn and $1/4^{th}$ of N were applied as basal dose. The rest of the N was applied at three equal split doses at 50, 70 and 90 DAS (days after sowing in seed bed). Transplanting was done with three seedlings $hill^{-1}$ maintaining 15 cm plant to plant and 20 cm row to row distance. Two hands weeder were used to control weed infestations in the experimental field at 50 DAS and 80 DAS. The experimental field was irrigated regularly depending upon the moisture content of the field and flood irrigation was applied during panicle initiation state. The crops were harvested at their full maturity when more than 80% of the seeds turned into golden color. The harvested crop of each plot was bundled separately, tagged properly and brought to the clean threshing floor. The bundles were dried in open sunshine and were threshed after proper drying. The grain and straw weight for each plot were recorded after proper drying and were adjusted to 14% moisture level. Data on growth and yield attributing characteristics were recorded from five randomly selected hills of each plot and data for growth parameters were recorded at 60, 75, 90,105 DAS (days after sowing in seed bed) and at harvesting and data for yields were collected after harvesting. Recorded data were analyzed statistically with the help of computer package program MSTAT-C and the mean differences were analyzed with Duncan's Multiple Ranges Test [8]. The harvest index has been calculated by the following formula:

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

For evaluating the economic prospect, a survey was conducted to collect price of Koshihikari rice in the online retailer shops. Data of rice production in Boro season were also collected [9] and both the collected data were later analyzed with the help of SPSS 20 computer package program. The expected export revenue was calculated by the following arithmetic formula:

Revenue (BDT) = % of Average Online Retailer Price of Koshihikari Rice (BDT Kg^{-1}) × % of Mean Rice Cultivated Land Area in Boro Season in Bangladesh (ha) × Yield of Koshihikari Rice (Kg ha^{-1}).

3. RESULTS AND DISCUSSION

This section represents the presentations and discussions of the results and findings.

3.1 Plant Height

The plant height was varied significantly (*P=0.01*) among the varieties at regular interval after sowing. Koshihikari produced the tallest plant (51.65 cm) followed by BRRI dhan47 (40.54 cm) and BRRI dhan50 (39.34 cm) while BRRI dhan28 produced the shortest plant height (34.33 cm) at 60 DAS. The plant heights of BRRI dhan47, BRRI dhan50 and BRRI dhan28 were found statistically similar at 60 DAS. Still Koshihikari was observed the tallest plant height (67.59 cm) at 75 DAS followed by BRRI dhan47 (60.10 cm) and BRRI dhan50 (55.45 cm) whereas BRRI dhan28 was observed the shortest plant height (51.59 cm). Again, at 90 DAS, Koshihikari was produced the tallest (82.19 cm) plants and was statistically similar with BRRI dhan47 whereas BRRI dhan50 produced the shortest height

(72.87 cm). The tallest (91.50 cm) plant height at 105 DAS was observed with BRRI dhan47 and the shortest (79.53 cm) plant was observed with Koshihikari (80.26 cm) rice variety, which was statistically similar with BRRI dhan50. At the time of harvesting BRRI dhan47 was the tallest (93.19 cm) followed by BRRI dhan28 (91.11 cm) which were statistically identical and Koshihikari was the shortest plant (78.30 cm) proceeded by BRRI dhan50 (80.33 cm) (Table 1). The growth of Koshihikari plant was relatively higher than the Bangladeshi varieties in early stage (up to 90 DAS) but the reduction of plant height was observed in Koshihikari rice variety from 105 DAS to harvest. Khoshihikari was the earliest variety in terms of grain maturity but it had to keep in the field to drain out of irrigation water to attain maturity for all the varieties. Meantime, due to genetic characteristics, after maturity Koshihikari plant dried out and plant cells were contracted as moisture reduced. Moreover, the leaf tip, including flag leaf dying was observed in every rice varieties causing height reduction as it approached to maturity but significant effect of height reduction was only observed in Khoshirkari rice. The cumulative effect of cell contraction and leaf tip dying were the main causes of plant height reduction of Koshihikari. BRRI [10] reported the plant height of 90,105, 82 cm for BRRI dhan28, BRRI dhan47 and BRRI dhan50, respectively. However, Salam et al. [11] found relatively higher pant height at harvest. He observed 101 and 105 cm plant height for BRRI dhan47 and BRRI dhan28, respectively.

3.2 Number of Tiller Hill^{-1}

The number of tiller hill^{-1} was influenced significantly among the tested varieties at four different stages (60 DAS, 75 DAS, 105 DAS and at harvest). At 60 DAS, BRRI dhan28 produced the highest tiller number hill^{-1} (13) and the lowest number of tiller hill^{-1} was found with BRRI dhan47 (9) which was statistically similar to BRRI dhan50 (9) and Koshihikari (10). At 75 DAS, BRRI dhan28 had the maximum tiller number hill^{-1} (17) whereas BRRI dhan47 had the lowest tiller number (12) which was statistically similar to BRRI dhan50 (13) and Koshihikari (14). Tiller number hill^{-1} was varied insignificantly (*P=0.01*) among the varieties at 90 DAS and the largest tiller number was found with the variety of Koshihikari (18). At 105 DAS and at harvest; Koshihikari produced the maximum tiller number per hill while the minimum number of tiller hill^{-1} was produced by BRRI dhan47 (Table 2). Tillers number hill^{-1} were increased up to 90 DAS for all the varieties but the entire tillers in the hill did not bear flowers and those flowerless tillers were gradually died after 90 DAS, for this reason, reduced number of tiller hill^{-1} were found at 105 DAS and at harvest from earlier.

3.3 Days to Flowering

The days required for flowering was also varied significantly (*P=0.01*) among the varieties. Result showed that Koshihikari was required the minimum days for flowering (85.7 DAS) while BRRI dhan50 required the maximum days for flowering (99.2 DAS) which was statistically similar to BRRI dhan28 (98 DAS) (Table 3). The statistical data reveal that Koshihikari variety flowers 7 to 14 days earlier than the Bangladeshi varieties tested in this study.

3.4 Days to Maturity

The statistical analysis showed that required grain maturity time was varied significantly (*P=0.01*) among the varieties. The result revealed that Koshihikari was matured earlier (113.2 DAS) than other tested varieties. BRRI dhan50 required maximum days to grain maturity (132.6 DAS) which was statistically similar to BRRI dhan47 (130 DAS) and BRRI dhan28 (126.2 DAS) (Table 3). The grain of Koshihikari variety mature 13 to 19 days before than the three popular varieties of Bangladesh. Koshihikari cultivation will substantially limit the use of agricultural resources as it stands minimum days in field that will gives farmers at least extra 13 days to prepare their land for the next corp.

3.5 Days to Harvesting

Required days for harvesting were varied significantly (*P=0.01*) among the varieties. The minimum days to harvesting (124 DAS) were observed in Koshihikari variety and the maximum days were required for BRRI dhan50 (145 DAS) which were statistically identical to BRRI dhan47 (144 DAS) (Table 3). However, BRRI [10] reported that the life span of BRRI dhan28, BRRI dhan47 and BRRI dhan50 were 140, 152 and 155 DAS, respectively. From the above discussion it can be stated that Koshihikari is the best variety in terms of days required for grain maturity as it took the minimum days to be harvested (Table 3). As the framers of Bangladesh have to depend on the natural drying system due to scarcity of artificial drying system. So, the lowest days required for

harvesting of koshihikari is not only reduces the chance of getting affected by seasonal storms that just begins before the harvesting of crops in Boro season in Bangladesh but also reduces agricultural resource uses.

3.6 Effective Tiller Hill^{-1}

A significant (*P=0.01*) variation was observed in effective tiller hill^{-1}. The maximum tiller hill^{-1} was noticed in Koshihikari (16) whereas the minimum tiller number hill^{-1} (9) was observed in BRRI dhan47 (Table 4). BRRI dhand28 (13) and BRRI dhan50 (12) were found statistically similar in producing effective tiller hill^{-1}(Table 4). It is likely that more tiller hill^{-1} will provide more grain yield but this phenomenon is not true here because of the major effects of other yield attributing characteristics like panicle length and effective grains panicle^{-1}. Tiller number hill^{-1} is one factor that influences the final yield of the rice varieties but not the soul factor and this study revealed that Koshihikari produced the maximum number of tiller hill^{-1} still it provided the lowest yield but BRRI dhan47 produced the minimum number of tiller hill^{-1} that provided the maximum yield.

Table 1. Effect of variety on plant height of the tested rice varieties at different growth stages

Varieties	Plant height (cm)				
	60 DAS	75 DAS	90 DAS	105 DAS	Harvest (DAS)
Koshihikari	51.65^{a}	67.59^{a}	82.19^{a}	80.26^{b}	78.30^{b}
BRRI dhan47	40.54^{b}	60.10^{b}	80.41^{a}	91.50^{a}	93.19^{a}
BRRI dhan28	34.33^{b}	51.59^{c}	74.86^{b}	89.48^{a}	91.11^{a}
BRRI dhan50	39.34^{b}	55.45b^{c}	72.87^{b}	79.53^{b}	80.33^{b}
Level of significance	**	**	**	**	**
CV (%)	9.15	4.43	3.84	3.50	3.18

*DAS= days after sowing; CV = co-efficient of variation;** = significant at 1% level*

Table 2. Effect of variety on tiller number hill^{-1} of the tested rice varieties at different growth stages

Varieties	Number of tiller hill^{-1}				
	60 DAS	75 DAS	90 DAS	105 DAS	Harvest
Koshihikari	10^{b}	14^{ab}	18	18^{a}	16^{a}
BRRI dhan47	9^{b}	12^{b}	15	12^{b}	9^{c}
BRRI dhan28	13^{a}	17^{a}	17	14^{ab}	13^{b}
BRRI dhan50	9^{b}	13^{b}	16	13^{b}	12^{bc}
Level of significance	*	*	NS	**	**
CV (%)	13.98	11.23	10.90	12.17	11.34

*DAS = days after sowing; CV = co-efficient of variation; ** = significant at 1% level; * = significant at 5% level*
NS = non significant

Table 3. Effect of variety on days required for flowering, grain maturity and harvesting of the tested rice varieties

Varieties	Flowering (DAS)	Grain maturity (DAS)	Harvesting (DAS)
Koshihikari	85.7^{c}	113.2^{b}	124.2^{c}
BRRI dhan47	92.2^{b}	130.0^{a}	144.6^{a}
BRRI dhan28	98.0^{a}	126.2^{a}	137.0^{b}
BRRI dhan50	99.2^{a}	132.6^{a}	145.2^{a}
Level of significance	**	**	**
CV (%)	2.35	2.85	1.67

*DAS = days after sowing; CV = co-efficient of variation; ** = significant at 1% level*

3.7 Panicle Length (cm)

The panicle lengths were differed significantly (*P=0.01*) among the four varieties. Data of analysis showed that BRRI dhan50 (22.87 cm) was produced the longest panicle which was statistically identical to BRRI dhan47 (22.64 cm) while the shortest panicle was produced by Koshihikari (14.93 cm) variety. Toriyama et al. [12] observed the panicle length of Koshihikari 17.7 cm which is longer than findings of this study that may be due to the effect of coastal saline soil. Here, Koshihikari is following behind in production of grain amount in comparison with other three high yielding rice varieties of Bangladesh due to its shorter panicle length (Table 4). The functional relationship revealed that a strong correlation (R^2 = 0.9029) existed between panicle length and yield of the rice varieties (Fig. 1). The lowest yield of Kosihikari variety is greatly influenced by the shortest panicle length and BRRI dhan47 provided the maximum yield backed by its longer panicle length that is statistically similarly with the maximum value of panicle length in this study.

3.8 Number of Spikelets Panicle^{-1}

Table 4 shows significance difference (*P=0.01*) among the varieties in number of spikelets panicle^{-1}. The maximum number of spikelets panicle^{-1} was found in BRRI dhan50 (136) whereas the minimum (66) number of spikelets panicle^{-1} was found in Koshihikari. BRRI dhan47 (108) and BRRI dhan28 (100) were found statistically similar in producing number of spikelets penicle^{-1}. Though Koshihikari bear the lowest number of spikelets but 90% spikelets produced effective grains, on the other hand BRRI dhan50 bear the highest number of spikelets but 88% spikelets produced effective grains. In terms of percentage the both varieties are very close but in real number, they differed more due to variation in panicle length.

3.9 Number of Effective Grain Panicle^{-1}

A significant (*P=0.01*) distinction was examined among the four rice varieties in case of grain number panicle^{-1}. The maximum number of grains panicle^{-1} was recorded by BRRI dhan50 (119) but the minimum number of grains per panicle was given by Koshihikari (60) variety (Table 4). BRRI dhan47 (89) and BRRI dhan28 (89) were found statistically similar in number of grains penicle^{-1}. Though, BRRI dhan50 bears the maximum number of effective grain panicle^{-1} but it did not provide the maximum yield because of the lowest grain weight. More noticeably, BRRI dhan47 and BRRI dhan26 bear same number of effective grain panicle^{-1} but the yield of BRRI dhan47 is higher than BRRI dhan28 and that may due to the major effect of higher grain weight of BRRI dhan47 over BRRI dhan28.

3.10 1000-grain Weight

1000-grain weight varied significantly (*P=0.01*) among the varieties. The highest 1000-grain weight was observed in BRRI dhan47 (22.21 g) which was statistically similar to Koshihikari (21.83 g) variety whereas BRRI dhan50 produced the lowest 1000-grain weight (17.30 g) (Table 4). Takai et al. [13] found that 1000-grain weight of Koshihikari was 21.7 grams which is almost similar to this study and Siddiq [14] observed 21.81 grams of 1000-grain weight for BRRI dhan28 which is slightly higher than this study. 1000-grain weight of Koshihikari and BRRI dhan47 is statistically identical but the BRRI dhan47 provided the maximum yield and Koshihikari the minimum. Higher grain weight is effective yield attributing character for higher yield. Despite of higher grain weight, Koshihikari lack behind due to limitation of other yield attributing characteristics like shorter panicle length that bears lower number of effective grain panicle^{-1} and ultimately provided the minimum yield.

3.11 Grain Yield (t ha^{-1})

Grain yield was significantly (*P=0.01*) influenced by the varieties. The maximum grain yield was obtained from the saline tolerant variety BRRI dhan47 (7.62 t ha^{-1}) which was statistically similar to BRRI dhan28 (7.05 t ha^{-1}) and BRRI dhan50 (7.02 t ha^{-1}) while the minimum grain yield was found in Koshihikari variety (5.60 t ha^{-1}) (Table 4). Takai et al. [13] suggested 5.6 tha^{-1} yield of Koshihikari and it is absolutely same as the result of this research. In another study conducted by Toriyama et al. [12] reported 5.5 tha^{-1} of grain yield of Koshihikari which is very closely to the present study. Salam et al. [11] found 7.4 and 5.9 t ha^{-1} of grain yield for BRRI dhan47 and BRRI dhan28, respectively and the findings is lower in comparison with this study. Siddiq [14] reported that the yield of BRRI dhan28 is 7.5 tha^{-1} which is similar with this study. BRRI dhan47 provided the maximum grain yield though it produced the minimum number of effective tiller hill^{-1} but its panicle length was statistically similar with the longest panicle of this

study and BRRI dhan47 was the 2nd in producing effective grains panicle^{-1}, top in 1000-grain weight. All the good yield attributing characteristics of BRRI dhan47 offset one limitation of this variety (the minimum number of effective tiller hill^{-1}) and finally get managed to provide the maximum yield. In contrast, Koshihikari produced the maximum tiller number hill^{-1} and tis 1000-grain weight was statistically similar to that of the top value but these two good yield attributing characteristics could not offset the one limitation (lower Number of effective grains panicle^{-1}) which might be due to the shortest panicle length and finally, this variety was observed as the lowest grain yield producer.

3.12 Biological Yield

Analysis of variance showed that biological yield was varied significantly (*P=0.01*). The highest biological yield was observed in BRRI dhan50 (13.44 t ha^{-1}) which was statistically similar with BRRI dhan28 (13.25 t ha^{-1}) and BRRI dhan47 (13.14 t ha^{-1}). The lowest biological yield was found in Koshihikari (9.34 t ha^{-1}) which was significantly lower than the other three high yielding rice varieties of Bangladesh (Table 4). The popular rice varieties of Bangladesh have the greater physiological competence of utilizing resources for greater dry matter accumulation than Koshihikari and Banaldeshi varieties also utilize relatively more resources and provided relatively higher grain yield.

3.13 Harvest Index

The experimental data analysis showed that the harvest index varied significantly (P=0.05) among the varieties. The highest harvest index was obtained in Koshihikari (59.93 %) which was statistically similar to BRRI dhan47 (57.48 %). The lowest value of harvest index was found in BRRI dhan50 (52.56%) and was found statistically similar to BRRI dhan28 (53.12%) (Table 4). Thought, Bangladeshi rice varieties have the greater physiological competences to utilize the resources but the physiological capacity to translocate photosynthates and mobilized the photosynthates into grains is better in Koshihikari rice variety.

3.14 Average Land Acquisition and Production for Local and High Yielding Rice Varieties in Bangladesh

The analysis of the rice production in Boro season reveals that local variety rice production is minimum in a unite land area (1.92 t ha^{-1}) while the highest production is observed in High Yielding Varieties (3.43 t ha^{-1}) but the average rice production in Boro season is still 3.37 t ha^{-1}. In an average, to produce 14.04 million tons of rice, farmers had to use 4.18 million hectors of land in Boro season between 2000 and 2009. Among the total cultivated land area Local and High Yielding rice varieties were cultivated in 0.16 and 4.02 million hectors of land that provided 0.31 and 13.73 million tons of rice, respectively (Table 5).

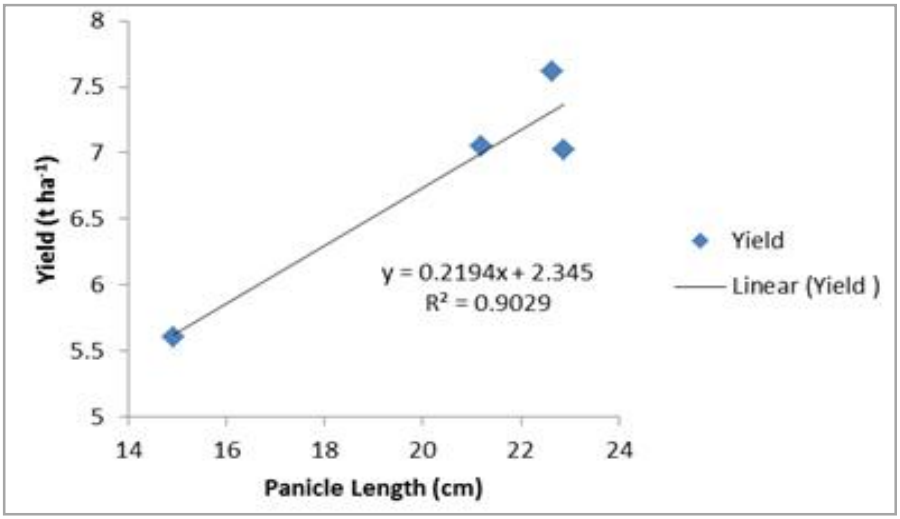

Fig. 1. Correlation between panicle length and yield

Table 4. Effect of variety on yield and yield attributing characters of the tested rice varieties in the experiment

Varieties	Number of effective tillershill^{-1}	Panicle length (cm)	Number of spikelets panicle^{-1}	Number of effective grains panicle^{-1}	1000 grain weight (g)	Grain yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
Koshihikari	16^{a}	14.93^{c}	66^{c}	60^{c}	21.83^{a}	5.60^{b}	9.34^{b}	59.93^{a}
BRRI dhan47	9^{c}	22.64^{a}	108^{b}	89^{b}	22.21^{a}	7.62^{a}	13.26^{a}	57.48^{a}
BRRI dhan28	13^{b}	21.19^{b}	100^{b}	89^{b}	19.20^{b}	7.05^{a}	13.44^{a}	53.12^{b}
BRRI dhan50	12^{bc}	22.87^{a}	136^{a}	119^{a}	17.30^{c}	7.02^{a}	13.14^{a}	52.56^{b}
Level of significance	**	**	**	**	**	**	**	*
CV (%)	9.13	3.54	10.73	8.37	2.89	7.27	8.52	6.12

*CV = co-efficient of variation; ** = significant at 1% level; * = significant at 5% level*

3.15 Market Price of Koshihikari Rice

The price of Koshihikari rice collected from different online shops all over the world. The analysis of the data shows that the average online retailer price of koshihikari rice is 465.82 BDT Kg^{-1} (Table 6), where as in Bangladesh the price of available rice ranges from 29 to 110 BDT Kg^{-1}. As Koshihikari is demand rice in world market, Bangladesh can cultivate it for exporting by utilizing its cheap production factors that are recently utilizing for producing the low valuable rice varieties.

3.16 Economic Prospect of Koshihikari in Bangladesh

The yield of Koshihikari (5.60 t ha^{-1}) is still higher than the average rice production (3.37 t ha^{-1}) in Boro season in Bangladesh. The projected production and exports table illustrates expected export revenues that are derived from different combination of percentages of rice cultivated land area in Bangladesh in Boro season and percentages of online retailer prices of Koshihikari rice in world market. In 2009 Bangladesh exported 7.53 million kg of native rice and gained revenue of 723.80 million BDT at an average unit price of 96.11 BDT/kg [15]. In contrast, Bangladesh can earn BDT 1,091 million only by cultivating Koshihikari rice in 0.1% average cultivated land area in Boro season in Bangladesh and exporting at a price of 10% of average retailer price of Koshihikari rice in international market (Table 7).

Table 5. Average rice production and rice cultivated land area in boro season in Bangladesh from 2000 to 2009 (10 years)

Category	Mean production (t ha^{-1})	Standard deviation	Mean cultivated land area (ha)	Standard deviation	Mean total production (ton)	Standard deviation
Local Varieties	1.92	0.169	162510	37108	312900	75425
High Yielding Varieties	3.43	0.476	4021336	575970	13730200	2320002
Average Rice Production in Boro Season	3.37	0.465	4183846	547384	14043100	2266364

Table 6. Online retailer price of Koshihikari rice

Number of brand of kohsihikari rice	Mean price (BDT Kg^{-1})	Standard deviation	Range
11	465.82	205.20	711.60

Table 7. Projected production and export revenue of Koshihikari rice

	Revenue (million BDT)				
	10% of RP	20% of RP	30% of RP	40% of RP	50% of RP
0.1% of CLA	1,091	2,183	3,274	4,366	5,457
0.25% of CLA	2,728	5,457	8,185	10,914	13,642
0.5% of CLA	5,457	10,914	16,371	21,828	27,285
0.75% of CLA	8,185	16,371	24,556	32,742	40,927
1% of CLA	10,914	21,828	32,742	43,656	54,570
2.5% of CLA	27,285	54,570	81,855	109,139	136,424
5% of CLA	54,570	109,139	163,709	218,279	272,849
7.5% of CLA	81,855	163,709	245,564	327,418	409,273
10% of CLA	109,139	218,279	327,418	436,558	545,697

CLA = mean rice cultivated land area in boro season in Bangladesh (4,183,846 ha); RP = average online retailer price of koshihikari rice (465.82 BDT Kg^{-1}); kosihikari rice yield in Bangladesh is 5600 Kg $ha^{-1;}$ revenue (BDT) = % of average online retailer price of koshihikari rice (BDT Kg^{-1}) × % of mean rice cultivated land area in boro season in Bangladesh (ha) × yield of koshihikari rice (Kg ha^{-1})

4. CONCLUSION

Koshihikari was the earliest and shortest (78.30 cm) variety among the rice varieties taken in this research. It took only 124 days for harvesting after sowing in seed bed but BRRI dhan50 took the longest time (145 days) for harvesting. The maximum yield (7.62 t ha^{-1}) was found in BRRI dhan47 but Koshihikari had the all the good yield attributing characteristics except the longer panicle length and the longest panicle (22.87 cm) was observed in BRRI dhan50 and it also bears the maximum number (119) of effective grain $panicle^{-1}$. Koshihikari variety had the shortest panicle length (14.93 cm), so it contains the lowest number of effective grains $panicle^{-1}$ (60) that results the lowest yield (5.60 t ha^{-1}) comparing with the other three popular high yielding rice varieties of Bangladesh. The effective tiller $hill^{-1}$ was the maximum (16) in Koshihikari that is one of the most important characters for higher yield. The shattering rate of grain was very low in Koshihikari and the maximum harvest index was also observed (59.93%) for this variety. The most dwarf rice variety was also Koshihikari which is good characteristic for rice cultivation in storm prone areas. Severe storms were observed in Bangladesh just before harvesting the rice in Boro season that results huge shattering loss of rice grain. So, Koshirhikari may be a good chose not only for its ease of production and good yield attributing characteristics but also for its bright economic prospect in Bangladesh. The average production of Koshihikari rice in 0.1% cultivated land in Boro season may brings about BDT 1,091 million export revenue at a exporting price of only 10% of the online retailer price of Koshihikari in the world market and that revenue will exceed total revenue comes from rice exporting at present. Moreover, Bangladeshi rice varieties are not that much popular in world market but Koshihikari is well accepted in many developed countries all over the world. As an agriculture dependent economy, Bangladesh can not only advance its economic situation in a great extent by best utilization of production factors and encouraging farmers to produce relatively valuable Koshihikari rice more for exporting to earn foreign remittance but also improve the socioeconomic conditions of the Bangladeshi poor farmers.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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