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Evaluation of Growth Performance of Some Rice Varieties in Relation to Their Economic Yield

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Abstract: The experiment was conducted during the period of March to August (*Aus* season), 2013 at the experimental farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar and Dhaka to evaluate the growth performance of some rice varieties in relation to their economic yield. The performance of BRRI hybrid dhan1, BRRI hybrid dhan2, ACI hybrid2, Jagoron and Panna1 were compared with check variety, BRRI dhan48. The experiment was laid out with Randomized Complete Block Design (RCBD) with three replications. Data were recorded on different growth parameters, grain yield, straw yield, biological yield and harvest index. The data were recorded at 30, 45, 60 and 75 days after transplanting (DAT) as well as at final harvest and obtained data were statistically analyzed for comparisons. In term of vegetative growth parameters, plant height, tiller hill^{-1}, leaf area index, stem dry matter hill^{-1}, leaves dry matter hill^{-1} and total dry matter hill^{-1}at different DAT, the ACI hybrid2 was superior over the check variety, BRRI dhan48 as well as BRRI hybrid dhan1 and BRRI hybrid dhan1. Highest and statistically significant grain yield (3.05 t ha^{-1}) straw yield (4.20 t ha^{-1}) biological yield (7.25 t ha^{-1}) and harvest index (42.01%) was observed in ACI hybrid2 which was statistically identical with hybrid riceJagoron and Panna. All test hybrid varieties were superior in vegetative and yield performance over inbreed BRRI dhan48 during *Aus* season.

Key words: Rice · Hybrid variety · *Aus* season · Economic yield

INTRODUCTION

Rice (*Oryza sativa* L.) is an important food around the world and the staple food approximately more than two billion people in Asia [1]. The population of Bangladesh is increasing at an alarming rate and the cultivable land is decreasing due to urbanization and industrialization resulting in more shortage of food. The nation is still adding about 2.3 million every year to its total of 150 million people [2]. Thus, the present population is supposed to swell progressively to 223 million by the year of 2030 which will require additional 48 million tons of food grains instead of current deficit of about 1.2 million tons every year [3]. So, the highest priority has been given to increase its production per unit area [4].

In Bangladesh, the geographical, climatic and edaphic conditions are favorable for year round rice cultivation. But the national average rice yield in Bangladesh is only 2.57 t ha^{-1}[5]. The average rice yield of rice in Bangladesh is far below compared to other rice growing countries, like China is (8.75 t ha^{-1}), Japan (8.22 t ha^{-1}) and Korea (8.04 t ha^{-1}) [6]. In Bangladesh, rice dominates over all other crops and covers 75% of the total cropped area of which around 79% is occupied by high yielding rice varieties [7].

Rice yield can be increased in many ways. Horizontal expansion of rice growing area, development of new high yielding and hybrid varieties, introduction of developed varieties, adaption of proper agronomic management practices can help to achieve potential yield per unit area and total production of rice. It has potentiality for food security of poor countries where arable land is scarce populations is expanding and labor is cheap. In our country, Bangladesh Rice Research Institute (BRRI) has started breeding program for the development of super high yielding varieties with large panicles and high yield potentialities.

Growth and yield of rice are strongly influenced by genotype as well as environmental factors [8, 9]. The genetic potentiality of a rice variety is almost fixed, but grain yield can be increased by the manipulation of

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management practices and by growing in recommended season [10]. Now a day's different hybrid rice varieties are available in Bangladesh which has more yield potential than conventional high yielding varieties [11]. Improvement of rice grain yield is the main target of breeding program to develop rice varieties for diverse ecosystems. In addition, grain yield also related with other characters such as growth duration and yield components [12].

There are three distinct rice growing seasons in Bangladesh namely *Aus, Aman* and *Boro*. Among these three, *Aus* rice covers only 12.27% of the rice growing area with average yield is 1.73 t ha^{-1} [5]. Recently various new high yielding rice varieties have been developed by BARI for *Aus* season like BRRI dhan42, BRRI dhan48, BRRI dhan55 etc. but there yield is much lower than hybrid rice varieties, because the hybrids have larger panicles and heavier seeds resulting an average grain yield of 7.27% [13]. The low yield of rice in the *Aus* season should be improved to meet the current demand of staple food and future food security. Hybrid rice is one of the viable options for increasing the yield over the best modern varieties. Based on above proposition, this research work was designed to evaluate the growth and yield performance of some hybrid rice varieties in *Aus* season.

MATERIALS AND METHODS

The current research work was conducted in the experimental field of Sher-e-Bangla Agricultural University, Dhaka during *Aus* season (March to August) of 2013. Geographically this location is under the subtropical climate, characterized by three distinct seasons, winter season from November to February and the pre-monsoon period or hot season from March to April and monsoon period from May to October [14].

The soil of the experimental area belongs to "The Modhupur Tract", AEZ-28 [15]. Top soil was silty clay in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. Soil pH was 5.6 and has organic carbon 0.45%. The experimental area was flat having available irrigation and drainage system. The experiment comprised of six rice varieties which were used as treatment for the experiment *viz*., V_1: BRRI dhan48, V_2: BRRI hybrid dhan1, V_3: BRRI hybrid dhan2, V_4: ACI hybrid2, V_5: Jagoron and V_6: Panna. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. All the rice varieties used in this study were hybrid except BRRI dhan48. Among the varieties, BRRI dhan48, BRRI hybrid dhan1 and BRRI hybrid dhan2 were released by BRRI, Joydebpur, Dhaka. The introduced Chinese varieties, ACI hybrid2, Jagoron and Panna1 were imported and marketed by ACI Ltd., Bangladesh. Seeds of these varieties were collected from respective organizations.

Healthy seeds were selected by specific gravity method and then immersed in water bucket for 24 hours and then they were kept tightly in gunny bags. The seeds started sprouting after about 48 hours and were sown after 72 hours. Seeds of the selected cultivars were sown separately in well prepared 2m × 1m sized wet seedbed for each cultivar on march 10, 2013. Recommended doses of fertilizers and manures were applied during seedbed preparation.

The selected plot was ploughed with a power tiller for sun-dry in April 6, 2013 and left for a week. After one week the land was irrigated, harrowed, ploughed and cross-ploughed several times followed by laddering to obtain desirable tilth of soil for transplanting seedlings. After removal of weeds and stubbles the plot was partitioned into unit plots in accordance with the experimental design. The fertilizers N, P, K, S, Zn and B were applied in the form of urea, Triple Super Phosphate (TSP), Muriate of Potash (MOP), gypsum, zinc sulphate and borax, respectively. The entire amount of TSP, MOP, gypsum, zinc sulphate and borax were applied during the final preparation of plot land. Recommended dose of Furadan 57 EC and decomposed cowdung @ 10 t ha^{-1} were applied during land preparation. Urea was applied in two equal installments at tillering and before panicle initiation. The rice seedlings were uprooted on April 09, 2013.The nursery bed was irrigated a day before uprooting of the seedlings to minimize mechanical injury of roots. Seedlings were transplanted in main plots laving 30cm × 25cm spacing between line to line and plant to plant in April 10, 2013.Two healthy seedlings were transplanted in each hill.

After establishment of seedlings, various intercultural operations were accomplished for better growth and development of the rice seedlings. Gap filling was executed for all of the plots at 10 days after transplanting (DAT) by planting same aged seedlings. In the early stage of growth flood irrigation was provided to maintain a constant level of standing water up to 6 cm to enhance tillering and 10-12 cm in the later stage to depress late tillering. The newly emerged weeds were uprooted carefully at tillering stage and before panicle initiation. The field was finally dried out 15 days before harvesting.

The rice was harvested manually from each plot depending upon the maturity. The harvested crop of each pot was bundled separately, properly tagged and brought to threshing floor. The threshing and cleaning of rice seed were conducted with great care. Plot wise fresh weight of grain and straw were recorded. Finally the weight of grains was adjusted to a moisture content of 14%. The straw was sun dried and the yields of grain and straw plot^{-1} were recorded.

Data Collection: Field data for plant height, tiller hill^{-1}, leaf area index, stem dry matter, tiller hill^{-1}, leaves dry matter hill^{-1}, stem dry matter hill^{-1}, total dry matter hill^{-1} were collected at 30, 45, 60 and 75 days after transplanting (DAT).The height of plant at harvest was also recorded. The height was measured from the ground level to the tip of the sample plants. The number of tillers hill^{-1} was recorded from each plot by counting total tillers of five random hills and average value was recorded. The leaf area index was measured manually from five randomly selected plants of inner rows of each plot. The final data calculated multiplying by a correction factor 0.75[12]. For stem and leaves dry matter hill^{-1}, three hills was randomly collected from inner rows of each plot. Collected hills were oven dried at 70°C for 72 hours then transferred into desiccator to cool down at room temperature. The desiccated stems and leaves were separated, weighted with electric balance as well as mean values hill^{-1} recorded. Total dry matter hill^{-1} was recorded by adding values of stem dry matter hill^{-1} and leaves dry matters hill^{-1}. Rice grains obtained from harvested area of plot were sun-dried and adjusted to 14% moisture content using a digital moisture meter. Then dried grains of each harvested area were measured carefully with electric balance and measured values were converted to t ha^{-1}. Rice straw of obtained from each unit plot were sun-dried and weighed carefully. The sub-samples of the straw of each plot were oven dried, weighted and finally converted to t ha^{-1}. Grain yield and straw yield together were regarded as biological yield. Harvest index was calculated from the grain and straw yield of rice for each plot and expressed in percentage.

$$Harvest\ Index,\ HI(\%) = \frac{Grain\ yield}{Biological\ yield} \times 100$$

Statistical Analysis: The data obtained were statistically analyzed using MSTAT software to observe the significant difference among the different rice varieties. The mean values of all the characters were calculated and factorial analysis of variance was performed. The significance of the difference among the treatment means was estimated by the Least Significant Difference Test (LSD) test at 5% level of probability [16].

RESULTS AND DISCUSSIONS

Plant Height: A statistically significant variation was observed in plant height of the hybrid rice varieties at different DAT (Table 1). At 30, 45, 60, 75 DAT and harvest, the tallest plant (35.87, 50.40, 76.50, 95.77 and 139.97 cm, respectively) was recorded from ACI hybrid2 which was statistically similar (35.00, 49.03, 76.20, 92.97 and 110.40 cm, respectively) with the height of Jagoron, whereas the shortest plant (29.33, 41.73, 69.03, 82.57 and 102.93 cm, respectively) was found in BRRI dhan48. Plant height varies differentially on the basis of their varietal characters and improved varieties are the first and foremost requirement for initiation and accelerated production program. Growth of rice is strongly influenced by genotype as well as environmental factors [8].

Tillers Hill^{-1}: Statistically significant variation was recorded in terms of tillers hill^{-1} due to different rice variety at 30, 45, 60 and 75 DAT (Figure 1). At 30, 45, 60 and 75 DAT, the maximum tillers hill^{-1} (5.67, 8.80, 15.70 and 16.80, respectively) was recorded from ACI hybrid2 which was similar with Jagoron. On the other hand, the minimum tillers hill^{-1} (4.07, 6.27, 9.57 and 12.03, at 30, 45, 60 and 75 DAT respectively) was observed from BRRI dhan48 which was statistically similar with BRRI hybrid dhan2 and BRRI hybrid dhan1.

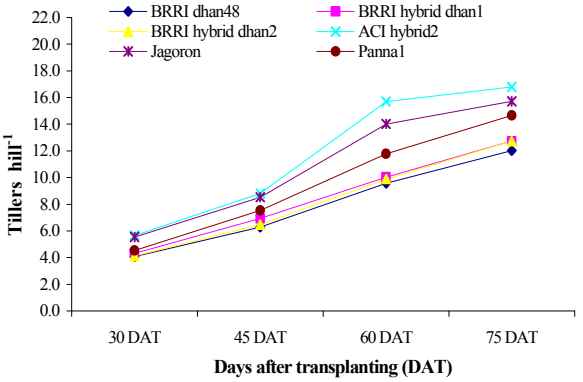

Fig. 1: Effect of rice varieties in tillers production of tiller hill^{-1}at different DAT.

Table 1: Plant height at different DAT and harvest of some selected rice varieties.

	Plant height (cm)				
Rice varieties	30 DAT	45 DAT	60 DAT	75 DAT	Harvest
BRRI dhan48	29.33 b	41.73 b	69.03 c	82.57 c	102.93 b
BRRI hybrid dhan1	30.30 b	43.30 b	70.20 bc	88.53 abc	106.77 b
BRRI hybrid dhan2	29.43 b	42.57 b	69.07 c	86.03 bc	106.30 b
ACI hybrid2	35.87 a	50.40 a	76.50 a	95.77 a	139.97 a
Jagoron	35.00 a	49.03 a	76.20 a	92.97 ab	110.40 b
Panna1	31.00 b	45.47 ab	73.30 ab	89.90 abc	105.50 b
$LSD_{(0.05)}$	3.675	5.426	3.733	8.066	9.764
Level of significance	0.01	0.05	0.01	0.05	0.01
CV (%)	6.35	6.57	4.84	4.97	4.79

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability.

Table 2: Leaf area index at different DAT of some selected rice varieties.

	Leaf area index			
Rice varieties	30 DAT	45 DAT	60 DAT	75 DAT
BRRI dhan48	0.202 c	0.836 c	2.64 c	5.13 b
BRRI hybrid dhan1	0.222 b	0.955 bc	3.11 abc	5.12 b
BRRI hybrid dhan2	0.204 c	0.922 bc	2.96 bc	5.03 b
ACI hybrid2	0.254 a	1.188 a	3.64 a	5.91 a
Jagoron	0.243 ab	1.067 ab	3.44 ab	5.68 ab
Panna1	0.232 b	1.024 ab	3.15 abc	5.60 ab
$LSD_{(0.05)}$	0.058	0.163	0.592	0.721
Level of significance	0.05	0.01	0.05	0.05
CV (%)	12.27	8.88	10.29	7.32

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability.

Leaf Area Index: Leaf area index of different rice varieties varied significantly at 30, 45, 60 and 75 DAT. The leaf area index of ACI hybrid2 (0.25, 1.18, 3.64 and 5.91 at 30, 45, 60 and 75 DAT respectively) was significantly higher and statistically similar with Jagoron at same DAT. The lowest leaf area index (0.20, 0.83, 2.64 and 5.13 at 30, 45, 60 and 75 DAT respectively) was found in BRRI dhan48 which was statistically similar with BRRI hybrid dhan2 (Table 2).

Stem and Leaves Dry Matter Hill^{-1}: Significant variation was observed in terms of stem and leaves dry matter hill^{-1}at different DAT of the rice varieties studied (Table 3). At 30, 45, 60 and 75 DAT, the highest stem dry matter hill^{-1} (2.63, 3.79, 6.16 and 5.85g, respectively) was recorded from ACI hybrid2 which was statistically similar with Jagoron. The lowest stem dry matter hill^{-1} (1.98, 2.98, 4.53 and 4.37 g at 30, 45, 60 and 75 DAT respectively) was observed from BRRI dhan48 which was statistically similar with BRRI hybrid dhan2 and BRRI hybrid dhan1. Data revealed that ACI hybrid2 accumulated maximum leaves dry matter hill^{-1} (1.58, 2.83, 5.39 and 5.04 g at 30, 45, 60 and 75 DAT, respectively) and statistically similar with Jagoron at same days after transplanting. On the other hand, BRRI dhan48 and BRRI hybrid dhan2 accumulated the lowest and statistically insignificant amount of leaves dry matter hill^{-1} at 30, 45, 60 and 75 DAT (Table 3).

Total Dry Matter Hill^{-1}: Rice varieties showed significant variation in total dry matter hill^{-1}under the present trial. At 30, 45, 60 and 75 DAT, the highest total dry matter hill^{-1} (4.21, 6.62, 11.55 and 10.89 g, respectively) was observed in ACI hybrid2 which was statistically similar with Jagoron but varied with other varieties. The lowest total dry matter hill^{-1} (3.21, 5.14, 8.653 and 8.43 g at 30, 45, 60 and 75 DAT respectively) was found in BRRI dhan48 which was statistically similar with BRRI hybrid dhan2 at same data recording date (Table 4). Amin et al. (2006) reported that traditional varieties accumulated higher amount of vegetative dry matter than the modern variety [17].

Table 3: Stem dry matter hill^{-1} at different DAT and at harvest of some selected hybrid rice varieties.\

	Stem dry matter hill^{-1} (g)				Leaves dry matter hill^{-1} (g)			
Rice varieties	30 DAT	45 DAT	60 DAT	75 DAT	30 DAT	45 DAT	60 DAT	75 DAT
BRRI dhan48	1.98 c	2.98 c	4.53 c	4.37 c	1.23 c	2.17 c	4.12 b	4.06 c
BRRI hybrid dhan1	2.12 bc	3.33 abc	5.51 ab	5.40 ab	1.45 ab	2.59 ab	4.19 b	4.07 c
BRRI hybrid dhan2	2.08 c	3.28 bc	5.07 bc	5.02 bc	1.39 abc	2.49 b	4.27 b	4.24 bc
ACI hybrid2	2.63 a	3.79 a	6.16 a	5.85 a	1.58 a	2.83 a	5.39 a	5.04 a
Jagoron	2.46 ab	3.47 ab	5.82 a	5.58 ab	1.56 ab	2.70 ab	4.75 ab	4.63 ab
Panna1	2.15 bc	3.36 abc	5.60 ab	5.22 b	1.37 bc	2.43 bc	4.61 ab	4.38 bc
$LSD_{(0.05)}$	0.257	0.438	0.630	0.521	0.191	0.304	0.787	0.386
Level of significance	0.01	0.05	0.01	0.01	0.05	0.01	0.05	0.01
CV(%)	6.32	7.16	6.36	6.67	7.40	6.63	9.52	6.20

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability.

Table 4: Total dry matter hill^{-1} at different DAT and at harvest of some selected hybrid rice varieties.

	Total dry matter hill^{-1} (g)			
Rice varieties	30 DAT	45 DAT	60 DAT	75 DAT
BRRI dhan48	3.21 c	5.14 c	8.65 c	8.43 c
BRRI hybrid dhan1	3.57 bc	5.92 ab	9.61 bc	9.47 b
BRRI hybrid dhan2	3.47 c	5.77 bc	9.34 bc	9.26 bc
ACI hybrid2	4.21 a	6.62 a	11.55 a	10.89 a
Jagoron	3.92 ab	6.17 ab	10.56 ab	10.21 ab
Panna1	3.52 c	5.80 bc	10.20 b	9.60 bc
$LSD_{(0.05)}$	0.382	0.700	1.258	0.840
Level of significance	0.01	0.01	0.01	0.01
CV(%)	5.78	6.53	6.92	5.97

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability.

Table 5: Effect of rice varieties on grain yield, straw yield, biological yield and harvest index.

Rice varieties	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological Yield (t ha^{-1})	Harvest index (%)
BRRI dhan48	2.51 b	3.87 b	6.38 b	39.34 b
BRRI hybrid dhan1	2.66 b	4.11 a	6.77 b	39.29b
BRRI hybrid dhan2	2.75 b	4.05 a	6.80 b	40.44ab
ACI hybrid2	3.05 a	4.20 a	7.25 a	42.07 a
Jagoron	2.97 a	4.15 a	7.12 a	41.71 a
Panna1	2.82 a	4.02 a	6.84 a	41.23 a
$LSD_{(0.05)}$	0.281	0.182	0.486	1.478
Level of significance	0.05	0.05	0.05	0.05
CV(%)	4.61	5.12	4.04	5.11

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability.

Grain Yield: Rice varieties of the current study showed significant variation in grain yield (Table 5). The highest grain yield (3.05 t ha^{-1}) was obtained from ACI hybrid2 which was statistically similar with Jagoron (2.97 t ha^{-1}) and Panna1 (2.82 t ha^{-1}). The lowest grain yield (2.51 t ha^{-1}) was observed in BRRI dhan48 which was statistically identical with BARI hybrid dhan1 and BARI hybrid dhan2.Grain yield is a polygenic character and greatly influenced by environmental factors. Varieties play an important role in producing high yield of hybrid rice. International Rice Research Institute (IRRI) started super rice breeding program to give up to 30% more rice yield

(13 to 15 t ha^{-1}) than the current modern high yielding plant types [18]. In 2004, Akbar reported that available hybrid rice varieties of Bangladesh have more yield potential than conventional high yielding varieties [11]. Wang et al. (2006) reported that compared with conventional cultivars, the hybrids had larger panicles, heavier seeds, resulting in an average yield increase of 7.27% [13]. Varietal influence of rice on grain yield was also reported [19].

Straw Yield, Biological Yield and Harvest Index: The test varieties of rice varied significantly in straw yield, biological yield and harvest index (Table 5).The highest straw yield (4.20 t ha^{-1}) was observed in ACI hybrid2 which was statistically similar with BRRI hybrid dhan1, BRRI hybrid dhan2, Jagoron and Panna1but varied significantly with BRRI dhan48. The highest biological yield (7.25 t ha^{-1}) was found from ACI hybrid2 which was statistically similar and with Jagoron (7.12 t ha^{-1}) and Panna1 (6.84 t ha^{-1}). The lowest biological yield (6.38 t ha^{-1}) was found from BRRI dhan48 which was statistically identical with BRRI hybrid dhan1. The highest harvest index (42.07%) was recorded from ACI hybrid2 which was statistically similar with Jagoron and Panna1 whereas the lowest harvest index (39.34%) was obtained from BRRI dhan48 and was statistically similar with BRRI hybrid dhan1 and BRRi hybrid dhan2. Patel (2000) reported that mean yield increased with Kranti over IR36 was 10.0% for straw yield [20].

CONCLUTIONS

ACI hybrid2 produced the tallest plant, the maximum number of tillers hill^{-1} the highest leaf area index, the highest stem dry matter hill^{-1}, the highest leave dry matter hill^{-1}and the highest total dry matter hill^{-1}, which was statistically significant over check variety, BRRI dhan48 as well as BRRI hybrid dhan1 and BRRI hybrid dhan2 but statistically similar with hybrid rice Jagoron and Panna1. The highest grain yield (3.05 t ha^{-1}) was obtained from ACI hybrid2 which was statistically similar with Jagoron and Panna1. The lowest grain yield (2.51 t ha^{-1}) was obtained from BRRI dhan48. The highest straw yield (4.20 t ha^{-1}) was observed from ACI hybrid2 whereas the straw yield (3.87 t ha^{-1}) was lowestin BRRI dhan48. The highest biological yield (7.25 t ha^{-1}) was found in ACI hybrid2, while the lowest biological yield (6.38 t ha^{-1}) in BRRI dhan48. The highest harvest index (42.07%) was recorded from ACI hybrid2, whereas the lowest (39.34%) was from BRRI dhan48.In term of grain yield, straw yield, biological yield and harvest index the ACI hybrid2, Jagoron and Panna1 were statistically indifferent. However, vegetative and yield performance of all five test hybrid varieties were superior over the inbreed variety BRRI dhan48. Above findings revealed that the ACI hybrid2 was superior compared to other varieties in term of growth parameters and yield of rice followed by hybrid rice variety Jagoron.

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