Original Research Article

Agronomic Performance of Local and High Yielding Varieties of Boro Rice Under Different Age of Seedlings

ABSTRACT

A field experiment was carried out during the period from November 2012 to June 2013 under Agroecological Zone 20 (Eastern Surma- Kushiyara Floodplain) to observe the performance of variety and seedling age on the growth, yield and economic performances of high yielding and local varieties of boro rice. Four varieties viz. BRRI dhan28, BRRI dhan29, Khoiaboro and Begunbichi, and three seedling ages viz. 15, 20 and 25 day-old were included as treatments in the experiment. The experiment was laid out in a factorial RCBD (Randomized Complete Block Design) with three replications. The results revealed that BRRI dhan29 produced significantly highest grain yield (6.25 t ha^{-1}) attributed by the higher number of effective tiller $hill^{-1}$, grain $panicle^{-1}$ and 1000-grain weight. BRRI dhan28 produced the second highest grain yield (5.37 t ha^{-1}) while the local variety Begunbichi produced the lowest grain yield (2.26 t ha^{-1}) in spite of its highest number of grain $panicle^{-1}$ because of its small sized grain. Total number of spikelet $panicle^{-1}$, number of grain $panicle^{-1}$, unfilled spikelet $panicle^{-1}$, grain and straw yield varied significantly but other characters did not among different ages of seedlings. The highest grain yield of 4.49 t ha^{-1} was obtained from 25 day-old seedling ascribed to higher number grain $panicle^{-1}$. Grain yield of 4.23 t ha^{-1} was produced by 20 day-old seedling which was statistically similar to that of 25 and 15 day-old seedlings. Interaction of variety and seedling age produced significant effect on most of the characters except plant height, number of non-effective tiller $hill^{-1}$, length of panicle and grain yield. Cost and return analysis showed that BRRI dhan29 gave maximum gross, net returns and BCR of Tk. 128360.00 ha^{-1}, Tk. 51102.00 ha^{-1} and 1.66, respectively with 25 day-old seedling. Local variety Begunbichi showed more profitability than BRRI dhan28 and Khoiaboro rice varieties.

Key words: Boro rice, Variety, Seedling age, Yield

1. INTRODUCTION

Rice is the staple food of about 149.69 million people of Bangladesh. About 75% of the total cropped area and more than 80% of the total irrigated area is planted to rice (Hossain and Deb, 2003). Almost all of the 13 million farm families grow rice in Bangladesh. It provides nearly 40% of national employment (48% of rural employment), about 70-76% of total calorie supply and 66% of protein intakes of an

average person in the country (Hossain and Deb, 2003; Dey *et al.*, 1996). Rice sector contributes one-half of the agricultural GDP and one-sixth of the national income in Bangladesh (Hossain *et al.,* 1989). Thus, rice plays a vital role in the livelihood of the Bangladeshi people. Rice production needs to be increased more as the population of Bangladesh is still growing by two million in every year and may increase by another 30 million over the next 20 years. There are less possibilities of bringing more lands under cultivation of rice; much of the additional rice requirement will have to be met by increasing the average yield from the existing land. Although rice is grown on large area in Bangladesh but its average yield is still far below the levels attained in other rice producing countries in spite of having many high yielding varieties. The average yield is about 2.74 t/ha as compared to Japan 5.93 t/ha and Korea 6.12 t/ha (IRRI, 1997). To combat the situation it will require adoption of modern technologies such as high management package, high yielding cultivars of both inbred and hybrid, and higher input use (Wang *et al.*, 2002). There are several reasons behind this but one of the most important reasons is that the seedling age is not managed properly to get vigorous seedlings for uniform stand and better bush establishment. Among the various factors that influence rice productivity, seedling age is rated high because it has tremendous effect on plant height, tiller production, panicle length, grain formation and other grain yield contributing characters (Ali *et al.*, 1995). Younger seedlings may not be able to withstand transplanting shock when shifted to main field whereas too old seedlings may not be able to produce its yield potential to the peak. Transplanting seedling in proper age in the main field can provide appropriate ground for achieving potential production by reducing the death of bushes of seedlings. When the seedling age goes beyond 35 days, it will reduce the yield (Khusrul and Haque, 2009). Chopra *et al. (*2002) evaluated the yield and quality of seeds of the rice cv. Pusa 44 by transplanting seedling ages of 25, 35, 45, 55, and 65 days. They found that 35-day old seedlings had greater number of panicles per hill, panicle length, 1000-seed weight, test weight, and seed yield than 55 to 65-day old seedlings. Farmers transplant seedlings at different ages but most often with 25 to 50 day-older in lowland rice (De Datta, 1981; Wagh *et al.,* 1988; Singh and Singh, 1999). Many researchers reported that grain yield increased by transplanting younger seedlings of 25 days (Singh and Singh, 1998; Ashraf *et al*., 1999; Nandini and Singh, 2000; Thanunathan and Sivasubramanian, 2002). On the other hand some studies exposed that grain yield was not affected by transplanting 30-60 day-old seedlings (Chandra and Manna, 1988). Recent studies on the System of Rice Intensification (SRI) also showed that yield and yield components of rice might be increased by transplanting seedlings as younger as 14 days as compared to older seedlings of 21-23 days (Makarim *et*

al., 2002). McHugh (2002) also observed in Madagascar that 8 to 15 day-old seedlings transplanted at 25 hills m^2 produced the highest yields. Bangladesh Rice Research Institute (BRRI) has recommended seedling age of rice for transplantation according to growing season. BRRI (1991; 1992) recommended 20-30 day-old seedling for Aus season, 20-35 day-old for T. Aman season and 40-45 day-old for Boro season. It is generally seen that Researchers' recommendations are not following by farmers (Hossain *et al*., 1989) and it has been reported that farmers' even use 80 day-old seedlings for transplanting Boro rice (Hossain *et al*., 1983). In Bangladesh, younger seedlings transplantation in boro season is very difficult and it is labour intensive because of stunted growth of seedlings due to cold weather. To avoid the situation older seedlings with optimum growth need to be transplanted. It was reported that paddy yield was decreased significantly after transplanting of younger seedlings due to its higher mortality rate in the main field while transplanting of older seedlings resulted in better performance (Kewat *et al.,* 2002). In most of the above citations transplantation of different ages of HYVs/modern varieties have showed variation in their performances in respect of yield but local boro rice varieties were mostly ignored to see their performances especially in the greater Sylhet region. In the present study some widely used local boro rice varieties along with HYVs included to find out their performances with different ages of seedling in transplanted condition. The major objectives of the study were to know the effect of seedling age on the growth and yield performance of High Yielding and Local Varieties of boro rice in Sylhet region.

2. MATERIALS AND METHODS

The experiment was conducted during the period from November 2012 to May 2013 at a farmer's field located at village Patnipara, Chicknagul union under Jointapur upazila of Sylhet district 18 km far North-East from Sylhet Agricultural University, Sylhet. Geographically the location is situated at 23° to $25^0 1^/$ North and $90^0 57^/$ to $92^0 28^/$ East longitude and latitude, respectively with an elevation of 34 m above the mean sea level. The experimental field had fairly leveled topography, medium low land and good drainage system and soil was silty clay loam under the Agroecological Zone 20 (AEZ 20). The land of the experimental plot was silty clay loams in texture and pH of the soil was about 5.5-6.5. Organic matter content of the soil was moderate. Levels of CEC and Zn was medium while the status of P, K and B was low. Sylhet has a tropical climate and in most months of the year, there is significant and heavy rainfall as the monsoon clouds blow on the area in summer in Sylhet. This area is much cooler and hotter than the other parts of Bangladesh. June and July receive the highest amount of rainfall.

Monthly maximum and minimum temperature, rainfall and humidity during the crop growing period have been presented in Table 1.

Table 1. Monthly average rainfall, minimum and maximum temperatures and relative humidity during the study period from November 2012-June 2013

Month	Year	Rainfall (mm)	Air Temperature (^{0}C)			Relative Humidity (%)
			Maximum	Minimum	Average	
November	2012	11.9	29.2	18.9	24.1	68
December	2012	Nil	25.0	14.5	19.8	75
January	2013	Nil	25.6	11.8	18.7	63
February	2013	2.3	31.2	15.9	23.6	49
March	2013	1.9	36.2	19.7	27.8	47
April	2013	13.9	33.0	21.9	27.5	59
May	2013	34.2	30.4	22.7	26.6	78
June	2013	26.9	33.9	25.8	29.9	75

Source: Department of Meteorology, Sylhet

The treatments included in the experiment were as follows.

Factor A. Variety: 4

i. BRRI dhan28 (HYV) (V_1)
ii. BRRI dhan29 (HYV) (V_2)
iii. Khoiaboro (Local) (V_3)
iv. Begunbichi (Local aromatic) (V_4)

Four varieties of rice mentioned above were denoted as V_1, V_2, V_3 and V_4, respectively.

Factor B. Seedling age: 3

i. 15 day-old seedlings (A_1)
ii. 20 day-old seedlings (A_2)
iii. 25 day-old seedlings (A_3)

The experiment was laid out following Randomized Complete Block Design (Factorial). The unit plot size was 3 m x 2 m. Seed was used @ 10 kg/ha having germination percentage of 93%, 95%, 92% and 95% for BRRI dhan28, BRRI dhan29, Khoiaboro and Begunbichi, respectively. Pregerminated seeds of all varieties were sown in nursery beds on 23 November 2012 (for 25 day-old seedling), 28 November 2012 (for 20 day-old seedling) and 03 December 2012 (for 15 day-old seedling). Frequent irrigation through hand watering jar was given to maintain enough moisture content in the seed bed. Main field

was prepared by power tiller on 1 December 2012 with a power tiller i.e. 15 days before transplanting. Organic manures and inorganic fertilizers were applied in the field. The source of organic manures was cowdung and applied @ 10 t ha^{-1} as basal application 10 days before final land preparation. Urea, Triple Super Phosphate, Muriate of Potash, Gypsum and Zinc Sulphate were applied according to recommended dose (BRRI, 2011). The fertilizers were applied @ 138-20-60-20-4 kg ha^{-1} NPKS & Zn for the variety of BRRI dhan29 and 121-20-60-20-4 kg ha^{-1} NPKS & Zn for BRRI dhan28. For Khoiaboro and Begunbichi fertilizers were applied @ 52-15-15 kg ha^{-1} NPK respectively and cowdung was applied @ 5 t ha^{-1} as basal application. Urea was applied into three installments- $1/3^{rd}$ at final land preparation, $1/3^{rd}$ at 21 DAT (tillering stage) and $1/3^{rd}$ at 36 DAT (active tillering stage) in each plot. The nursery beds were made wet by application of water both in morning and evening on the previous day of uprooting the seedlings. Seedlings were uprooted carefully so that minimum damage was done in the root system and uprooted seedlings kept in shade before transplanting. The methods were followed for each case of uprooting and transplanting for different ages of seedling. The seedlings uprooted from the nursery bed were transplanted on the same day. Seedlings of 15, 20 and 25 days-old seedlings were transplanted on the well puddled experimental plots on 16 December 2012. Single seedling per hill was transplanted in a square pattern having 25 cm × 25 cm spacing. During transplanting of seedling the plot was saturated with sufficient water but not standing. Seedlings in some hills died off and those were replaced by gap filling to maintain the desired plant population in the experimental plots within 10 days of transplanting with the respective seedling age from the same source. The first manual weeding was done at 21 DAT after which first top dress of urea was done. Second top dress of urea was done after second weeding at 36 DAT for each crop. At both weeding and top dressing sufficient moisture was ensured in each plot. Water management was done properly following flood irrigation method with the help of shallow tubewell from surface water. After transplanting 3-4 cm water depth was maintained throughout the life cycle of the crop but removed 10 days before maturity. For controlling insect-pest granular insecticide Carbofuran 5G (Furadan) was applied @ 16 kg ha^{-1} by maintaining 4-5 cm water depth in the crop field at maximum tillering stage. Crop maturity was determined when 80% grain of all panicles in a plot turned into golden yellow in colour except Khoiaboro. Grain colour of khoiaboro rice was blackish yellow. At this stage culm and leaves were also turn into yellow colour. At maturity ten random hills were sampled for collection of data on yield and yield attributes. BRRI dhan28 was harvested on 12, 19, 25 April 2013 respectively for the seedling age of 25 day-old, 20 day-old and 15 day-old seedling, respectively. BRRI dhan29 was harvested on 2, 9 and 15 May 2013 April, respectively

of the seedling age of 25 day-old, 20 day-old and 15 day -old seedling. Khoiaboro was harvested on 12, 16 and 18 April 2013, respectively of the seedling age of 25 day-old, 20 day-old and 15 day-old seedling and Begunbichi was harvested on 12, 20 and 24 April 2013, respectively of the seedling age of 25 day-old, 20 day-old and 15 day-old seedling. First of all, border row from each side were harvested and these were excluded from final threshing. Remaining net plot area was harvested manually at ground level using sickle and kept separately for recording crop yield plot wise. Then grains were separated from each bundle by beating with bamboo sticks and grains were dried in the sun. Then moisture was recorded with moisture meter (GMK-303RS) and grain weight of individual plot was adjusted at 12% moisture content. After thorough sun drying straw weight was recorded separately. Finally, grain and straw weights in kg/plot of the individual plot were converted into t ha^{-1}. Data were collected on the growth, yield and yield attributes as follows.

i. Number of tiller $plant^{-1}$ at every 10-day intervals
ii. Days to 80% flowering (when at least 80% tillers had panicle in each plot).
iii. Plant height at harvest
iv. Number of effective tiller $hill^{-1}$
v. Number of non-effective tiller $hill^{-1}$
vi. Number of panicle $hill^{-1}$
vii. Length of panicle
viii. Number of filled grain $panicle^{-1}$
ix. Number of unfilled grain $panicle^{-1}$
x. 1000 grain weight
xi. Percentage of filled spikelet
xii. Grain weight $plot^{-1}$
xiii. Straw weight $plot^{-1}$
xiv. Harvest index

Number of total tillers was counted from the selected five hills at every 10 day intervals. Tiller was counted by spreading the base of each standing hill so that small tiller may not be left out. Number of tillers counted in each date from five hills was averaged for individual plot and this data were statistically analyzed.

Harvest index (HI) was worked out on the basis of grain and straw yields using the following formula and expressed in percentage (Gardner *et al*., 1985).

$$\text{Harvest index} = \frac{\text{Grain yield}}{\text{Biological yield}} \text{x} 100$$

Where Biological Yield= Grain yield + Straw yield

Statistical analysis

The collected data were properly tabulated and these were analyzed by using computer software MSTATC. Means separations were done at 5% level of significance by Least Significant Difference (LSD) Test wherever F values were significant at either 0.01% or 0.05% level of probability.

3. RESULTS AND DISCUSSION

Number of tiller hill^{-1} at 10-day intervals

Individual effect of variety and age of seedling have not discussed here as interaction effect of variety and age of seedling was found significant for number of tiller hill^{-1} at 10-day intervals at most of the time. Interaction effect of variety and seedling age was found non-significant for number of tiller hill^{-1} at 40 DAT but at 50 DAT (Figure 1). The highest number of tiller (14.00 hill^{-1}) was recorded from the combination V_2A_3 and the lowest (1.89 hill^{-1}) was obtained from the combination V_3A_1 at 50 DAT. The result indicated that the highest number of tiller (25.66 hill^{-1}) was found in the combination V_2A_3 which was statistically similar to that of V_2A_2 (23.67 hill^{-1}) and the lowest (6.88 hill^{-1}) was found in the combination V_3A_1 at 60 DAT. Number of tiller hill^{-1} was significantly affected by the interaction of variety and seedling age at 70 DAT. The maximum number of tiller (33.67 hill^{-1}) was recorded from the combination V_1A_3 which was statistically similar to that of V_2A_2 (29.78 hill^{-1}) and V_2A_3 (32.22 hill^{-1}). The minimum number of tiller (14.56 hill^{-1}) was obtained from the combination V_4A_1 which was statistically similar to that of V_2A_1 (16.65 hil^{-1}) and V_3A_1(17.33 hill^{-1}).

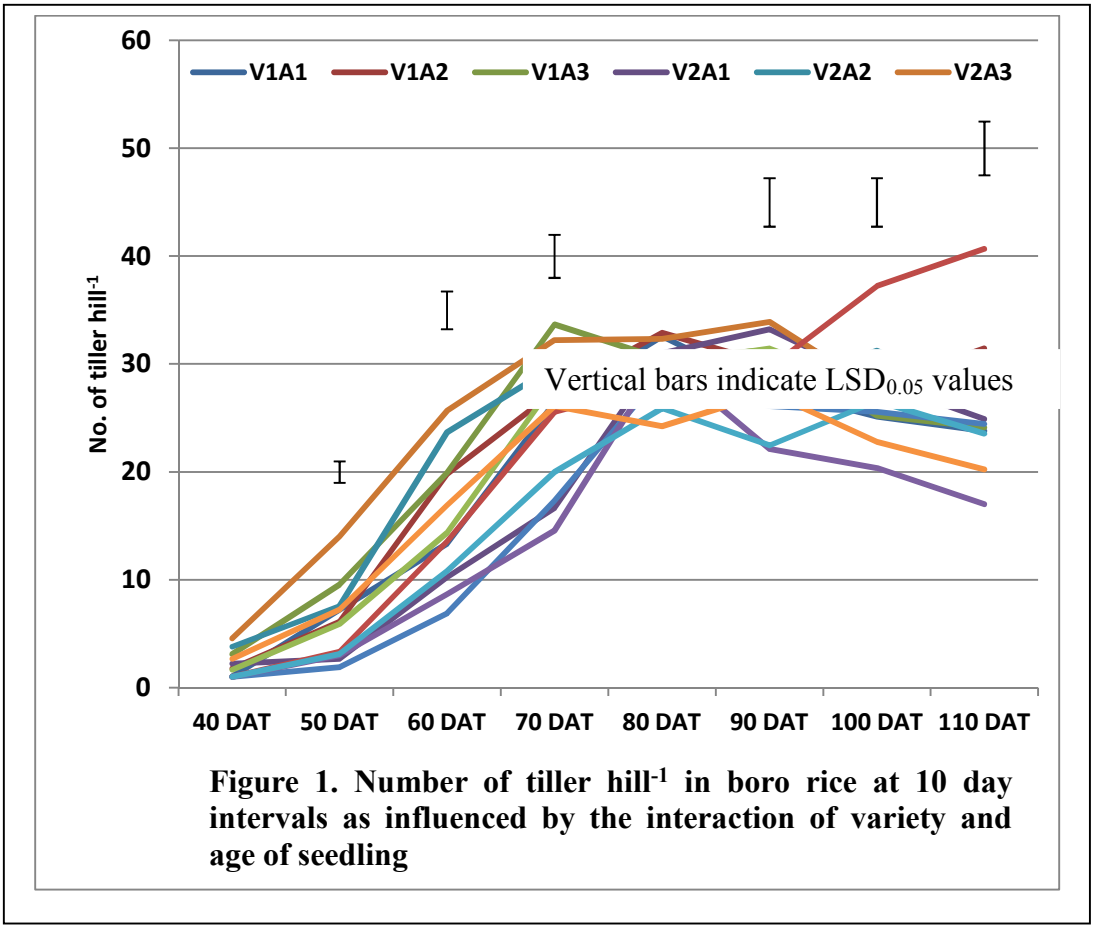

Figure 1. Number of tiller hill^{-1} in boro rice at 10 day intervals as influenced by the interaction of variety and age of seedling

The interaction effect of variety and seedling age was non-significant for number of tiller hill^{-1} at 80 DAT while the same was significant at 90 DAT (Figure 1). The highest number of tiller (33.89 hill^{-1}) was recorded in the combination V_2A_3 which was statistically similar to that of V_2A_1 (33.22 hill^{-1}), V_1A_3 (31.33 hill^{-1}) and V_3A_3 (31.44 hill^{-1}) combinations. On the other hand, the lowest number of tiller (22.11 hill^{-1}) was found in the combination V_4A_1which was statistically identical with V_4A_2 (22.44 hill^{-1}). The result revealed that older seedling produced more number of tiller hill^{-1}. Interaction of variety and seedling age produced significant effect on the number of tiller hill^{-1} at 100 DAT and the results showed that the highest number of tiller (37.22 hill^{-1}) was produced by the combination V_3A_2 while the lowest (20.33 hill^{-1}) was produced by the combination V_4A_1. The highest number of tiller (40.67 hill^{-1}) was obtained due to the treatment combination of V3A2 which was significantly different from the others while the lowest (17.00 hill^{-1}) was obtained in the combination V_4A_1 at 110 DAT.

Phenology, yield components and yield

Performance of variety

Maximum days to 80% flowering (115.0) was recorded from the variety Begunbichi and minimum days to flowering (97.3) was recorded from the variety Khoiaboro (Table 2). Both the varieties BRRI dhan29 and Begunbichi took maximum days for their maturity (141.8 days) while Khoiaboro took the minimum days for maturity (122.0) (Table 2). Plant height was influenced significantly among the varieties irrespective of age of seedling. Result revealed that the local variety Begunbichi produced the tallest plant (154.49 cm) significantly different from the others. Moderate plant height was found in Khoiaboro whilst the shortest plant was found in BRRI dhan29 (96.82 cm) which was statistically similar to BRRI dhan28 (100.33 cm). Both the local varieties produced the taller plant and HYV's produced the shorter might be due to genetically characteristics of the varieties. The results corroborated with that of Shamsuddin *et al*. (1998) who reported plant height varied significantly among the varieties (Table 2). Total number of tiller hill^{-1} included effective and non-effective tillers was significantly differed among the varieties. Maximum number of tiller (27.2 hill^{-1}) was obtained from local Boro rice variety Khoiaboro which was significantly different from the others. Minimum total number of tiller (20.70 hill^{-1}) was found in the local aromatic boro rice Begunbichi. BRRI dhan28 and BRRI dhan29 produced statistically similar total number of tiller (22.3 and 22.7 hill^{-1}, respectively) to the local variety Begunbichi (Table 2). The highest number of effective tiller (22.51 hill^{-1}) was found in the variety Khoiaboro which was significantly different from the others (Table 2). The Begunbichi produced the lowest number of effective tiller (16.41 hill^{-1}) while both the varieties BRRI dhan28 and BRRI dhan29 produced moderate number of effective tiller hill^{-1}. Venugopal and Singh (1985) obtained the highest number of effective tiller in short duration rice variety. There was significant variation among the varieties in respect of number of non-effective tiller hill^{-1}. Both the varieties Khoiaboro and Begunbichi produced statistically having the highest number of non-effective tiller (4.7 and 4.3 hill^{-1}, respectively) in the variety Khoiaboro. The lowest number of non-effective tiller (3.0 hill^{-1}) was found in the variety BRRI dhan29 which was statistically similar to the variety BRRI dhan28. The variety BRRI dhan28 also produced similar number of non-effective tiller hill^{-1} to the varieties Khoiaboro and Begunbichi. Boro rice varieties differed significantly in terms of length of panicle. The varieties BRRI dhan29 and Begunbichi had statistically similar panicle length having the highest value (25.0 cm) in the variety Begunbichi. The variety Khoiaboro had the lowest panicle length (20.0 cm) which was similar to that of the variety BRRI dhan28 (22.2 cm) (Table 3). There was also significant variation in terms of total number of filled and unfilled spikelet panicle^{-1}. The variety Begunbichi produced the highest total

number of spikelet (200.89 panicle^{-1}) while the variety Khoiaboro produced the lowest (87.57 panicle^{-1}). BRRI dhan29 produced the second highest total number of spikelet (177.92 panicle^{-1}) which was significantly different from that of BRRI dhan28 (141.29) (Table 3). Variation was found significant among all varieties in respect of number of grain panicle^{-1}. Significantly highest number of grain (163.92 panicle^{-1}) was found in the variety Begunbichi while the lowest number (69.18 panicle^{-1}) was found in the variety Khoiaboro (Table 3). BRRI dhan29 produced the second highest number of grain (121.09 panicle^{-1}) which was significantly different from BRRI dhan28 and others also.

Table 2. Phenology and yield components of rice varieties during Boro season 2012-2013

Varieties	Days to 80% flowering	Days to maturity	Plant height (cm) at harvest	Total number of tiller hill^{-1}	Number of effective tiller hill^{-1}	Number of non-effective tiller hill^{-1}
V_1	101.7b	126.8b	100.33c	22.14b	18.11b	4.0ab
V_2	114.3a	141.8a	96.82c	21.69b	18.72b	3.0b
V_3	97.3c	122.0c	146.02b	27.20a	22.51a	4.7a
V_4	115.0a	141.8a	154.49a	20.72b	16.41c	4.3a
CV(%)	2.11	1.55	3.73	9.70	8.85	27.54
$LSD_{0.05}$	2.206	2.015	4.542	2.121	1.638	1.077

V_1= BRRI dhan28, V2=BRRI dhan29, V3= Khoiaboro, V_4= Begunbichi

BRRI dhan29 produced significantly highest number of unfilled spikelet (56.8 panicle^{-1}) and the local variety Khoiaboro produced the lowest (18.4 panicle^{-1}) (Table 3). The second highest number of unfilled spikelet of 37.3 panicle^{-1}was found in the variety Begunbichi and it was 32.7 panicle^{-1} in BRRI dhan28.

Table 3. Yield components of boro rice varieties during Boro season 2012-2013

Variety	Length of panicle (cm)	Total number of spikelet panicle^{-1}	Number of grain panicle^{-1}	Number of unfilled spikelet panicle^{-1}	1000 grain weight (g)
V_1	22.2b	141.29c	108.63c	32.69c	22.01a
V_2	24.7a	177.92b	121.09b	56.82a	22.38a
V_3	22.0b	87.57d	69.18d	18.40d	20.81b
V_4	25.0a	200.89a	163.92a	37.30b	12.10c
CV(%)	5.21	3.88	6.53	9.26	4.05
$LSD_{0.05}$	1.197	5.769	7.382	3.287	0.765

V_1= BRRI dhan28, V_2=BRRI dhan29, V_3= Khoiaboro, V_4= Begunbichi

Statistically similar 1000 grain weight was found in both varieties BRRI dhan28 and BRRI dhan29 and having the highest (22.38 g) in BRRI dhan29 (Table 3). The variety Begunbichi gave the lowest 1000 grain weight (12.10 g) which was significantly different from others. Significant variation was also observed among varieties in terms of grain yield. The result showed that the highest grain yield (6.25 t ha^{-1}) was produced in BRRI dhan29. The lowest grain yield (2.26 t ha^{-1}) was obtained in Begunbichi (Table 4). The second highest grain yield (5.37 t ha^{-1}) was obtained from BRRI dhan28. The highest grain yield in BRRI dhan29 was possibly attributed by the higher number of effective tiller $hill^{-1}$ and grain $panicle^{-1}$. In spite of lower number of effective tiller $hill^{-1}$ in BRRI dahn28 than Khoiaboro grain yield was compensated in BRRI dhan28 probably due to its higher number of grain as well as larger grain size. On the contrary, the local variety Begunbichi had the highest number of grain $panicle^{-1}$ but due to its lower number of tiller $hill^{-1}$ and smallest grain size produced the lowest grain yield (Table 4). Variety showed significant variation in respect of straw yield. The variety Khoiaboro produced the highest straw yield (6.86 t ha^{-1}) among the variety irrespective of age of seedling which was statistically similar to that of BRRI dhan29 (6.82 t ha^{-1}) (Table 4). Moderate straw yield (5.71 t ha^{-1}) was found in BRRI dhan28 and the lowest straw yield (4.88 t ha^{-1}) was found in the local variety Begunbichi. Local variety Khoiaboro produced the highest straw yield might be due to its taller plant stature but in spite of taller plant in Begunbichi lowest straw yield was produced might be due to its thin plant stature.

Table 4. Yield and harvest index of boro rice varieties during Boro season 2012-2013

Varieties	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
V_1	5.37b	5.71b	11.08b	48.60a
V_2	6.25a	6.82a	13.07a	47.95a
V_3	2.90c	6.86a	9.77c	30.09b
V_4	2.26d	4.88c	7.14d	31.78b
CV(%)	10.54	8.42	7.06	7.67
$LSD_{0.05}$	0.432	0.499	0.708	2.968

V_1= BRRI dhan28, V_2=BRRI dhan29, V_3= Khoiaboro, V_4= Begunbichi

Variation on biological yield was also found significant among the varieties. BRRI dhan29 gave the highest biological yield (13.07 t ha^{-1}) while the lowest biological yield (7.14 t ha^{-1}) was found in the variety Begunbichi (Table 4). BRRI dhan28 had biological yield of 11.08 t ha^{-1} followed by that of

Khoiaboro (9.77 t ha^{-1}) which was significantly different from each others. Harvest index (HI) was found to be significant among the varieties. The result revealed that variety BRRI dhan28 produced the highest HI (48.67%) and it was identical to that of BRRI dhan29 (47.95%). There were statistically identical harvest indices of 30.09% and 31.78% of the local varieties Khoiaboro and Begunbichi (Table 4). This results indicated that assimilate partitioning is more in the grains of HYV's than local which in turn resulted larger size of seed as well as higher grain yield in HYV's.

Effect of seedling age

Twenty-five day-old seedling took maximum duration for flowering (110.9 days) and 15 day-old seedling took minimum (103.5 days) (Table 5). The results confirmed with the findings of Raju *et al*. (1989) who stated that days to flowering delayed in case of older seedlings. But Padalia (1981) observed that days from sowing to flowering decreased with the increase of seedling age. Twenty-five day-old seedling took maximum duration for maturity (136.4 days) while 15 day-old seedling took minimum (130.3 days) (Table 5). Plant height did not vary significantly by the seedling age. However, plant height ranged from 123.06 cm in 15 day-old seedling to 125.97 cm in 20 day-old seedling (Table 5). Twenty-five day-old seedling produced shorter plant of 124.23 cm than 20 day-old seedling. Similar result has been reported by Murthy *et al.* (1993). Gani *et al*. (2000) reported that younger seedlings produced taller plant than older. Total number of tiller $hill^{-1}$ as well as number of effective tiller $hill^{-1}$ did not vary significantly due to variation of seedling age. The results revealed that number of effective tiller $hill^{-1}$ ranged from 18.14 in 20 day-old seedling to 19.55 in 25 day-old seedling (Table 5). Mannan and Siddique (1991) also observed similar results with 30 to 60 day-old seedlings. On the contrary, Das *et al*. (1988) obtained higher tiller $hill^{-1}$ in younger seedling.

Table 5. Phenology and yield attributes of boro rice as influenced by seedling age during Boro season 2012-2013

Age of seedlings	Days to 80% flowering	Days to maturity	Plant height (cm) at harvest	Total number of tiller $hill^{-1}$	Number of effective tiller $hill^{-1}$	Number of non-effective tiller $hill^{-1}$
A_1	103.5c	130.3c	123.06	23.09	19.13	3.9
A_2	106.8b	132.6b	125.97	22.22	18.14	4.0
A_3	110.9a	136.4a	124.23	23.50	19.55	3.9
CV(%)	2.11	1.55	3.73	9.70	8.85	27.54
$LSD_{0.05}$	1.910	1.745	NS	NS	NS	NS

A_1= 15 day- old seedling, A_2= 20 day-old seedling, A_3= 25 day-old seedling

Number of non-effective tiller hill^{-1} variation was not significant and it was found that number of non-effective tiller was about 4.0 hill^{-1} for different ages of seedling (Table 5).

Table 6. Yield attributes of boro rice as influenced by seedling age during Boro season 2012-2013

Age of seedlings	Length of panicle (cm)	Total number of spikelet panicle^{-1}	Number of grain panicle^{-1}	Number of unfilled spikelet panicle^{-1}	1000 grain weight (g)
A_1	23.6	143.74c	111.8b	32.0c	19.52
A_2	23.3	151.57b	114.8ab	36.8b	19.07
A_3	23.7	160.44a	120.6a	40.1a	19.39
CV(%)	5.21	3.88	6.53	9.26	4.05
LSD $_{0.05}$	NS	4.996	6.393	2.847	NS

A_1= 15 day-old seedling; A_2= 20 day-old seeding; A_3= 25 day-old seedling

Length of panicle did not vary significantly due to variation in the age of seedling in this experiment. Rao and Raju (1987) also recorded similar findings and stated that age of seedling produced no significant effect on panicle length of rice. But Singh *et al*. (2004) concluded that 21 day-old seedling produced higher panicle length than 31, 41 and 51day-old seedlings. A significant variation was found in terms of total number of spikelet panicle^{-1}. The highest number of spikelet (160.4 panicle^{-1}) was obtained from 25 day-old seedling. Fifteen day-old seedling produced the lowest number of spikelet (143.7 panicle^{-1}) (Table 6). The results exhibited that there was significant variation in terms of number of grain panicle^{-1}. The highest number of grain (120.4 panicle^{-1}) was found in the 25 day-old seedling and the lowest number of grain (111.7 panicle^{-1}) was found in the 15 day-old seedling (Table 6). Number of grain of 114.7 panicle^{-1} was produced in 20 day-old seedling. The result did not agree with many other scientists (Hariom *et al.,* 1989; Raju *et al*., 1989; Roy *et al.,* 1992). Twenty-five day-old seedling had significantly highest number of unfilled spikelet (40.1 panilce^{-1}) while 15 day-old seedling produced the lowest (32.0 panicle^{-1}) (Table 6). Reddy and Narayana (1981) observed that spikelet sterility decreased with the increased seedling age. But Gill and Shahi (1987) opined that spikelet sterility increased in the older seedlings. Age of seedling also failed to produce significant variation in respect of 1000 grain weight. It was found that 15, 20 and 25 day-old seedlings gave 19.52, 19.07 and 19.39 g 1000 grain weight, respectively (Table 6). The result did not agree with the findings of Sunder Singh *et al*. (1983) who reported that 1000 grain weight increased significantly with the increase of seedling age. On the contrary, Kamdi *et al.* (1991) reported that 1000 grain weight reduced with transplanting older seedling. Age of seedling showed a significant influence on grain yield. The result showed that grain yield increased with the increase of seedling age (Table 7). Twenty-five day-old

seedlings gave the highest grain yield (4.49 t ha^{-1}) and it was significantly different from other treatments. Twenty day-old seedling produced grain yield of 4.23 t ha^{-1} which was statistically similar to that of both 25 and 15 day-old seedlings. The lowest grain yield of 3.86 t ha^{-1} was obtained from 15 day-old seedlings (Table 7). Higher grain yield in 25 day-old seedling was ascribed to mainly by the higher number of grain panicle^{-1}. Similar result was reported by Teetharappan and Palaniappan (1984) and they stated that 25 day-old seedling gave the highest grain yield of rice. Prasad *et al.* (1992) reported that grain yield increased with the age of seedlings at transplanting up to 35 day-old. Rashid *et al*. (1990) opined that 40 day-old seedlings gave higher grain yield than 20 or 60 day-old seedlings.

Table 7. Yield and harvest index of boro rice as influenced by seedling age during Boro season 2012-2013

Age of seedlings	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
A_1	3.86b	5.25c	9.11c	40.79
A_2	4.23ab	6.19b	10.40b	39.33
A_3	4.49a	6.78a	11.27a	38.70
CV(%)	10.54	8.42	7.06	7.67
$LSD_{0.05}$	0.374	0.435	0.613	NS

A_1= 15 day-old seedling, A_2= 20 day-old seedling, A_3= 25 day-old seedling

The highest straw yield of 6.78 t ha^{-1} was obtained from 25 day-old seedling while the lowest of 5.25 t ha^{-1} was obtained from 15 day-old seedling. The 20 day-old seedlings produced 6.19 t ha^{-1} straw yield which was significantly different from all others (Table 7). The result indicated that 20 day-old seedling had a little bit higher plant height as well as total number of tiller $hill^{-1}$ which attributed to produce more straw yield. The lowest straw yield was obtained from 15 day-old seedling because of little bit lower plant height and tillering capacity than others. Forty day-old seedling produced higher straw yield than those of 20 or 60 day-old seedlings (Rashid *et al*., 1990). Furuk *et al*. (2009) also stated that 2 week-old seedlings gave the lowest straw yield than 4 week-old seedling of rice. Biological yield was significantly influenced by seedling age. The highest biological yield (11.27 t ha^{-1}) was obtained from 25 day-old seedling whilst the lowest biological yield (9.11 t ha^{-1}) was recorded from 15 day-old seedlings. The result clearly indicated that biological yield was increased with increase of seedling age from 15 to 25 day (Table 7). Harvest index (HI) did not influence significantly due to seedling age (Table 7). The highest HI (40.79%) was obtained from 15 day-old seedling. Both 20 and 25 day-old seedlings gave harvest indices of 39.33% and 38.70%, respectively.

Interaction effect of variety and seedling age

The result exhibited that BRRI dhan29 took maximum days for 80% flowering (121.3 days) with 25day-old seedling closely followed by Begunbichi (119.0 days) (Table 8). Khoiaboro took the minimum duration for 80% flowering (91.67 days) at 15 day-old seedling. It was found that the variety BRRI dhan29 took the maximum days for maturity (146.0) closely followed by the variety Begunbichi (145.3) at 25 day-old seedling. The variety Khoiaboro took minimum days (116.7) for its maturity (Table 8). Variations of plant height at harvest, total number of tiller hill-1 and number of non-effetive tiller hill-1 due to the interaction of variety and seedling age were not significant. Interaction of varieties and ages of seedling exerted significant influence on number of effective tiller hill^{-1}. The results revealed that the combination V_3A_3 gave the highest number of effective tiller (25.47 hill^{-1}) while the combination V_4A_2 gave the lowest (15.67 hill^{-1}) (Table 8). The combinations V_1A_3, V_4A_1 and V_4A_3 also produced statistically similar number of effective tiller hill^{-1} to that of V_4A_2. Actually there was no consistent trend in the number of effective tiller hill^{-1} with different ages of seedlings for different varieties.

Table 8. Phenology and yield attributes of boro rice as influenced by the interaction of variety and seedling age during Boro season 2012-2013

Interaction (V x A)	Days to 80% flowering	Days to maturity	Plant height(cm) at harvest	Total number of tiller hill^{-1}	Number of effective tiller hill^{-1}	Number of non-effective tiller hill^{-1}
V_1A_1	101.0d	126.3de	101.43	23.63	19.37 bcd	4.27
V_1A_2	101.3d	125.7de	100.60	22.76	18.77bcde	4.00
V_1A_3	102.7d	128.3d	98.97	20.03	16.20ef	3.83
V_2A_1	111.7c	140.7bc	93.63	22.00	19.27bcd	2.73
V_2A_2	110.0c	138.7c	98.10	20.03	17.07cdef	2.97
V_2A_3	121.3a	146.0a	98.73	23.03	19.83bc	3.20
V_3A_1	91.67e	116.7f	142.53	25.50	21.00b	4.50
V_3A_2	99.67d	123.3e	151.30	26.23	21.07b	5.17
V_3A_3	100.7d	126.0de	144.23	29.86	25.47a	4.40
V_4A_1	109.7c	137.3c	154.63	21.23	16.87def	4. 37
V_4A_2	116.3b	142.7ab	153.87	19.86	15.67f	4. 20
V_4A_3	119.0ab	145.3a	154.97	21.06	16.70def	4. 37
CV(%)	2.11	1.55	3. 73	9.70	8.85	27. 54
$LSD_{0.05}$	3.821	3.491	NS	NS	2.837	NS

Note: V_1= BRRI dhan28, V_2=BRRI dhan29, V_3= Khoiaboro, V_4= Begunbichi, A_1= 15 day-old seedling, A_2= 20 day-old seedling, A_3= 25 day-old seedling.

Interaction of variety and age of seedling was found non-significant in respect of length of panicle and total number of spikelet panicle^{-1} and number of grain panicle^{-1} also did not vary significantly due to interaction of variety and age of seedling (Table 9). Number of unfilled spikelet panicle^{-1} varied significantly due to the interaction of variety and age of seedling. The results exhibited that the variety V_2 (BRRI dhan29) comparatively higher number of unfilled spikelet panicle^{-1} with significantly highest number of unfilled spikelet panicle^{-1} (62.5) at 25 day-old seedling (Table 9). Variety V_3 (Khoiaboro) produced lowest number of unfilled spikelet panicle^{-1} (11.0) at 15 day-old seedling which was statistically identical to that of 20 day-old seedling (14.6 panicle^{-1}) of the same variety. A moderate number of unfilled spikelet panicle^{-1} was observed in both the varieties V_1 (BRRI dhan28) and V_4 (Begunbichi) with all ages of seedlings.

Table 9. Yield attributes of boro rice as influenced by the interaction of variety and seedling age during Boro season 2012-2013

Interaction (V x A)	Length of panicle (cm)	Total number of spikelet panicle^{-1}	Number of grain panicle^{-1}	Number of unfilled spikelet panicle^{-1}	1000 grain weight (g)
V_1A_1	22.10	136.30f	105.5e	30.9d	22.27
V_1A_2	21.83	148.63e	115.7de	32.87d	22.10
V_1A_3	22.63	138.93ef	104.7e	34.2d	21.67
V_2A_1	25.73	166.70d	113.5de	53.2b	21.97
V_2A_2	23.93	174.93d	120.2cd	54.7b	23.03
V_2A_3	24.57	192.13bc	129.6c	62.5a	22.13
V_3A_1	21.83	86.70h	75.7f	11.0e	21.17
V_3A_2	22.33	66.03i	51.5g	14.6e	20.17
V_3A_3	21.87	109.97g	80.4f	29.6d	21.10
V_4A_1	24.57	185.27c	152.4b	32.9d	12.67
V_4A_2	24.97	216.67a	171.7a	45.0c	10.97
V_4A_3	25.53	200.73b	167.7a	34.0d	12.67
CV(%)	5.21	3.88	6.53	9.26	13.49
$LSD_{0.05}$	NS	9.993	12.79	5.693	0.239

Note: V_1= BRRI dhan28, V_2=BRRI dhan29, V_3= Khoiaboro, V_4= Begunbichi, A_1= 15 day-old seedling, A_2= 20 day-old seedling, A_3= 25 day-old seedling.

The results revealed that interaction of variety and seedling age failed to produce significant effect on 1000 grain weight. The values of 1000 grain weight presented in Table 9 indicated that the varieties V_1, V_2 and V_3 had comparatively larger sized grain (ranged from 20.17 g to 23.03 g) while V_4 had small sized grain (ranged from 10.97 g to 12.67 g). Grain yield was not significantly influenced due to

interaction of variety and seedling age (Table 10). The results indicated that all varieties included in the experiment had a particular age of seedling for producing maximum grain yield.

Table 10. Yield and harvest index of boro rice as influenced by the interaction of variety and seedling age during Boro season 2012-2013

Varieties	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
V_1A_1	5.24	5.50cd	10.74b	49.19
V_1A_2	5.42	5.59cd	11.01b	49.28
V_1A_3	5.44	6.04bc	11.48b	47.33
V_2A_1	5.58	5.63cd	11.20b	49.83
V_2A_2	6.23	7.96a	14.19a	43.78
V_2A_3	6.94	6.88b	13.81a	50.23
V_3A_1	2.66	5.84cd	8.50cd	31.32
V_3A_2	2.98	6.13bc	9.10c	32.70
V_3A_3	3.07	8.62a	11.69b	26.24
V_4A_1	1.97	4.04e	6.01e	32.81
V_4A_2	2.30	5.00d	7.30d	31.54
V_4A_3	2.51	5.59cd	8.10cd	31.00
CV(%)	10.54	8.42	7.67	7.67
LSD $_{0.05}$	NS	0.865	1.227	NS

Note: V_1= BRRI dhan28, V_2=BRRI dhan29, V_3= Khoiaboro, V_4= Begunbichi, A_1= 15 day-old seedling, A_2= 20 day-old seedling, A_3= 25 day-old seedling.

Effect of interaction between variety and seedling age on straw yield was significant. The highest straw yield (8.62 t ha^{-1}) was obtained from the combination V_3A_3. The lowest straw yield (4.04 t ha^{-1}) was recorded from the combination V_4A_1 (Table 10). The combinations V_1A_1, V_1A_2, V_1A_3, V_2A_1, V_3A_1 and V_3A_2 produced statistically similar straw yield. Significant variation was found in respect of biological yield due to interaction effect of variety and seedling age. The highest (14.19 t ha^{-1}) biological yield was obtained from the combination V_2A_2 which was statistically identical to that of V_2A_3 (13.81 t ha^{-1}). The lowest biological yield (6.01 t ha^{-1}) was recorded from the combination V_4A_1 (Table 10). The results showed that the combinations of V_1A_2, V_1A_3 and V_3A_3 produced statistically similar biological yields of 11.01, 11.48 and 11.69 t ha^{-1}, respectively. The combinations V_1A_1 and V_2A_1 also produced similar biological yields of 10.74 and 11.20 t ha^{-1}, respectively. Biological yields of 7.30 and 8.10 t ha^{-1} of the combinations V_4A_2 and V_4A_3 were statistically similar. Interaction effect of variety and seedling age also produced significant influence on HI. The highest HI (50.23%) was obtained from the combination V_2A_3 which was similar to the combinations of V_1A_1, V_1A_2 and V_2A_1 (Table 10). The lowest HI

(26.24%) was obtained from the V_3A_3 which was significantly different from other combinations. The combinations V_3A_1, V_3A_2, V_4A_1 and V_4A_2, and V_4A_3 produced statistically similar HI of 31.32%, 32.71%, 32.81%, 31.54% and 31.00%, respectively.

Economic performance

Total cost of cultivation was calculated maximum (Tk. 77258/- ha^{-1}) in the variety BRRI dhan29 followed by the variety BRRI dhan28. The maximum production incurred in the HYV's due to the requirement of more inputs for its production (Table 11). Maximum gross return (Tk. 128360 ha^{-1}), net return (Tk. 51102.00 ha^{-1}) and BCR (1.66) were also obtained from the same variety BRRI dhan29 with 25day-old seedling. The higher profitability in BRRI dhan29 was due to its higher yield. It was found that cultivation of local variety 'Begunbichi' was more profitable at 25day-old seedling than BRRI dhan28 and Khoiaboro at all seedling ages. This was due to more market price of the scented grain of Begunbichi compared to BRRI dhan28. Cultivation of Khoiaboro was found non-profitable due to its lower productivity as well as low market price because of its large sized grain.

Table 11. Cost and return analysis of different varieties of boro rice production during Boro season 2012-2013

Interaction		Yield (t ha^{-1})		Total cost of cultivation (Tk ha^{-1})	Gross return (Tk ha^{-1})			Net return (Tk ha^{-1})	BCR
Variety (V)	Seedling age (A)	Grain	Straw		Grain	Straw	Total		
V_1	A_1	5.24	5.50	76583.00	94320.00	2750.00	97070.00	20487.00	1.27
	A_2	5.42	5.59	76583.00	97560.00	2795.00	100355.00	23772.00	1.31
	A_3	5.44	6.04	76583.00	97920.00	3020.00	100940.00	24357.00	1.32
V_2	A_1	5.58	5.63	77258.00	100440.00	2825.00	103265.00	26007.00	1.34
	A_2	6.23	7.96	77258.00	112140.00	3980.00	116120.00	38862.00	1.50
	A_3	6.94	6.88	77258.00	124920.00	3440.00	128360.00	51102.00	1.66
V_3	A_1	2.66	5.87	48933.00	43890.00	2935.00	46825.00	-2108.00	0.96
	A_2	2.98	6.13	48933.00	49170.00	3065.00	52235.00	3302.00	1.07
	A_3	3.07	8.62	48933.00	50655.00	4310.00	54965.00	6032.00	1.12
V_4	A_1	1.97	4.04	57915.00	66980.00	2020.00	69000.00	11085.00	1.19
	A_2	2.30	5.00	57915.00	78200.00	2500.00	80700.00	22785.00	1.39
	A_3	2.51	5.53	57915.00	85340.00	2765.00	88105.00	30190.00	1.52

Note: V_1= BRRI dhan28, V_2=BRRI dhan29, V_3= Khoiaboro, V_4= Begunbichi, A_1= 15 day-old seedling, A_2= 20 day-old seedling, A_3= 25 day-old seedling.

Selling price: Rice grain - Tk 18.00 kg^{-1} for both BRRI dhan28 and BRRI dhan29; Tk 16.50 kg^{-1} for Khoiaboro; Tk 34.00 kg^{-1} for Begunbichi; Straw- Tk 0.50 kg^{-1}, BCR = Benefit-Cost ratio.

4. CONCLUSIONS

On the basis of the results obtained from the experiment following conclusions may be that 25 day-old seedling was found to produced the highest grain yield and therefore, all High Yielding and local varieties are suggested to be grown with 25 day-old seedling. BRRI dhan29 gave the maximum economic benefit followed by Begunbichi a local aromatic boro rice variety. Flush flood is a natural vulnerability in this region and although economic return is higher from both BRRI dhan29 and Begunbichi varieties, cultivation of these varieties in this region may be unsafe due to their long field duration (142 days). BRRI dhan28 matures about 15 days earlier (field duration 127 days) than both BRRI dhan29 and Begunbichi. So, BRRI dhan28 thus may be a suitable variety for cultivation with less profit but risk free of flush flood. Another conclusion is that there is only one high yielding aromatic rice

variety BRRI dhan50 recommended for cultivation in Boro season in the country. So, Begunbichi may also be recommended for cultivation in other parts of the country in the same season.

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