Reprint

ISSN 1991-3036 (Web Version)

International Journal of Sustainable Crop Production (IJSCP)

(*Int. J. Sustain. Crop Prod.*)

Volume: 12	Issue: 1	February 2017

Int. J. Sustain. Crop Prod. 12(1): 1-9 (February 2017)

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ISSN-1991-3036 (Online)
Int. J. Sustain. Crop Prod. 12(1):1-9(February 2017)

PERFORMANCE OF AEROBIC METHOD ON FIVE VARIETIES OF *BORO* RICE

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Accepted for publication on 15 January 2017

ABSTRACT

Begum MA, Alam MM, Rahman MA, Islam SS, Rahman MS (2017) Performance of aerobic method on five varieties of *boro* rice. *Int. J. Sustain. Crop Prod.* 12(1), 1-9.

A field experiment was conducted at the Agronomy Field Laboratory of Hajee Mohammad Danesh Science and Technology University, Dinajpur during *boro* season, 2013 to find out suitable rice varieties for aerobic rice cultivation. The treatments comprised of five varieties *viz.* BR16, BRRI dhan28, BRRI dhan29, BRRI dhan47 and BRRI dhan55 and two methods of planting (conventional transplanting method and aerobic system of planting). The experiment was laid out in randomized complete block design with four replications. Method of planting had significant effect on most of the yield contributing characters and yield. Yield was higher (5.61 t ha^{-1}) in conventional method than aerobic method (5.30 t ha^{-1}). On the other hand, there were significant differences among the rice varieties. BRRI dhan29 gave the highest grain yield (6.53 t ha^{-1}) followed by BR16 (5.84 t ha^{-1}) and the lowest grain yield was obtained from BRRI dhan28 (4.69 t ha^{-1}). The irrigation cost for *boro* rice was more or less Tk.14450 ha^{-1} while the additional income from *boro* rice was only Tk. 4,650 ha^{-1}. So, Tk. 9800 ha^{-1} was saved when aerobic method was adopted. Due to the looming water crisis situation *boro* rice production could be sustained by using the technology that requires very less water like aerobic method.

Key words: *transplanting, aerobic and conventional method, boro rice, yield, economic analysis*

INTRODUCTION

Rice (*Oryza sativa*) is the most important staple food crop worldwide for nearly half of the world population, particularly for those living in developing countries and the demand for rice is expected to continue to grow as population increases (Bernier *et al*. 2008). Bangladesh agriculture is predominantly rice based and is the fourth rice producing country in the world (BBS 2012). Rice contributes about 97% of the total food grains consumed in Bangladesh. It has been estimated that the production of rice in the country was 33.89 million tons from 11.53 million hectares in 2011-12 (BBS 2012) The population of Bangladesh is projected to rise to 233.2 million by the middle of this century (BBS 2007) against the present population of 152.4 million in 2012 (UNFPA 2012). The rice requirement will be 55.90 million tons by 2050 (BBS 2007) against the present requirement of 33.89 million tons. It is, therefore, needed to increase rice production to a great extent to maintain the future food security in the country. Rice is produced in three growing seasons' *viz. aus*, *aman* and *boro* in Bangladesh among which *boro* season produced the highest yield and estimated that area, production and yield of *boro* rice show the increasing trend over the decades while that of *aus* rice shows decreasing trend and *aman* rice remains more or less constant (BBS 2012). It is, therefore, evident that, in Bangladesh food security depends disproportionately on the *boro* rice production. *Boro* rice is mainly cultivated in puddled transplanted system and it requires full irrigation. In Bangladesh, about 80% and 20% irrigation is sourced from underground water and surface water, respectively. To draw this irrigation water deep tube wells, shallow tube wells and treadle pumps are used which highly expensive. It has been estimated that, at present, around 28% of the total cost of production of *boro* rice goes for irrigation in the country. On the other hand, in Bangladesh the reserve of irrigation water from both surface and underground sources is decreasing. Under this situation, there is a need of developing water saving rice production technology to sustain *boro* rice production to ensure food security in the country (Moshiur and Mehedi, 2012). Aerobic rice cultivation is a new concept of reducing water requirement for rice in which rice is grown like an upland crop with high inputs and supplementary irrigation when rainfall is insufficient (Bouman 2001). Hence, water requirement varied from 470-650 mm compared with 1350-1400 mm in lowland rice and water productivity was 64-88% higher than the lowland rice (Bouman *et al*. 2002) due to no water losses during land preparation, less percolation & seepage and less evaporation (Bouman *et al*. 2005). Thus, a comparison of water requirement of lowland flooded rice and aerobic rice system clearly showed that aerobic rice system could save about 45 per cent of water (Lampayan and Bouman, 2005). In Bangladesh, total cost of rice production was lowest in aerobic system and highest in conventional system but, there was higher net return and cost saving from aerobic system over conventional system (Moshiur and Mehedi, 2012). Keeping the above view in mind a study was undertaken with the objective of; to evaluate the performance of aerobic method of *boro* rice production over conventional method.

MATERIALS AND METHODS

The experiment was conducted at the Agronomy Field Laboratory of Hajee Mohammad Danesh Science and Technology University, Dinajpur during the period from January to June, 2013 to study the effect of cultivation methods (aerobic & conventional method) on the yield and yield attributes of five varieties of *boro* rice. The experimental field was a medium high land having sandy loam soil with pH 5.35. Treatments included two method of planting namely, Aerobic method (M_1) and Transplanting method (M_2) and five varieties namely, BR16 (V_1), BRRI dhan28 (V_2), BRRI dhan29 (V_3), BRRI dhan47 (V_4) and BRRI dhan55 (V_5). The experiment was laid out in a Randomized Complete Block Design (RCBD) with four (4) replications. All the treatment combinations were randomly distributed to the experimental plots within each block. Lay out of the experiment was done maintaining plot to plot distance 75 cm and replication to replication distance 1.0 m. The total numbers of plots were 40 and the size of unit plot was 10 m^2 (4.0 m x 2.5 m). Fourty five days old seedlings of the rice varieties were transplanted with two seedlings $hill^{-1}$ on 30 January, 2013. Direct sowing of seeds was done in case of aerobic method on the same day. Various intercultural operations were done for maintaining the normal growth and development of the crop. The crop was harvested at full maturity when 90% of the spikelets became golden yellow in color. Five hills (excluding border hills) were selected randomly from each unit plot and collected by uprooted prior to harvesting for recording necessary data on various plant characters. Data were statistically analyzed by using the "Analysis of variance" (ANOVA) technique and differences among the treatment means were adjudged by Duncan's Multiple Range Test (DMRT) with the help of a computer package (MSTATC) program (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Plant height

The results showed that planting method, variety and the interaction effect of planting method and variety had significant effect on plant height (Table 1, 2 & 3). It was observed that taller plant (97.79 cm) was obtained from aerobic method and the smaller one (89.74 cm) was obtained from transplanting method. Plant height significantly reduced due to transplanting shock in transplanted rice. The findings collaborate with the finding reported by Ali *et al*. (1993) who stated that direct seeded rice showed taller plants over transplanted. BRRI dhan29 produced the tallest plant (99.45 cm) which was followed by BRRI dhan28 (95.42 cm) and the shortest plant (89.55 cm) was produced by BRRI dhan55. It was evident that plant height differed significantly from variety to variety. This result was in agreement with Das *et al*. (2012) who observed variable plant height among the rice varieties. The tallest plant (100.14 cm) was obtained from BRRI dhan29 from aerobic method (M_1V_3) and the shortest plant (82.55 cm) was produced by BRRI dhan55 from transplanting method (M_2V_5).

Number of total tillers $hill^{-1}$

It was observed that variety showed a highly significant effect on the number of tillers $hill^{-1}$ (Table 2). The highest number of total tillers $hill^{-1}$ (19.50) was obtained from BRRI dhan29 and the lowest number of total tillers $hill^{-1}$ (13.98) was found from BRRI dhan28. Mannan *et al*. (2012) reported that the number of total tillers $hill^{-1}$ differed significantly due to varietal characteristics. Number of total tillers $hill^{-1}$ was not significantly affected by planting method and the interaction effect of planting method and variety.

Number of effective tillers $hill^{-1}$

It was evident that the number of effective tillers $hill^{-1}$ was significantly influenced by variety (Table 2). The highest number of effective tillers $hill^{-1}$ (18.03) was obtained from BRRI dhan29 and the lowest number of effective tillers $hill^{-1}$ (12.25) was obtained from BRRI dhan28. It was evident that the number of effective tillers $hill^{-1}$ varies significantly from variety to variety due to genetic makeup (Sikdar *et al.* 2006). Planting method and the interaction effect of planting method and variety were not exerted any significant effect on the number of effective tillers $hill^{-1}$.

Number of total spikelets $panicle^{-1}$

Number of total spikelets $panicle^{-1}$ was significantly influenced by the planting method and variety where the interaction between them had no significant effect on this character. Higher number of number of spikelets $panicle^{-1}$ (138.6) was found in transplanting method and lower number of number of spikelets $panicle^{-1}$ (109.2) was found in aerobic method. It was probably due to the reason of better availability and utilization of nutrients in properly spaced transplanted crop during panicle growth period (Awan *et al.* 2011). Hayashi *et al.* (2007) also reported that direct seeded rice produced minimum spikelets per panicle. Table 2 showed that the highest number of spikelets $panicle^{-1}$ (148.8) was recorded from the variety BRRI dhan29 and the lowest number of spikelets $panicle^{-1}$ (99.5) was found from the variety BRRI dhan28. Varietal differences regarding the number of total spikelets $panicle^{-1}$ might be due to their differences in genetic constituents (Islam *et al.* 2014).

Table 1. Effect of method of planting on the yield and yield contributing characters of *boro* rice

Method of planting	Plant height (cm)	Total tillers hill^{-1} (no.)	Effective tillers hill^{-1} (no.)	Total spikelet panicle^{-1} (no.)	Filled grains panicle^{-1} (no.)	Sterile spikelet panicle^{-1} (no.)	1000 grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})
M_1	97.79a	16.21	14.92	109.2b	96.2b	13.07b	22.82b	5.30b	5.99b	11.29b
M_2	89.74b	17.06	14.81	138.6a	115.5a	23.15a	23.38a	5.61a	6.56a	12.17a
Level of significance	0.01	NS	NS	0.01	0.01	0.01	0.01	0.05	0.01	0.01
CV (%)	3.52	15.47	14.61	15.71	16.07	11.03	1.70	8.70	5.55	6.33

In a column, the treatment means having similar letter(s) do not differ significantly

Note: M_1: Aerobic method and M_2: Conventional method, 'NS' means not significant

Table 2. Effect of variety on the yield and yield contributing characters of *boro* rice

Variety	Plant height (cm)	Total tillers hill^{-1} (no.)	Effective tillers hill^{-1} (no.)	Total spikelet panicle^{-1} (no.)	Filled grains panicle^{-1} (no.)	Sterile spikelets panicle^{-1} (no.)	1000 grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})
V_1	91.35c	18.30ab	16.85a	140.7ab	117.9ab	22.80	23.22bc	5.84b	6.72b	12.56b
V_2	95.42b	13.98c	12.25b	99.5d	86.16d	13.39	22.83c	4.69d	5.77c	10.46c
V_3	99.45a	19.50a	18.03a	148.8a	124.8a	23.96	21.51d	6.53a	7.36a	13.89a
V_4	93.07bc	15.18c	13.22b	105.6cd	94.4cd	11.15	24.50a	4.91cd	5.62c	1053c
V_5	89.55c	16.23bc	13.97b	124.9bc	105.7bc	19.25	23.44b	5.30c	5.91c	11.21c
Level of significance	0.01	0.01	0.01	0.01	0.01	NS	0.01	0.01	0.01	0.01
CV (%)	3.52	15.47	14.61	15.71	16.07	11.03	1.70	8.70	5.55	6.33

In a column, the treatment means having similar letter(s) do not differ significantly

'NS' means not significant

Note: V_1: BR16, V_2: BRRI dhan28, V_3: BRRI dhan29, V_4: BRRI dhan47 and V_5: BRRI dhan55

Table 3. Interaction effect of method of planting and variety on the yield and yield contributing characters of *boro* rice

Treatment combination	Plant height (cm)	Total tillers hill^{-1} (no.)	Effective tillers hill^{-1} (no.)	Total spikelet panicle^{-1} (no.)	Filled grains panicle^{-1} (no.)	Sterile spikelet panicle^{-1} (no.)	1000 grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})
$M_1 \times V_1$	92.63bc	16.75	15.80	124.65	108.58	16.10	23.05	5.81	6.65b	12.46
$M_1 \times V_2$	99.94a	13.95	12.80	86.15	78.23	7.93	22.31	4.59	5.11e	9.70
$M_1 \times V_3$	100.14a	18.40	17.45	139.43	121.13	18.30	21.45	5.96	6.91b	12.87
$M_1 \times V_4$	99.70a	15.85	14.20	92.13	86.20	6.03	24.04	4.88	5.59de	10.47
$M_1 \times V_5$	96.55ab	16.10	14.35	103.75	86.75	17.00	23.26	5.28	5.71d	10.99
$M_2 \times V_1$	90.08cd	19.85	17.90	156.80	127.30	29.50	23.38	5.87	6.79b	12.66
$M_2 \times V_2$	90.90cd	14.00	11.70	112.95	94.10	18.85	23.35	4.79	6.43bc	11.22
$M_2 \times V_3$	98.74a	20.60	18.60	158.13	128.50	29.63	21.57	7.09	7.88a	14.97
$M_2 \times V_4$	86.43de	14.50	12.25	119.03	102.68	16.28	24.97	4.97	5.65d	10.62
$M_2 \times V_5$	82.55e	16.35	13.60	146.18	124.68	21.50	23.62	5.33	6.11cd	11.44
Level of significance	0.01	NS	NS	NS	NS	NS	NS	NS	0.05	NS
CV (%	3.52	15.47	14.61	15.71	16.07	11.03	1.70	8.70	7.48	6.33

Table 4. Cost and return of *boro* rice under conventional and aerobic method of cultivation system

Treatment combination	Total cost of production (Tk. ha^{-1})	Return (Tk. ha^{-1})		Gross return (Tk. ha^{-1}) (a+b)	Net return (Tk. ha^{-1})	Benefit cost ratio (BCR)
		Due to produced (a)	Due to by product (b)			
$M_1 \times V_1$	45550.00	116200.00	6650.00	122850.00	77300.00	2.70
$M_1 \times V_2$	42410.00	92000.00	5360.00	97360.00	54950.00	2.30
$M_1 \times V_3$	45560.00	124200.00	6910.00	131110.00	85550.00	2.88
$M_1 \times V_4$	42450.00	72600.00	5590.00	78190.00	35740.00	1.84
$M_1 \times V_5$	42445.00	105600.00	5710.00	111310.00	68865.00	2.62
$M_2 \times V_1$	52890.00	117400.00	6790.00	124190.00	71300.00	2.35
$M_2 \times V_2$	51885.00	95400.00	6430.00	101830.00	49945.00	1.96
$M_2 \times V_3$	52885.00	141800.00	7880.00	149680.00	96795.00	2.83
$M_2 \times V_4$	52000.00	78300.00	5650.00	83950.00	31950.00	1.61
$M_2 \times V_5$	51892.00	106600.00	6120.00	112720.00	60828.00	2.17

In a column, the treatment means having similar letter(s) do not differ significantly

Note: M_1: Aerobic method and M_2: Conventional method V_1: BR16, V_2: BRRI dhan28, V_3: BRRI dhan29, V_4: BRRI dhan47, V_5: BRRI dhan55 ‘NS’ means not significant

Number of filled grains panicle^{-1}

The variation in the number of filled grains panicle^{-1} was significantly influenced by planting method and variety but the interaction effect of planting method and variety was not significantly influenced. Table 1 showed that higher number of filled grains panicle^{-1} (115.5) was found from transplanting method and lower number of filled grains panicle^{-1} (96.2) was found in aerobic method. The maximum number of grains panicle^{-1} in transplanting might be due to the utilization of edaphic conditions more efficiently in transplanted crop, than that in direct seeded rice, and therefore produces maximum number of grains panicle^{-1} (Akhgari *et al.* 2013). BRRI dhan29 produced the highest number of filled grains panicle^{-1} (124.8) which was followed by BR16 while BRRI dhan28 produced the lowest one (86.16) (Table 2). It was evident that varietal differences regarding the number of filled grains panicle^{-1} might be due to their differences in genetic constituents (Mannan *et al.* 2012).

Number of sterile spikelets panicle^{-1}

Number of sterile spikelets panicle^{-1} was significantly influenced by planting method. Higher number of unfilled grains panicle^{-1} (23.15) was found in case of transplanting method and aerobic method produced the lower number of unfilled grains panicle^{-1} (13.07). The higher number of sterile spikelets panicle^{-1} in transplanting method probably due to severe competition of plants for resource shearing (Javaid *et al.* 2012). Awan *et al.* (2011) also reported that higher sterility percentage in transplanting method is because of more tertiary tiller production results late flowering which remains un-fertilized.

Weight of 1000 grains (g)

The thousand grain weight was significantly affected by planting method and variety. Higher 1000 grain weight (23.38 g) was obtained from transplanting method and lower 1000 grain weight (22.82 g) was found from aerobic method. Rana *et al.* (2014) and Awan *et al.* (2007) reported lower 1000 grain weight in direct seeded rice than transplanting method. Results revealed that the highest 1000-grain weight (24.50 g) was obtained from the variety BRRI dhan47; might be its large grain size and the lowest 1000-grain weight (21.51 g) was produced from the variety BRRI dhan29. Akhgari *et al.* (2013) reported that 1000 grain weight an important yield component that differed significantly among the cultivars due to genetic make-up which supported the present experimental result. BRRI (2003) also stated that the 1000 grain weight is stable varietals character, which remained unaffected due to the manipulation of management practices.

Grain yield (t ha^{-1})

Results showed that the grain yield was significantly influenced by planting method and variety. Fig. 1 showed that transplanting method performed higher in respect of grain yield (5.61 t ha^{-1}) whereas the aerobic method produced lower grain yield (5.30 t ha^{-1}). This higher grain yield in transplanting method might be due to good crop condition, efficient use of natural resources which results in higher number of tillers, panicle and spikelets panicle^{-1} (Aslam *et al.* 2008) then in dense populated aerobic method. BRRI dhan29 performed the highest in respect of grain yield (6.53 t ha^{-1}) which was mostly dependent on the number of effective tillers hill^{-1}, panicle length, filled grains panicle^{-1} and crop duration. BRRI dhan28 performed the lowest in respect of grain yield (4.69 t ha^{-1}) (Fig. 2). It was evident that the differences in grain yield might be due to the differences in the number of effective tillers hill^{-1}, grains panicle^{-1} and 1000-grain weight which was mostly dependent on genetic make-up of the studied varieties (Mondal *et al*. 2005; Jianchang *et al*. 2006; Yang *et al*. 2007).

Straw yield (t ha^{-1})

Straw yield was significantly influenced by the planting method, variety and the interaction effect of planting method and variety. Table 1 represented that higher straw yield (6.56 t ha^{-1}) was found in case of transplanting method and lower straw yield (5.99 t ha^{-1}) was found from aerobic method. These results are in agreement with those of Kumhar *et al.* (2016). The highest straw yield (7.36 t ha^{-1}) was produced from BRRI dhan29 and the lowest one (5.62 t ha^{-1}) was produced from BRRI dhan47. Roy *et al.* (2014) and Mannan *et al.* (2013) also reported variable straw yields among varieties due to the combined effect of plant height and tiller numbers.

Biological yield

Biological yield was significantly influenced by planting method and variety. Highest biological yield (12.17 t ha^{-1}) was obtained from transplanting method and lower biological yield (11.29 t ha^{-1}) was obtained from aerobic method. This result was also obtained by Ghosh *et al.* (2016). The highest biological yield (13.89 t ha^{-1}) was recorded from BRRI dhan29 and the lowest biological yield (10.46 t ha^{-1}) was recorded from BRRI dhan28. Islam *et al.* (2014) reported that biological yield was positively correlated with grain and straw yield in rice.

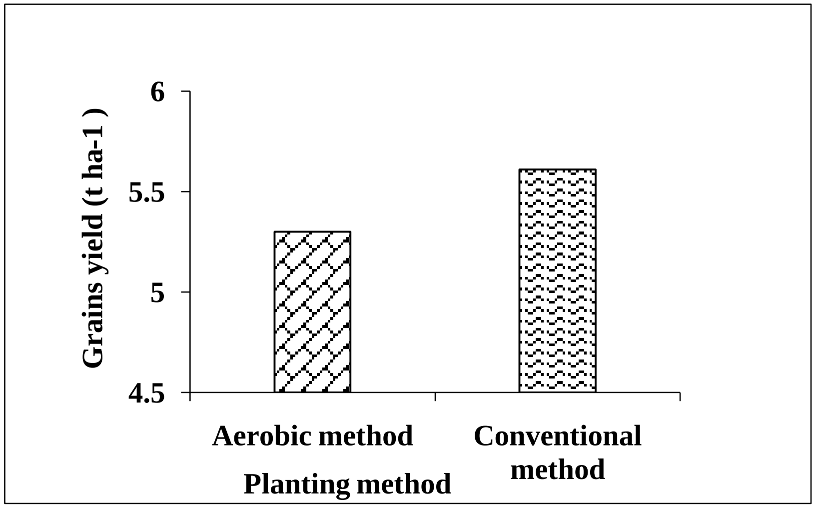

Fig. 1. Grain yield of *boro* rice as influenced by planting method of cultivation

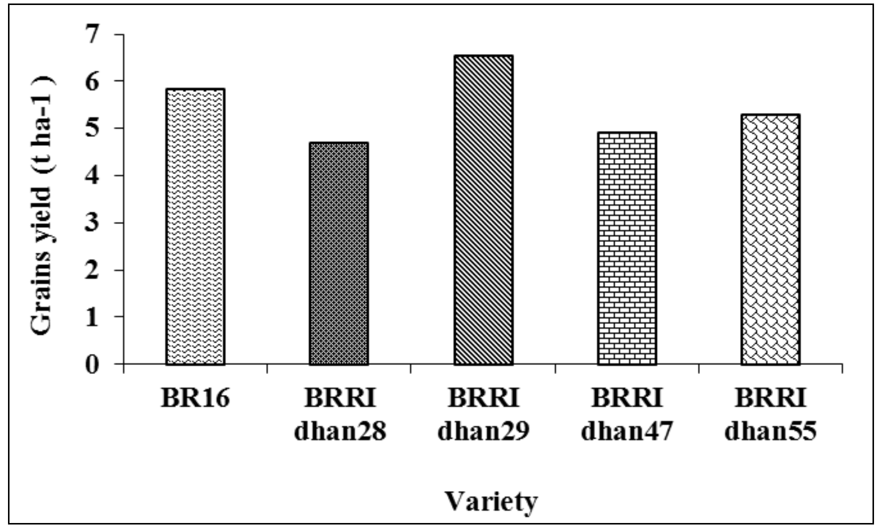

Fig. 2. Grain yield of *boro* rice as influenced by variety

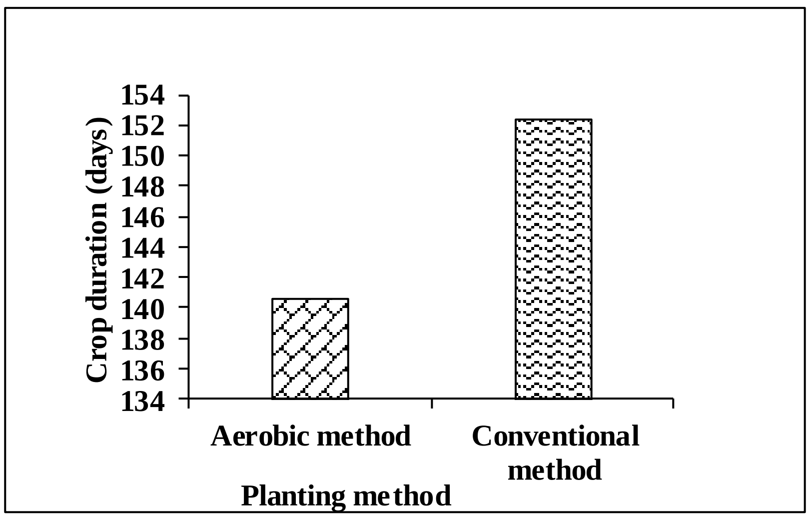

Fig. 3. Crop duration of *boro* rice as influenced by planting method of cultivation

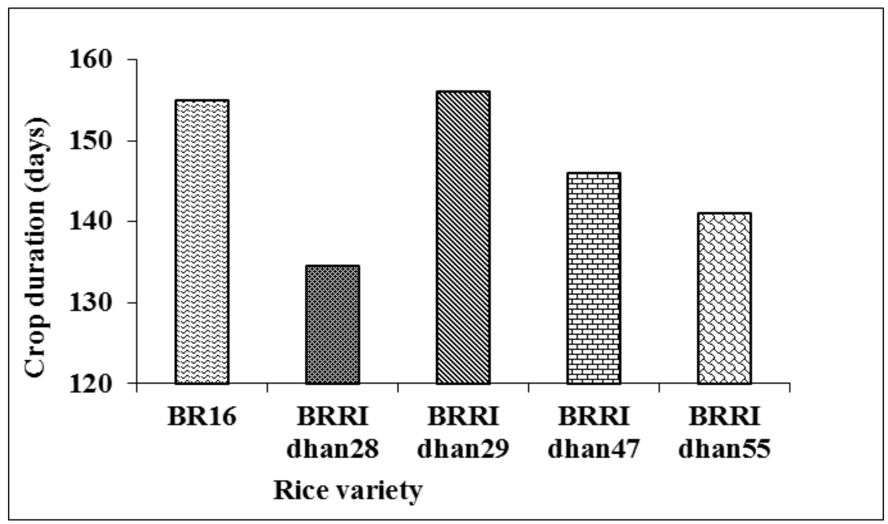

Fig. 4. Crop duration of *boro* rice as influenced by variety

Crop duration (days)

Crop duration was significantly influenced by planting method, variety and the interaction effect of planting method and variety. Fig. 3 showed that conventional method needed more crop duration (152.4 days) than aerobic method (140.6 days). IRRI (2008) reported that depending on a cultivar, rice crops directly sown by aerobic method matures 7 to 10 days earlier than transplanted rice. BRRI dhan29 took the highest crop duration (156 days) to come to harvestable maturity stage and BRRI dhan28 took the lowest crop duration (134.5 days) to come to harvestable maturity stage. (Fig. 4). Rice seedling showed a very slow growth immediately after transplanting which is an expression of shock due to the change in the environment from the nursery to the main field. Duration of shock may exist only for a few days or may be as long as three weeks or more (Salam 1992).

Economic Analysis

The total cost of production in the conventional method was higher and in aerobic system was lower. On the other hand, the highest benefit cost ratio (2.88) was obtained from BRRI dhan29 under aerobic method and lowest benefit cost ratio (1.61) was obtained from BRRI dhan47 under conventional method. The total cost of production in the conventional system was Tk. 52885.0 ha^{-1} while that was Tk. 45560.00 ha^{-1} in aerobic system for BRRI dhan29. The net return was Tk. 96795.00 and 85550.00 ha^{-1} in conventional and aerobic systems, respectively. Thus, there was 4.74% higher net return for BRRI dhan29 in aerobic system over conventional system. The net return was 35%, 34%, 23% and 45% higher in aerobic system over conventional system for BR16, BRRI dhan28, BRRI dhan47 and BRRI dhan55, respectively (Table 4) though rice yield was about 5.5% higher in conventional transplanting method over aerobic method. Hence, 28% of the total cost for production of *boro* rice goes for mere irrigation in conventional system. The irrigation cost for *boro* rice was more or less Tk.14450 ha^{-1} while the additional income from *boro* rice was only Tk. 4,650 ha^{-1}. So, Tk. 9800 ha^{-1} was saved when aerobic method was adopted. Similar results were obtained by Rahman and Masood (2014).

CONCLUSION

It can be concluded from the results that variety BRRI dhan29 performed better than other varieties when grown with aerobic method. Therefore, it would be better to adopt aerobic method for *boro* rice cultivation along with the other crop management than conventional method of rice cultivation.

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