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Agronomic performance and farmers perception on zinc enriched rice BRRI dhan62

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Abstract

Newly developed zinc enriched rice variety BRRI dhan62 was evaluated along with three other short maturing Transplanted Aman (wet season) rice varieties namely BINA dhan7, BRRI dhan33 and BRRI dhan56 at six different locations of Bangladesh during 2014. The study was laid out in randomized complete block design where each of the six dispersedly located locations act as replications. Agronomic performance, yield and yield components were determined at maturity. Economic performance and farmer's perceptions on the newly developed zinc enriched rice BRRI dhan62 were measured after harvest. Maximum genotypic difference was 12% in plant height, ranging from 122 to 109 cm among the tested varieties where BRRI dhan62 was the shortest and BRRI dhan56 was the tallest plant. The maximum grain yield was obtained from BINA dhan7 (5.70 ton h^{-1}) which was similar with BRRI dhan33 and minimum grain yield was obtained from BRRI dhan62 (4.78 ton h^{-1}) that was statistically similar with BRRI dhan56. BINA dhan7 gave maximum yield compared to other because of its maximum panicle number m^{-2}. The highest yielding variety BINA dhan7 produced highest productivity day^{-1} (55 kg) which was statistically similar with BRRI dhan62 (51 kg) and lowest productivity day^{-1} was found BRRI dhan56 (48 kg). BRRI dhan33 produced highest benefit cost ratio (2.33) compared to other variety and BRRI dhan62 and BRRI dhan56 produced lowest benefit cost ratio (2.16). The short maturing characteristic of BRRI dhan62 was most preferred attribute by the farmers rather than higher yield or higher zinc content.

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Introduction

Rice is the staple food of about 160 million people of Bangladesh. It provides nearly 48% of rural employment, about two-thirds of total calorie supply and about one-half of the total protein intakes of an average person in the country. The rice sector contributes one-half of the agricultural GDP and one-sixth of the national income; almost all of the registered 13 million farm families grow rice on about 10.5million ha which has remained almost stable over the past three decades (BRKB, 2012). Bangladesh is one of the poorer countries of the world which is densely populated and threatened by floods and storms. About 75% of the total cropped area and more than 80% of the total irrigated area is planted to rice (Hossain and Deb, 2003). Total rice production in Bangladesh was about 10.59 million tons in 1971 when the country's population was only about 70.88 million. However, Bangladesh now produces about 34.0 million tons to feed 164 million people. This indicates that the growth of rice production was much faster than population growth. This increase in rice production was possible largely due to the adoption of modern rice varieties on around 66% of land dedicated to rice, contributing about 73% of the country's total rice production (BRRI, 2013). Bangladesh has been increasing rice production over many years and is now relatively self-sufficient in rice production. The country's rice imports declined from about 1 million ton in 1995 to a mere 0.017 million ton in 2009 but increased to 0.66 million ton in 2010. Exports of rice began in the year of 2000. Some rice is still imported, however, mainly to control domestic prices.

The predominant cropping pattern of this country is Rice-Rice and Rice based cropping system. For increasing cropping intensity as well as ensuring food security, there is a way to introduce short duration rice varieties in different rice growing season. For *Aman* season, Bangladesh Rice Research Institute (BRRI) and Bangladesh Institute of Nuclear Agriculture (BINA) has developed some early maturing HYV varieties. These varieties perform well and have acceptability among farmers in different part of Bangladesh. Recently a new short duration *Aman* variety; BRRI dhan62 has released by BRRI which is said to have medium level Zinc- enriched with medium grain yield.

Zinc is essential for normal growth and immune function of the human body. Zinc deficiency is the most prevalent nutritional deficiency in Bangladesh, affect 45% of pre-school children 57% of NPNL (non-pregnant, non-lactating) women. Rice is the primary food source in Bangladesh, providing 70% of per capita calorie intakes, (average per day per head rice intake is about 416 g against the total of 1000 g food intake per day per head) and could thus serve as a useful food vehicle for Zinc. This could be achieved by developing high zinc rice variety through bio fortification for our people. Thus, Bangladesh is the first country who stepped forward with the development of bio-fortified Zinc enriched rice variety, BRRI dhan62. The variety contains 19 g of Zinc in one kg of cleaned rice and nine percent of protein, which would ensure better nutrition for our people (Rashid, 2014).

Therefore, a study is undertaken to evaluate BRRI dhan62 along with others short duration *Aman* varieties released by BRRI and BINA in northern and central part of Bangladesh.

Materials and methods

Location and experimental design

Field experiment was conducted in the *Aman* season 2014 in six different location of Bangladesh. Five locations were the northern part (two locations in Kurigram, two in Bogra, one in Lalmonirhat) and one in the central part (Gazipur) of Bangladesh. Field size was 30 decimal for each type of variety in all location. The experiment was laid out in Randomized Complete Block Design (RCBD). Variety was treated as a treatment and location as a replication.

Plant material

Four rice varieties *viz*, BINA dhan7, BRRI dhan33, BRRI dhan56 and BRRI dhan62 were evaluated in this study.

Agronomic management

Clean seeds of each variety with a minimum of 90% germination rate were soaked in water for 24 h and incubated for another 24 hour. Then the pre germinated seeds were shown in seedbed to produce uniform seedlings. For synchronizing maturity, BINA dhan7, BRRI dhan33 and BRRI dhan56 were seeded last week of June 2014 and BRRI dhan62 was seeded around 10 days later. Twenty days old seedlings were used for each variety. Transplanting was done at mid-July of 2014 for all the varieties. In all locations transplanting were done at a time. Plant to plant and row to row spacing was 20 cm × 20 cm and three seedlings per hill were used. Fertilizer was applied at the rate of 165-50-70-45-5 kg ha^{-1} of Urea, TSP, MoP, Gypsum and Zinc sulphate. TSP, Gypsum and Zinc sulphate were applied as basal at final land preparation. Urea was applied in three splits as basal, 10 days after transplanting and 30 days after transplanting. Two-third of MoP was used at final land preparation and one-third at 30 days after transplanting. All other agronomic management was done as and when necessary in optimum level to maximize the yield.

Data collection

Data on grain yield was taken from 20 m^2 area and converted into ton per hectare. Growth duration was counted as number of days required to physiological maturity from sowing. The data on plant height, tiller m^{-2}, panicle m^{-2}, spikelet $panicle^{-1}$, grain filling percentage, 1000 grain weight and grain yield (t ha^{-1}) at 14% moisture content were recorded. Maximum genotypic difference, productive tillers percentage and productivity per day were calculated using the following formula:

Maximum genotypic difference = 100 × (maximum-minimum)/Mean

Productive tillers percentage = 100 × (Panicle number at PM / Tiller number at PI)

Productivity per day = Grain yield / Growth duration

Economic performance of different types of varieties was recorded time to time at the specific location. The total cost of production for each variety were calculated based on the labor requirement for sowing/transplanting, weeding and irrigation, manure and fertilizer cost, seed cost, harvesting and other input cost. The total income calculated based on the market price grain and straw. The benefit cost ratios (BCR) of cultivation of each variety were calculated by dividing the income by total cost of production. For farmer's opinion, BRAC agriculture and food security programme took interview of 50 farmers about 10 rice related question for each varieties and response were expressed as percent.

Statistical analysis

The data were analyzed statistically using MSTATC package. The significance of the difference among the treatment was estimated by Least Significant Difference (LSD) test at 5% and 1% level of probability (Gomez and Gomez, 1984).

Results and discussion

Plant height and tiller dynamics

The plant height of *Aman* rice was significantly influenced by different varieties at panicle initiation stage, flowering stage and maturity stage but there was not any significant difference at mid-tillering stage (Table 1). Plant height of rice is the pre-requisite for attaining desired yield (Gurfu *et al.*, 2006). Maximum genotypic difference was 12% in plant height, ranging from 122 to 109 cm in *Aman* season. The result revealed that at panicle initiation stage, flowering stage and maturity stage BRRI dhan56 produced the tallest plant (104, 114 and 122 cm respectively). At panicle initiation and flowering stage BINA dhan7 produced the lowest plant height (90 and 103 cm respectively) which was statistically similar with BRRI dhan62 and BRRI dhan33 but at maturity stage BRRI dhan62 produced the shortest plant (108 cm) that statistically similar with BINA dhan7 and BRRI dhan33. The height of BRRI dhan56 is higher than BRRI dhan62 (BRRI, 2013). Tiller number m^{-2} was significantly influenced by the varieties at all growth stage (Table 1). Tiller number m^{-2} increased with age reaching until panicle initiation stage and thereafter declined.

Tiller number plays an important role in the formation of grain yield of rice (Gurfu *et al.,* 2006). The maximum number of tiller m^{-2} was found in BINA dhan7 at all growth stage such as mid-tillering stage, panicle initiation stage, flowering stage and maturity stage (467, 471, 471 and 454 respectively) which was similar with BRRI dhan62 and the lowest number of tiller m^{-2} was found in BRRI dhan33 at all growth stage (337.5, 337.5, 333.3 and 316.7 respectively) that statistically similar with BRRI dhan56. These results are in agreement to the findings of Rana (2011) and Jalil (2013). There was not any significant difference of productive tiller percentage in tested varieties (Table 1). But numerically maximum productive tiller percentage produce BRRI dhan56 (97) compare to BRRI dhan62 (94).

Table 1. Plant height and tiller dynamics at four growth stage of four rice varieties grown during 2014 *Aman* season.

Variety	Plant height (cm) at different growth stages				Tillers m^{-2} (no.) at different growth stages				Productive tillers (%)
	MT	PI	FL	PM	MT	PI	FL	PM	
BINA dhan7	78	90	103	109	467	471	471	454	93
BRRI dhan33	83	93	106	113	338	338	333	317	94
BRRI dhan56	88	104	114	122	350	346	346	333	97
BRRI dhan62	77	92	105	108	421	454	450	425	94
Mean	81	95	107	113	394	402	400	382	94
$LSD_{.05}$	NS	*	*	**	**	**	**	**	NS
CV (%)	11	8	5	4	14	15	15	15	5

* and ** Level of significance of F value at 0.05 and 0.01 probability levels, respectively, NS=Not significant at P = 0.05: MT = Mid-tillering, PI = Panicle initiation, FL = Flowering and PM=Physiological maturity.

Yield components

Yield component such as panicles m^{-2}, spikelets $panicle^{-1}$ and thousand grain weights was significant difference by tested varieties but there was not any significant difference in spikelet filling percentage. Yield components data measured in tested varieties are presented in Table 2. The maximum number of panicle m^{-2} was showed in BINA dhan7 (433) which was similar with BRRI dhan62 and minimum number of panicle m^{-2} was produced BRRI dhan33 (317) that was similar with BRRI dhan56. This result is supported by the findings of Jalil (2013). BRRI dhan33 produced highest spikelets $panicle^{-1}$ (136) which was statistically similar with BRRI dhan56 and BINA dhan7 and lowest spikelets $panicle^{-1}$ (91) was found in BRRI dhan62. But spikelet filling percentage was statistically similar among these varieties and numerically highest number was BRRI dhan62 (76%) and lowest BINAdhan7 (71%). It was observed that highest 1000 grain weight showed in BRRI dhan62 (24.3 g) which was similar with BRRI dhan56 and BRRI dhan33 and lowest 1000 grain weight showed in BINA dhan7 (20.8 g). Cultivars with larger grain size tend to have higher grain filling rate, resulting in higher assimilate accumulation and heavier grain weight (Jeng *et al*., 2003).

Table 2. Yield components of four rice varieties grown during 2014 *Aman* season.

Variety	Panicles m^{-2} (no.)	Spikelets $panicle^{-1}$ (no.)	Spikelet filling (%)	1000 grain weight (g)
BINA dhan7	433	121	71	20.8
BRRI dhan33	317	136	74	22.5
BRRI dhan56	333	132	74	21.8
BRRI dhan62	425	91	76	24.3
Mean	377	120	74	22.0
$LSD_{.05}$	**	**	NS	*
CV (%)	14	11	7	12.5

* and ** Level of significance of F value at 0.05 and 0.01 probability levels, respectively, NS=Not significant at P = 0.05.

Grain yield, growth duration and productivity day^{-1}

There was a significant difference of grain yield among tested varieties (Table 3). The maximum grain yield was obtained from BINA dhan7 (5.70 ton h^{-1}) which was similar with BRRI dhan33 and minimum grain yield was obtained from BRRI dhan62 (4.78 ton h^{-1}) that was statistically similar with BRRI dhan56. BINA dhan7 gave maximum yield compared to other because of its maximum panicle number m^{-2}. Zou *et al.* (1991) suggest that number of panicle per unit area is closely related with rice yield. BRRI dhan62 produced lower grain yield compared to other tested varieties because of its lower spikelet panicle^{-1}. Growth duration was significantly influenced by tested varieties (Table 3). The most early variety was BRRI dhan62 having growth duration 96 days. Short duration high yielding rice varieties have ability to increase cropping intensity and can be improved annual yield potential remarkably. BRRI dhan62 rice seed can be harvested within a 100-day cycle (BRRI, 2015). The highest growth duration was found in BRRI dhan33 (107 days) which was similar with BINA dhan7 and BRRI dhan56.

Table 3. Grain yield, growth duration and productivity day^{-1} of four rice varieties grown during 2014 *Aman* season.

Variety	Grain yield (t h^{-1})	Growth duration (days)	Productivity day^{-1} (kg ha^{-1} d^{-1})
BINA dhan7	5.70	105	54.5
BRRI dhan33	5.30	107	49.8
BRRI dhan56	5.00	104	48.2
BRRI dhan62	4.78	95	50.5
Mean	5	103	51
$LSD_{.05}$	0.53*	3**	6.0*
CV(%)	8.3	2	9.6

* and ** Level of significance of F value at 0.05 and 0.01 probability levels, respectively.

The growth duration of BRRI dhan56 is around 110 days (BRRI, 2013). Significant variation in productivity day^{-1} was observed among the tested varieties (Table 3). Besides grain yield, productivity day^{-1} is also very important for comparing genotypes (Islam, 2008).The highest yielding variety BINA dhan7 produced highest productivity day^{-1} (55 kg) which was statistically similar with BRRI dhan62 (51 kg) and lowest productivity day^{-1} was found BRRI dhan56 (48 kg). Usually varieties with longer growth duration produce more yield than the varieties with shorter growth duration (Islam, 2008). Daily productivity may be a better criterion for comparing varietal performance and BRRI dhan62 produced lower grain yield compared to other varieties but its productivity day^{-1} was similar with highest yielding variety BINA dhan7.

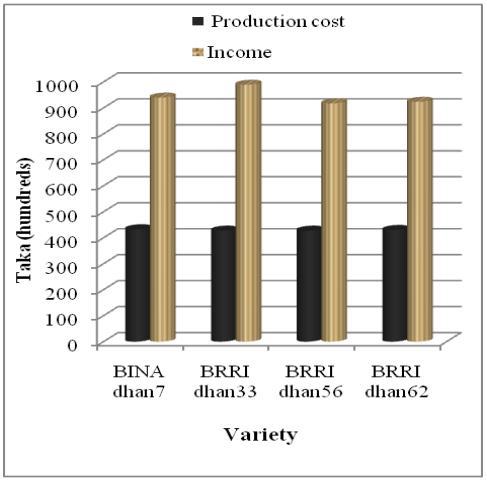

Fig 1. Production cost and total income of four rice varieties grown during 2014 *Aman* season (wet season).

Economic performance

Total cost of production and income are showed in fig. 1 and benefit cost ratio (BCR) showed in fig. 2. It observed that total cost of production of BINA dhan7 was higher having 47257 taka per hectare and lowest cost of production was found BRRI dhan56 having 42727 which almost similar with BRRI dhan33 and BRRI dhan62. But in case of total income BRRI dhan33 gave highest income (98908 taka) compared to BINA dhan7 (93946 taka) which required more cost for production. BRRI dhan62 and BRRI dhan56 gave similar income per hectare. BRRI dhan33 produced highest benefit cost ratio (2.33) compared to other variety and BRRI dhan62 and BRRI dhan56 produced lowest benefit cost ratio (2.16).

Farmer's opinion

It observed that 100% farmers gave opinion BRRI dhan62 is Zinc enriched, short life duration and 90% farmers said it has a high market price. From electronic media and newspaper they have known that BRRI dhan62 is enriched of Zinc but growth duration and market value was there practical experience. The farmer's opinion questionnaire results are showed in table 3.

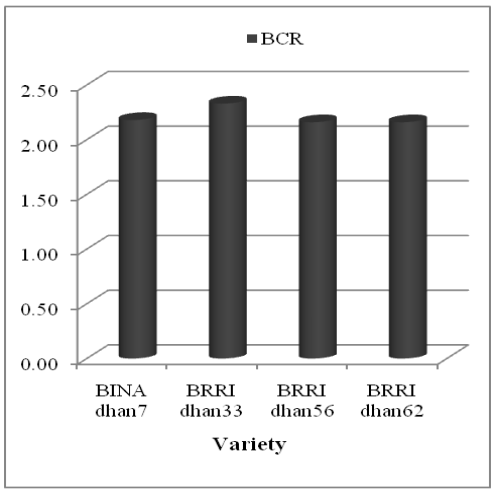

Fig 2. Benefit cost ratio of four rice varieties grown during 2014 *Aman* season (wet season).

About 50% said BRRI dhan62 is fine grain and other 50% farmers said BINA dhan7 is fine rice.

After boiling of rice, 80% farmers gave opinion BRRI dhan33 is nonsticky but no one said BRRI dhan62 non sticky. In case of pest infestation and disease incidence 50% farmers gave opinion BINA dhan7 showed low disease and pest infestation and 30-40% farmers said BRRI dhan62showed low disease and pest infestation. About 70% farmers said BINA dhan7 was not lodging and 20% farmers said BRRI dhan62 was not lodging. BINA dhan7 produced maximum yield, said 60% farmers and 40% farmers gave opinion BRRI dhan33 gave maximum yield but no one said BRRI dhan62 can give maximum yield. Straw quality also good in BINA dhan7, said 50% farmers and 40% farmers said BRRI dhan56 produced good quality straw than other variety.

Table 4. Farmer's opinion of four rice varieties grown during 2014 *Aman* season.

Sl. No.	Question	BINA dhan7	BRRI dhan33	BRRI dhan56	BRRI dhan62
1	Which lifecycle is short?				100%
2	Which market price is high?			10%	90%
3	Which is Zinc enriched?				100%
4	Which rice is fine?	50%			50%
5	Which rice is not sticky after boiling?	10%	80%	10%	
6	Which insect & pest infestation is low?	50%	5%	15%	30%
7	Which disease incidence is low?	50%		10%	40%
8	Which do not lodging?	70%	10%		20%
9	Which production rate is high?	60%	40%		
10	Which produced good quality straw?	50%	10%	40%	

This result suggests that BRRI dhan62 is zinc enriched and very short duration variety for *Aman* season in Bangladesh. But its grain yielding capacity could not meet up the farmer's expectation. Therefore, future research should be needed to improve grain yield of zinc enriched rice and then it will have better acceptance by general farmers.

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