Research in
ISSN : P-2409-0603, E-2409-9325
AGRICULTURE, LIVESTOCK and FISHERIES
An Open Access Peer Reviewed Journal

Open Access
Research Article

Res. Agric. Livest. Fish.
Vol. 2, No. 2, August 2015: 207-213

GENETIC VARIABILITY FOR GRAIN YIELD AND YIELD ASSOCIATED TRAITS IN TRANSPLANT AMAN RICE (*Oryza sativa* L.)

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ARTICLE INFO

Received
15.08.2015

Accepted
29.08.2015

Online
03.09.2015

Key words
Phenology of rice
Chlorophyll content
G X E interaction
Genetic advance

ABSTRACT

For any crop improvement program, it is imperative to assess the grain yield progress of the existing crop varieties to find the further avenue to out yield the existing superior ones. Therefore, an experiment was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh from July to December 2013 to find out the genetic variation for grain yield and their associated traits of transplant Aman rice varieties. The experiment consisted of 11 varieties viz. Bashiraj, Binadhan-7, BR10, BR11, BR22, BR23, BRRIdhan32, BRRIdhan39, BRRIdhan49, BRRIdhan57 and IR64. The high yielding Bangladeshi varieties were selected based on their releasing year with a local and one exotic T. Aman rice varieties. Among the varieties, BR10 produced the highest grain yield (3.83 t ha^{-1}). Binadhan-7 rice variety recorded the highest chlorophyll content (39.93 SPAD value) at 29DAT, (44 SPAD value) at 39 DAT and (47.30 SPAD value) at 49 DAT. The highest phenotypic (1491.81) and genotypic (1147.26) variances and genetic advance (61.19) were obtained from spikelets $panicle^{-1}$ and this parameter had greater ability to increase yield. Among the traits, the highest heritability was recorded by effective tillers $hill^{-1}$ (87.91%) which influenced the grain yield. Therefore, it may be concluded that the variety BR10 of transplant Aman rice produced maximum grain yield, spikelets $panicle^{-1}$, showed high phenotypic and genotypic variances and genetic advance. Bashiraj, BRRIdhan49 and BRRIdhan57 also can be considered as planting materials as their yield performance is close to BR 10. Therefore, the findings of the present study will help the breeders for further yield improvement of rice.

To cite this article: M Begum, MA Hossain, FMM Hossain and AK Hasan, 2015. Genetic variability for grain yield and yield associated traits in transplant Aman rice (*Oryza sativa* L.). Res. Agric. Livest. Fish. 2 (2): 207-213.

INTRODUCTION

Rice (*Oryza sativa* L.) is an important food crop which supplies staple food for nearly 50% of the global population (FAO, 2011; Garris et al., 2005). Among the most cultivated cereals in the world, rice ranks as second to wheat (Abodolereza and Racionzer, 2009). It is the basis of food security and is intimately associated with traditional culture and customs of Bangladesh. Bangladesh is the fourth largest producer and consumer of rice in the world (FAO, 2011), with annual production of 33.54 million metric tons in an area of 11.52 million hectares of land (BBS, 2012). The wide environmental diversity in Bangladesh, attributed mainly to the considerable variation in topographic and seasonal components, is reflected in the range of rice groups cultivated. Among the five distinct rice ecotypes of Bangladesh (boro, transplanted aus, transplanted Aman, upland or direct-seeded aus and deep-water or floating rice), aman rice is the major rice ecotype that is grown completely under rainfed ecosystems. In addition, Aman rice is the second largest rice ecotype of the country in terms of volume of production while boro tops the production. Moreover, the area coverage of Aman is the largest as a single crop and Boro remains the second. Land under cultivation for T. Aman, Boro and Aus season is 5.64 million hectares, 4.77 million hectares and 1.11 million hectares, respectively (BBS, 2012). Though the soil and climate of our country is quite suitable for the production of rice, still it is facing many problems of which the poor yielding inherent capability of our rice varieties is the most important one. Poor plant type, such as tall plants, long and droopy leaves, weak culms, susceptible to lodging etc, are the main causes of the low yield of the rice varieties. Aman rice is timely fixed and photosensitive, which is an important crop in Bangladesh for the free availability of water for its cultivation. Several local, high yielding and exotic varieties are cultivated in Aman season but national average yield is not satisfactory. This is due to genetic makeup of the varieties and their appropriate management practices.

Varieties have a great effect on the yield and yield contributing characters of Aman rice. Mia (2003) reported that plant height differed significantly among BR3, BR11, BR22, Nizershail, Pajam, and Badshabhog varieties in Amanseason (Jul-Dec). Chowdhury et al. (1995) showed that grain and straw yields were higher in the improved (BR3, BR11, Pajam, and Mala) than the native (Maloti, Nizershail, and Chandrashail) varieties. Mondal et al. (2005) also found similar type of result after evaluating 11 translplant aman rice varieties where HYV outyielded local varieties and found that number of grains per panicle is the most responsible traits for the grain yield variation. To increase inherent yield potential and its adoption to environment is important aspect for varietal improvement. As yield is a polygenic character, it has more impact on environment to get maximum yield potentials (Yousida, 1983).

Genetic variation is the basis of plant breeding and provides a wide range of genotypes that can be selected to develop new varieties or breeding materials (Pandey et al., 2009) Variability in terms of genetic divergence for agronomic traits is the key component of breeding programmes for broadening the gene pool of rice and requires reliable estimates of heritability to plan an efficient breeding programme (Akinwale et al., 2011). The phenotypic and genotypic variance influences the yield of rice. The relatively high genetic variances for physiological traits, yield and yield contributing characters indicated that these traits predominantly control its inherent genetic yield potential and would be possible for further improvement. The estimates of heritability act as predictive instrument in expressing the reliability of phenotypic value. Therefore, high heritability helps in effective selection for a particular trait. The genetic advance is a useful indicator of the progress yield that can be expected as result of exercising selection on the pertinent population. The information on heritability and genetic advance helps to predict the genetic gain that could be obtained in later generations, if selection is made for improving the particular trait under study. Therefore, the experiment was undertaken to analyze the genetic variations in transplant Aman rice varieties for their yield and yield associated traits.

MATERIALS AND METHODS

The research was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during the period from July to December, 2013. One experimental factor was included in the study, namely, variety. Among the varieties one is local (Bashiraj), one is exotic (IR64) and the others (Binadhan-7, BR10, BR 11, BR22, BR23, BRRIdhan32, BRRIdhan39, BRRIdhan49, BRRIdhan57) are Bangladeshi high yielding T. Aman rice varieties. They were selected as the representative variety in terms of their popularity during different years in Aman season.

The experiment was laid out in a randomized complete block design with three replications. The area of each unit plot was 2.5m x 2.0m. The total number of unit plots was 33.The recommended doses of fertilizers were 110, 40, 50, 37 and 5 g/5m^2 of urea, triple super phosphate, muriate of potash, gypsum and zinc sulphate, respectively. All the fertilizers except urea were applied at the time of final land preparation. Urea was top dressed in three equal splits at 15, 35 and 55 days after transplanting (DAT).Intercultural operations were done for maintaining the normal growth and development of the crop. During the crop cycle, the dates of booting, heading, anthesis and physiological maturity were recorded using the scale proposed by Zadoks et al. (1974). Randomly five leaves were selected on each plot and Chlorophyll content was measured by the chlorophyll meter (SPAD meter) at 29, 39 and 49 DAT. Five sample plants were randomly chosen from each plot for recording observations on some yield contributing characters viz. plant height (cm), number of total tillers hill^{-1}, number of effective tillers hill^{-1}, number of non-effective tillers hill^{-1}, panicle length (cm), number of spikelets panicle^{-1}, number of sterile spikelets panicle^{-1}, grain yield (t ha^{-1}), straw yield (t ha^{-1}). The collected data were analyzed statistically with the help of a computer package MSTAT. The mean differences among the treatments were adjudged with Duncan's Multiple Range Test (Gomez and Gomez, 1984).Genetic parameters were estimated according to the formula given by Johnson et al. (1955).

RESULTS AND DISCUSSION

Phenology of rice

Transplant Aman rice varieties under study differed for their phenology (Table 1). Among the varieties, local variety Bashiraj, BR11, BR22 reached to physiological maturity at 134 days and exotic variety IR64, Binadhan-7, BRRIdhan39 and BRRIdhan57 took 84 days. Binadhan-7, BRRIdhan39, BRRIdhan57, IR64 required same time in reaching booting stages at 49 DAT. Bashiraj reached to booting stages at 89 DAT. Heading and anthesis stage were earlier in case of Binadhan-7, BRRIdhan39, BRRIdhan57 and IR64 and those stages occurred at 51 DAT and 57 DAT, respectively. Bashiraj completed heading and anthesis stages at 92 DAT and 98 DAT, respectively.

Table 1. Phenology of transplant Aman rice varieties

Variety	Transplanting date	Days after transplanting			
		Booting	Heading	Anthesis	Physiological maturity
Bashiraj		89	92	98	134
BINAdhan-7		49	51	56	84
BR10		66	69	74	111
BR11		89	92	98	134
BR22		89	92	98	134
BR23	3-Aug/2013	56	59	64	111
BRRIdhan32		56	59	64	111
BRRIdhan39		49	51	56	84
BRRIdhan49		56	59	64	111
BRRIdhan57		49	51	56	84
IR64		49	51	56	84

Chlorophyll content

Chlorophyll content varied among the varieties from 39.93 SPAD value to 34.90 SPAD value at 29 DAT (Table 2). Binadhan-7 recorded the highest value (39.93 SPAD value), while IR64 gave the lowest value (34.90 SPAD value) at 29 DAT (Table 2). In case of 39DAT, Binadhan-7 gave the highest value (44 SPAD value) and BR22 gave the lowest value (37.60 SPAD value) (Table 2). Chlorophyll content in case of 49DAT was not found significant.

Table 2. Chlorophyll content of Transplant Aman rice varieties at different DAT

Variety	Chlorophyll content (SPAD value)		
	29DAT	39DAT	49DAT
Bashiraj	36.37bc	38.50bc	42.6
Binadhan-7	39.93a	44.00 a	47.30
BR10	39.53a	41.73abc	45.23
BR11	38.30ab	42.20ab	46.67
BR22	34.93c	37.60c	41.37
BR23	37.37abc	40.20abc	44.30
BRRIdhan32	37.23abc	40.57abc	43.70
BRRIdhan39	38.27ab	41.73abc	45.37
BRRIdhan49	36.30bc	38.93bc	43.53
BRRIdhan57	37.47abc	38.00 c	40.70
IR64	34.90c	38.40bc	42.00
CV (%)	4.09	5.26	6.47
Level of significance	**	*	NS

In a column figurer with same letter or without letter do not differ significantly whereas figures with dissimilar letters differ significantly (as per DMRT). *indicates significant at 5% level of probability; **indicates significant at 1% level of probability; NS=Not-significant

Performance of yield and yield associated traits

Plant height is mostly governed by the genetic makeup of the cultivar, though environmental factors influence on it. This result is consistence with finding of Mohammad et al. (2002) who found genotypic variation for plant height. The tallest plant (143.2cm) was obtained from IR64 and the shortest (85.40cm) was found in Bashiraj (Table 3). Bashiraj (85.40 cm) was the shortest due to shorter internode length. The variety BR22 produced the highest number of total tillers hill^{-1} (11) and BR23, BRRIdhan32, BRRIdhan49 produced the same number of total tillers hill^{-1} (8) which is the lowest among all varieties (Table 3). Number of effective tillers hill^{-1}, number of non-effective tillers hill^{-1}, harvest index did not show significant variations. The longest panicle (28.37 cm) was obtained from BR10 and the shortest one (22.51 cm) was produced from Bashiraj (Table 3). However, Shriname and Muley (2003) observed that panicle length had no significant difference among the genotypes studied. On the other hand Sharma (2002) worked with fine grain rice and reported that there had been significant variation in panicle length. BR10 produced the highest number of filled grains panicle^{-1} (159.30) and the lowest one (48.00) was obtained from the variety Bashiraj (Table 4). BRRIdhan57 produced the highest number of sterile spikelets panicle^{-1} (24.33) and the lowest one (7.67) was produced by the variety IR64 (Table 4). The highest 1000-grain weight (23.07 g) was obtained in Bashiraj and the lowest one (18.80 g) was produced from BRRIdhan49. BR10 produced the highest grain yield (3.83 t ha^{-1}) and BR23 produced the lowest grain yield (1.5 t ha^{-1}). The highest straw yield (5.00 t ha^{-1}) was obtained from BR10 and the lowest one (2.17 t ha^{-1}) was found from BR22. The highest biological yield (8.50 t ha^{-1}) was observed in BR10 and the lowest one (3.83 t ha^{-1}) was produced by BR 23.

Table 3. Variability of grain yield and yield associated traits of transplant Aman rice

Variety	Plant height (cm)	No. of total tillers hill^{-1}	No. of effective tillers hill^{-1}	No. of non-effective tillers hill^{-1}	Panicle length (cm)	No. of spikelets panicle^{-1}	No. of sterile spikelets panicle^{-1}	1000- grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)
Bashiraj	85.4f	10.00ab	9.00	1.00	22.51g	48.00e	14.33bcd	23.07a	3.67ab	3.67abc	50.67
Binadhan-7	100cd	9.00ab	8.00	1.00	26.65b	138.70ab	19.00abc	21.42abc	3.17abc	4.33a	42.34
BR 10	107.8b	9.0ab	8.33	0.66	28.37a	159.30a	19.67ab	22.45ab	3.83a	5.00a	41.34
BR 11	102.1bc	8.33b	7.00	1.33	24.57de	149.70a	14.67bcd	20.78bcd	2.50bcd	3.50ab	48.48
BR 22	92.6c	11.00a	9.66	1.33	25.10cde	87.67cd	24.00a	21.38abc	2.50bcd	2.17c	53.33
BR 23	93.3dc	8.00 b	7.00	1.00	26.48bc	115.30bc	11.67cd	21.95ab	1.50d	2.33bc	38.73
BRRIdhan32	100.7c	8.00b	6.67	1.33	22.91fg	131.70ab	12.33bcd	21.17abc	2.50bcd	2.58bc	49.47
BRRIdhan39	98.3cde	9.00ab	7.33	1.67	23.74efg	76.67de	12.00bcd	21.68abc	2.17cd	2.67bc	45.15
BRRIdhan49	98cde	8.00b	7.33	0.67	24.18ef	113.30bc	23.67a	18.80e	3.50ab	4.33a	46.64
BRRIdhan57	95.3cde	10.00ab	9.00	1.00	25.74bcd	152.30a	24.33a	19.10de	3.50ab	4.50a	43.68
IR64	143.2a	10.00ab	9.00	1.00	22.63g	92.33cd	7.67d	19.72cde	2.67a-d	3.50abc	44.54
CV (%)	6.78	11.75	14.92	77.68	3.29	16.14	24.65	4.93	22.29	23.93	23.33
Level of significance	**	*	NS	NS	**	**	**	**	**	**	NS

In a column figurer with same letter or without letter do not differ significantly whereas figures with dissimilar letters differ significantly (as per DMRT).
*indicates significant at 5% level of probability; **indicates significant at 1% level of probability; NS=Not-significant

Table 4. Estimation of genetic parameters of T. Aman rice varieties based on their grain yield associated traits

Traits	Phenotypic variance (δ^2_p)	Genotypic variance(δ^2_g)	Heritability (%)	Genetic advance (GA)
Plant height (cm)	256.36	208.92	81.50	26.88
No. of total tillers hill^{-1}	2.15	0.56	26.16	0.79
No. of effective tillers hill^{-1}	1.47	1.29	87.91	2.20
No. of non-effective tillers hill^{-1}	0.57	0.25	44.19	0.69
Panicle length (cm)	3.94	3.28	83.12	3.40
No. of spikelet's panicle^{-1}	1491.81	1147.26	76.90	61.19

Genetic analysis of yield and yield associates

The highest phenotypic variance (1491.81) and genotypic variance (1147.26) was obtained from spikelets panicle^{-1}, and the lowest phenotypic variance (0.57) and genotypic variance (0.25) was obtained from non-effective tillers hill^{-1}. The estimates of heritability act as predictive instrument in expressing the reliability of phenotypic value. Heritability was classified as low (below 30%), medium (30-60%) and high (above 60%) as suggested by Johnson et al. (1955). Among the traits, highest heritability was recorded by effective tillers hill^{-1} (87.91%) and the lowest heritability value was recorded by total tiller number hill^{-1} (26.16%) (Table 4). In the present study genetic advance was the highest for number of spikelets panicle^{-1} (61.19) and the lowest for non-effective tiller number hill^{-1} (0.69) among yield contributing traits (Table 4). Babu et al. (2012) also found the highest genetic advance for number of spikelets panicle^{-1} and highest genetic advance as percent of mean in case of number of sterile spikelets panicle^{-1}.

CONCLUSIONS

The results of this research indicated that considering the entire yield contributing characters the variety BR10 produced maximum grain yield and followed by Basiraj and BRRIdhan49 and BRRIdhan57. In order to improve grain yield the characters spikelets per panicle, plant height, panicle length, number of effective tiller per hill are more responsible. The characters spikelets per panicle, number of sterile spikelets per panicle, plant height and panicle length are attributed to additive gene effects which indicating that improvement in theses character is possible through hybridization followed by selection. The character number of effective and non-effective tiller per hill with high heritability with low genetic advance indicating the character is influenced by environmental effects and selection may not be useful.

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