Bangladesh Agron. J. 2016, 19(1): 59-66

YIELD OF INBRED AND HYBRID RICE AS AFFECTED BY CLONAL TILLERS OF SUCCESSIVE GENERATION

P. K. Hore[1*], P. K. Biswas[1], A. K. M. R. Amin[1], Raziuddin[2], M. S. Mahmud[3] S. M. Mohsin[4]

[1] Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh
[2]Scientific Officer, Regional Agricultural Research Station, BARI, Rahamatpur, Barishal, Bangladesh
[3]Research Associate, Collection, Evaluation and Introduction of White Maize for Human Consumption in Bangladesh, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh
[4]Department of Plant Pathology, Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh
*Corresponding Author: shuvosau@gmail.com

Key Words: Yield, clonal tillers, rice
Key Words: Inbred, hybrid, clonal tillers, yield

Abstract

A field experiment was conducted at the Agronomy field, Sher-e-Bangla Agricultural University, Dhaka from November 2012 to July 2013. Experiment consisted of two factors, viz. (i) variety- BRRI dhan29 (V_1) and BRRI hybrid dhan2 (V_2), and (ii) planting materials- nursery seedlings (N), first generation clonal tillers (C_1) collected from N, second generation clonal tillers (C_2) collected from C_1, third generation clonal tillers (C_3) collected from C_2 and fourth generation clonal tillers (C_4) collected from C_3, following split-plot design with three replications. Results revealed that despite higher (161.29) number of filled grains as obtained from BRRI dhan29 while lower (139.31) from BRRI hybrid dhan2, and maximum weight of 1000-grains (26.50 g) from hybrid variety and the minimum from the inbred one (19.70 g), the grain yield was not varied significantly. Among the planting materials nursery seedlings gave the maximum (9.23 t ha^{-1}) grain yield that followed by first generation clonal tillers (7.44 t ha^{-1}), and second generation clonal tillers (6.57 t ha^{-1}). The third and fourth generation clonal tillers also produced around 3 t ha^{-1} grain yield. The maximum grain yield (9.6 t ha^{-1}) was observed from the combination of nursery seedlings with BRRI hybrid dhan2 which is statistically similar to the combination of same planting material with BRRI dhan29 (8.86 t ha^{-1}). The first and second generation clonal tillers of both the varieties produced more than 6.0 t ha^{-1} grain yield. Therefore, clonal tillers can be used as planting materials for both hybrid and inbred rice cultivation in case of scarce supply of nursery seedlings.

Introduction

Bangladesh is the fourth highest rice (*Oryza sativa* L.) producing country in the world (FAO, 2013). About 76.71% of the total cropped area was planted with rice in 2012-13. 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, the country is now producing about 34.00 million tons to feed her 149.69 million people (Mondal and Choudhury, 2014). Rice yield therefore, needs to be increased from the present 2.74 to 3.74 t ha^{-1} (BRRI, 2011) but there is a little scope to increase rice area. Moreover, the arable land is decreasing at the rate of 1% per annum (BBS, 2011). In such situation, there is no other alternative rather than development and adoption of yield enhancing technologies. To get higher productivity, hybrid rice is an important option which contribute 20-30% yield advantage over inbred varieties (Julfiquar *et al.*, 2009). Hossain *et al.* (2003) reported that hybrid rice has the potentiality to increase 15-20% yield but it costs about 19% higher compared to inbred rice of which seed cost is the prime issue. Among different groups of rice, *boro* season covers

about 43.57% of total rice area which contributes 61.33% of the total rice production (BBS, 2008), but this rice production is affected by various biotic and abiotic constraints. Damage of seedling in the seedbed due to cold has been identified as a constraint. In this perspective separation of tillers from rice plants could escape cold damage and replanting of the separated tillers to the new rice fields may be vital alternatives for growing *boro* rice (Mamun *et al.*, 2012). The detached tillers can be used as seedling, especially during scarcity of seedlings after flood or any other natural hazards (Biswas, 2001). It is possible to transplant the separated tillers in the prepared main field those have the potentiality to produce yield as main crop (Debnath, 2010). Beside this, use of rice clonal tillers might be an option for maximum yield and reduce seed cost especially hybrid rice (Debnath, 2010). As hybrid rice seeds are costly and scarce, successful use of their clonal tillers can help to reduce seed cost as well as expansion of hybrid rice cultivation area in Bangladesh. On the other hand, the potentiality of inbred clonal tillers is reported by many researchers (Biswas, 2001; Biswas and Saloke, 2001; Parveen *et al.*, 2008; Hossain *et al.*, 2011; Sarkar *et al.*, 2011; Alim and Sheuly, 2012). Therefore, the present study with an inbred and a hybrid variety of *boro* rice was undertaken to compare the yield performance of the crop grown from their inbred and hybrid clonal tillers of successive generation and nursery seedlings.

Materials and Methods

The experiment was conducted at the Agronomy field of Sher-e-Bangla Agricultural University, Dhaka-1207 during the period from December 2012 to July 2013. The experimental area was situated at 23°77′N latitude and 90°33′E longitude at an altitude of 8.6 meter above sea level (Anon., 2004) belongs to the Agro-ecological zone of "The Modhupur Tract", AEZ-28 (Anon., 1988). The experiment was comprised of variety (V_1 = BRRI dhan29 and V_2 = BRRI hybrid dhan2) and planting materials (N= nursery seedlings, C_1 = first generation clonal tillers collected from, C_2 = second generation clonal tillers collected from C_1, C_3 = third generation clonal tillers collected from C_2 and C_4 = fourth generation clonal tillers collected from C_3). The experiment was laid in a split-plot design with three replications having variety in the main plots and planting materials in the sub-plots. The size of unit plot was 5.0 m by 2.0 m. Seeds were sown on the seedbed on November 12, 2013 for raising nursery seedlings. 33 days old nursery seedlings were uprooted carefully on December 15, 2012 and were kept in soft mud in shade**.** The seedlings were then transplanted with 25 cm × 15 cm spacing on the well-puddled plots. Two sub-plots in each main plot was transplanted with nursery seedlings of which the entire hills of one plot was uprooted and splitted for using as first generation clonal tilletrs. The separated tillers were then re-transplanted as per treatment having one clonal tiller per hill on 30 January, 2013. Second generation (C_2) clonal tillers were separated from C_1 plants at 30 DAT and the separated tillers were then re-transplanted as per treatment having one clonal tiller hill^{-1} on 2 March, 2013. Third generation (C_3) clonal tillers were separated from C_2 plants as earlier at 25 DAT and the separated tillers were then re-transplanted as per treatment having one clonal tiller per hill on 27 March, 2013. Lastly the fourth generation (C_4) clonal tillers were separated from C_3 plants at 20 DAT and the separated tillers were then re-transplanted as per treatment having one clonal tiller hill^{-1} on 17 April, 2013. Before re-transplanting, the individual plots were spaded properly for well puddle and an extra dose of urea (one third of basal) was top dressed after seven days of re-transplanting on uprooted plots and entire basal dose for newly transplanted plots. Maturity of crop was determined when 90% of the grains become golden yellow in color. The harvesting of BRRI dhan29 was done on May 12; Jun 3; Jun 14; Jul 1, 2013 for nursery seedlings (N) and first generation clonal tiller (C_1); second generation clonal tiller (C_2); third generation clonal tiller (C_3) and fourth generation

clonal tiller (C_4), respectively and the harvesting of BRRI hybrid dhan2 was done on May 4; May 21; Jun 14; Jul 1, 2013 for nursery seedlings (N) and first generation clonal tiller (C_1); second generation clonal tiller (C_2); third generation clonal tiller (C_3) and fourth generation clonal tiller (C_4), respectively. The grains were cleaned and sun dried to moisture content of about 12%. Straw was also sun dried properly. Finally grain and straw yields plot^{-1} were recorded and converted to t ha^{-1}. All the data collected on different parameters were statistically analyzed and the mean differences were adjudged by least significant difference (LSD) test at 5 % level of significance (Gomez and Gomez, 1984).

Results and Discussion

Effect of variety

Among yield contributing characters related to grain yield. panicle length, filled and unfilled grains panicle^{-1}, and weight of 1000-grain were significantly influenced by the variety (Table 1). The highest (26.79 cm) and lowest (22.77 cm) panicle length were obtained from BRRI dhan29 and BRRI hybrid dhan2, respectively. Ahmed (2010) also observed maximum panicle length in BRRI dhan29 than hybrid variety and Debnath (2012) found the highest panicle length in BRRI dhan29 and lowest in BRRI hybrid dhan2 among other varieties. The number of filled grains panicle^{-1} differed significantly for variation of the variety. Higher number of filled grains panicle^{-1} (161.29) was found from inbred variety BRRI dhan29 and lower number of filled grains panicle^{-1} (139.31) from BRRI hybrid dhan2. Higher number of unfilled grains panicle^{-1} (51.53) was found from inbred variety BRRI dhan29 and lower number of unfilled grains panicle^{-1} (8.52) from BRRI hybrid dhan2. This finding similar with Debnath (2010) who found the highest number of unfilled grains panicle^{-1} from the inbred variety BRRI dhan29 than hybrid variety BRRI hybrid dhan2 though Obaidullah (2007) observed the highest number of unfilled grains panicle^{-1} in the hybrid variety and the lowest in the inbred variety. The maximum (26.50 g) weight of 1000-grains was obtained from BRRI hybrid dhan2 and the minimum (19.70 g) weight from BRRI dhan29. The result supports the findings of Obaidullah (2007), Ashrafuzzaman (2006) and Debnath (2010) who found the highest weight of 1000-grains in hybrid variety than the inbred variety BRRI dhan29.

Table 1. Effect of variety on yield and other crop characters related to yield of two rice varieties

Treatments	Effective tillers (no. m^{-2})	Ineffective tillers (no. m^{-2})	Panicle length (cm)	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1} (no.)	1000-grains weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)
V_1	234.27	24.99	26.79a	161.29a	51.53a	19.70b	6.05	5.59	52.26
V_2	218.59	18.66	22.77b	139.31b	8.52b	26.50a	6.01	5.5	51.48
LSD $_{(0.05)}$	NS	NS	0.591	7.978	15.150	0.486	NS	NS	NS
CV (%)	23.87	52.98	1.54	3.38	32.11	1.34	5.08	7.80	4.27

V_1 = BRRI dhan29, V_2 = BRRI hybrid dhan2

Effect of planting material

Yield and other characters such as ineffective tillers m^{-2}, panicle length, filled and unfilled grains panicle^{-1}, and weight of 1000-grains were significantly influenced by the planting

material (Table 2). The maximum (33.44) ineffective tillers m^{-2} was obtained from C_1 which was statistically similar with nursery seedlings N (30.80) and the lowest (12.32) number in C_4 which was statistically similar with C_3 (15.84) and C_2 (16.72). Debnath (2012) also observed highest ineffective tillers m^{-2} in nursery seedlings compared to clonal tillers though Ahmed (2010) found higher ineffective tillers m^{-2} in clonal tillers compared to nursery seedlings. The maximum (25.72 cm) panicle length was observed from C_1 which was statistically similar with C_2 (25.67 cm) and nursery seedlings (24.88 cm), and the lowest (23.72 cm) from C_4 which was statistically similar with C_3 (23.92 cm) and nursery seedlings (24.88 cm). Paul (1999) and Rahman (2001) found that nursery seedlings gave the longest panicles compared to the clonally propagated tillers. The maximum (171.60) number of filled grains $panicle^{-1}$ was observed in C_1 which was statistically similar with C_2 (168.60) and the lowest (128.20) number in C_4 which was statistically similar with C_3 (139.80). The maximum (42.65) number of unfilled grains $panicle^{-1}$ was observed in C_1 which was statistically similar with C_4 (37.83) and the lowest (19.75) number from C_3 which was statistically similar with C_2 (21.60) and nursery seedlings (28.30). The maximum 1000-grains weight (24.62 g) was obtained from C_1 which was statistically similar with nursery seedlings (24.40 g) and the lowest (21.60 g) from C_4 which was statistically similar with C_3 (22.37 g). The highest (9.23 t ha^{-1}) grain yield was obtained from the nursery seedlings (N) and the lowest (2.97 t ha^{-1}) in C_3. The yield reduction of clonal tillers than nursery seedlings was 19.39, 28.82, 67.827 and 57.62% for C_1, C_2, C_3 and C_4, respectively. The reduction of yield in clonal tillers compared to nursery seedlings might be due to the removal of tillers from the mother plant (Murthy *et al*., 1991). The highest (8.27 t ha^{-1}) straw yield was obtained from the nursery seedlings (N) and the lowest (2.82 t ha^{-1}) in C_3. Debnath (2012), Obaidullah (2007) and Ahmed (2007) also found higher grain and straw yield in nursery seedlings than clonal tillers of first generation.

Table 2. Effect of planting material on yield and other crop characters related to yield of two rice varieties

Treatments	Effective tillers (no. m^{-2})	Ineffective tillers (no. m^{-2})	Panicle length (cm)	Filled grains $panicle^{-1}$ (no.)	Unfilled grains $panicle^{-1}$ (no.)	1000-grains weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)
N	224.4	30.80a	24.88b	143.30b	28.30bc	24.40a	9.23a	8.26a	52.73
C_1	237.6	33.44a	25.72a	171.60a	42.65a	24.62a	7.44b	6.87b	52.06
C_2	214.7	16.72b	25.67a	168.60a	21.60c	22.53b	6.57c	6.07c	52.03
C_3	208.6	15.84b	23.92b	139.80bc	19.75c	22.37bc	2.97e	2.82e	51.34
C_4	246.9	12.32b	23.72b	128.20c	37.83ab	21.60c	3.91d	3.69d	51.20
$LSD_{(0.05)}$	NS	12.370	1.216	14.258	12.617	0.780	0.59	0.63	NS
CV (%)	20.28	46.33	4.01	7.75	34.33	2.75	8.09	9.27	5.44

N = Nursery seedlings, C_1 = First generation clonal tillers collected from N, C_2 = Second generation clonal tillers collected from C_1, C_3 = Third generation clonal tillers collected from C_2, C_4 =Fourth generation clonal tillers collected from C_3, NS = Not significant

Interaction effect of variety and planting material

Yield and all other crop characters related to yield was significantly influenced by the interaction effect of variety and planting material (Table 3). The maximum number of effective tillers m^{-2} (260.5) was observed in C_1 of the inbred variety (V_1) which was statistically similar with C_2 (253.4), N (241.1) C_4 (231.5), and C_3 (184.8) of the inbred variety

(V_1) and C_3 (232.3), C_1 (214.7) and N (207.7) of the hybrid variety (V_2). Lower number of effective tillers m^{-2} (176.0) was obtained from C_2 of the hybrid variety (V_2) which was statistically similar with C_3 (184.8), C_4 (231.5), N (241.1), C_2 (253.4) and of the inbred variety (V_1) and C_3 (232.3), C_1 (214.7) and N (207.7) of the hybrid variety (V_2). Debnath (2012) also observed combination of clonal tiller with BRRI dhan29 produce more effective tillers m^{-2} than combination with nursery seedlings of the same variety. The maximum (44.00) number of ineffective tillers m^{-2} was observed in nursery seedlings of the inbred variety (V_1) which was statistically similar with C_1 (33.44) of the same variety and C_1 (33.40) of the hybrid variety (V_2). The lowest number (8.80) of ineffective tillers m^{-2} was obtained from C_4 of the hybrid variety (V_2) which was statistically similar with C_2 (12.30), C_4 (15.84), and C_3 (19.36) of the inbred variety (V_1) and C_3 (12.32), N (17.6) and C_2 (21.12) of the hybrid variety (V_2). Debnath (2010) also found the highest ineffective tillers m^{-2} in combination of nursery seedlings with BRRI hybrid dhan2. The highest (25.72 cm) panicle length was observed in C_4 (28.57 cm) of the inbred variety (V_1) and the lowest ((18.87 cm) in C_4 of the hybrid variety (V_2).

Table 3. Interaction effect of variety and planting material on yield and other crop characters of two rice varieties

Treatments	Effective tillers (no. m^{-2})	Ineffective tillers (no. m^{-2})	Panicle length (cm)	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1} (no.)	1000-grains weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)
V_1N	241.1ab	44.00a	26.20bc	139.7c	47.67bc	21.13c	8.86a	8.38a	51.46ab
V_1C_1	260.5a	33.44ab	26.67b	166.6ab	77.00a	21.19c	7.23b	7.04b	50.76ab
V_1C_2	253.4ab	12.32c	26.47bc	170.4a	36.90c	19.07d	6.22c	5.44c	53.22ab
V_1C_3	184.8ab	19.36bc	26.03bc	145.7c	31.23c	19.20d	3.39e	2.94e	53.77ab
V_1C_4	231.5ab	15.84c	28.57a	184.0a	64.87ab	17.89e	4.55d	4.16d	52.10ab
V_2N	207.7ab	17.60bc	23.57d	146.8bc	8.933d	27.66a	9.60a	8.18a	54.00a
V_2C_1	214.7ab	33.44ab	24.77cd	176.6a	8.300d	28.05a	7.67b	6.71b	53.36ab
V_2C_2	176.0b	21.12bc	24.87cd	166.8ab	6.300d	25.98b	6.94c	6.72b	50.83ab
V_2C_3	232.3ab	12.32c	21.80e	133.9c	8.267d	25.53b	2.57e	2.70e	48.90b
V_2C_4	262.2a	8.80c	18.87f	72.43d	10.80d	25.30b	3.28e	3.22e	50.31ab
LSD $_{(0.05)}$	79.5	17.5	1.72	20.17	17.84	1.1	0.8444	0.891	4.88
CV (%)	20.28	46.33	4.01	7.75	34.33	2.75	8.09	9.27	5.44

V_1 = BRRI dhan29, V_2 = BRRI hybrid dhan2 , N = Nursery seedlings, C_1 = First generation clonal tillers collected from N, C_2 = Second generation clonal tillers collected from C_1, C_3 = Third generation clonal tillers collected from C_2, C_4 =Fourth generation clonal tillers collected from C_3

The maximum (184.90) number of filled grains panicle^{-1} was observed in C_4 of the inbred variety (V_1) which was statistically similar with C_2 (170.40) and with C_1 (166.60) of the inbred variety (V_1) while lowest (72.43) from C_4 of the hybrid variety (V_2). Higher (77.00) number of unfilled grains panicle^{-1} was observed in C_1 of the inbred variety (V_1) which was statistically similar with C_4 (64.87) of the inbred variety (V_1). The lowest (6.30) number of unfilled grains panicle^{-1} was obtained from C_2 of the hybrid variety (V_2) which was statistically similar with C_3 (8.26), C_1 (8.30), N (8.93) and C_4 (10.80) of the hybrid variety (V_2). Debnath (2010) also observed similar result. The maximum 1000-grains 928.05g) was obtained from C_1 of the hybrid variety (V_2) which was statistically similar with nursery seedlings (27.66 g) of the hybrid variety (V_2) and the lowest ((17.89 g)) from C_4 of the inbred variety (V_1). Among the treatments, the maximum (9.60 t ha^{-1}) grain yield was observed in nursery seedlings of the

hybrid variety (V_2), which was statistically similar with nursery seedlings (8.86 t ha^{-1}) of the inbred variety (V_1). The lowest (2.57 t ha^{-1}) grain yield was observed in C_3 of the hybrid variety (V_2) which was statistically similar with C_4 (3.28 t ha^{-1}) of the same variety (V_2), and with C_3 (3.39 t ha^{-1}) of the inbred variety (V_1). Higher straw yield (8.36 t ha^{-1}) was observed in nursery seedlings (N) of the inbred variety (V_1), which was statistically similar with nursery seedlings (8.18 t ha^{-1}) of the hybrid variety (V_2). The lowest straw (2.70 t ha^{-1}) yield was observed in C_3 of the hybrid variety (V_2) which was statistically similar with C_3 (2.94 t ha^{-1}) of the inbred variety (V_1) and C_4 (3.22 t ha^{-1}) of the hybrid variety (V_2).

Conclusion

The results of the experiment revealed that the yield of rice was identical between the inbred variety BRRI dhan29 and hybrid variety BRRI hybrid dhan2 though the crop grown from nursery seedlings produced the highest yield over that from the clonal tillers of successive generations. The highest grain yield and harvest index (9.60 t ha^{-1} and 54.00%, respectively) were observed from nursery seedlings of BRRI hybrid dhan2 and the lowest from third generation clonal tillers of BRRI hybrid dhan2 (2.57 t ha^{-1} and 48.90%, respectively). So the clonal tillers can be used up to second generation with little sacrifice of yield irrespective of inbred and hybrid rice.

References

Ahmed, Q. N. and P. K. Biswas. 2010. Different cultivation methods of paddy: New scopes for Bangladesh, A comparative study of different cultivation methods on inbred and hybrid rice. VDM Verlag Dr. Muller Aktiengesellschaft & Co. KG, Dudweiler Landstr. 99, 66123 Saarbrucken, Germany.

Ahmed, Q. N., P. K. Biswas and M. H. Ali. 2007. Influence of cultivation methods on the yield of inbred and hybrid rice. Bangladesh J. Agric. 32(2): 65-70.

Alim, M. A. and M. S. Sheuly. 2012. Effect of time of tiller separation on grain growth and seed yield of transplant aman rice. J. Sci. Found. 10(1): 12-19.

Anonymous. 1988. The Year Book of Production. FAO, Rome, Italy.

Anonymous. 2004. Annual Internal Review for 2000-2001. Effect of seedling throwing on the grain yield of wart land rice compared to other planting methods. Crop Soil Water Management Program, Agron. Division, BRRI, Gazipur.

Ashrafuzzaman, M. 2006. Influence of tiller separation days on yield and yield attributes of inbred and hybrid rice. M.S. Thesis. Dept. of Agron., SAU, Dhaka.

Babiker, F. S. H. 1986. The effect of zinc sulphate levels on rice growth and productivity. Alexandria J. Agril. Res. 31(2): 480-481.

Bari, S. M. W. 2004. Effect of method of planting and weeding on the yield and yield contributing characters of aman rice cv. BRRI dhan 32. M. S. Thesis. Dept. of Agron., BAU, Mymensingh.

BBS (Bangladesh Bureau of Statistics). 2008. Statistical Yearbook of Bangladesh for 2008.

BBS (Bangladesh Bureau of Statistics). 2011. Statistical Yearbook of Bangladesh for 2011.

Biswas, P. K. 2001. Tiller dynamics and yield of parent and clonal plant of transplanted rice. Doctoral Dissertation. School of Environment, Resources and Development, AIT, Thailand.

Biswas, P. K., and V. M. Salokhe. 2001. Effects of planting date, intensity of tiller separation and plant density on the yield of transplanted rice. J. Agril. Sci. Camb. 137(3): 279-287.

BRRI, 2011. Bangladesh Rice Knowledge Bank. Internet Edition. http://www.knowledgebank-brri.org/riceinban.php. Accessed in December, 2011.

Debnath, A. 2010. Influence of planting material and variety on yield of boro rice. M.S. Thesis. Dept. of Agron., SAU, Dhaka.

Debnath, A., P. K. Biswas, M. S. A. Sardar and A. Rahman. 2012. Influence of mother and clonal tillers on yield and performance of inbred and hybrid boro rice. Bangladesh Agron. J. 15(1): 1-7.

Donald, C. M. 1963. Competition among crops and pasture plants. Adv. Agron. 15: 11-18.

FAO (Food and Agriculture Organization). 2013. FAO Statistics. Internet Edition. http://faostat.fao.org/site/339/default.aspx. Accessed in October, 2013.

Gardner, F. P., R. B. Pearce and R. L. Mistechell. 1985. Physiology of Crop Plants. Iowa State Univ. Press, Powa. p. 66.

Gomez, K. A. and A. A. Gomez. 1984. Statistical procedure for agricultural research. 2nd Edn. Intl. Rice Res. Inst., John Wiley and Sons. New York. Pp. 1-340.

Hossain, M. A., M. A. R. Sarkar and S. K. Paul. 2011. Growth analysis of late transplant aman rice (cv. BR23) raised from tiller seedlings. Libyan Agric. Res. Cen. J. Intl. 2(6): 265-273.

Hossain, M., A. Janaiah and M. Husain. 2003. Hybrid rice in Bangladesh-Farm level performance. Economic and Political weekly, June 21.

IRRI. 2013. Internet Edition. http://irri.org/our-impact/increase-food-security. Accessed in August, 2013.

Julfiquar, A. W., S. S. Virmani., M. M. Haque., M. A. Mazid and M. M. Kamal. 2009. Hybrid rice in Bangladesh: opportunities and challenges. Rice research for food security and poverty allevation. Proc. Int. Rice Research Conference.

Main, M. A. 2006. Influence of planting material and planting methods on yield and yield attributes of inbred and hybrid rice. M.S. Thesis. Dept. of Agron., SAU, Dhaka.

Mamun, M. A. A., R. Shultana., B. C. Roy., M. M. Rana., A. Parvez and A. J. Mridha. 2012. Effect of transplanting with separated tillers and planting time on the performance of *boro* rice. Bangladesh Agron. J. 15(2): 83-88.

Mondal, M. R. I. and D. A. Choudhury. 2014. Agronomic Visions for Sustainable Food Security. Keynote paper presented at the 13th Biennial Conference of the Bangladesh Society of Agronomy. Pp. 26-29.

Murthy, P. S. S., P. J. R. Reddy and S. S. R. Prasad. 1991. Effect of grain yield of shoot removal at different stage of aman rice crop growth. Intl. Rice Res. Newsl. 16(3): 10.

Obaidullah, M. 2007. Influence of clonal tiller age on growth and yield of aman rice varieties. M.S. Thesis. Dept. of Agron., SAU, Dhaka.

Parveen, S., M. P. Anwar., S. M. A. Hossain., L. H. Abru and T. Yeasmin. 2008. Yield ability of tillers separated from T. aman rice cv. BRRI dhan41. J. Agrofor. Environ. 2(2): 171-175.

Paul, S. K. 1999. Effect of row management and tiller separation on the growth and yield of transplant aman rice. M.S. Thesis. Dept. of Agron., BAU, Mymensingh, Bangladesh.

Rahman, M. S. 2001. Effect of tiller plantation on the performance of transplant aman rice. M.S. Thesis. Dept. of Agron., BAU, Mymensingh, Bangladesh.

Sarkar, M. A. R., M. A. Hossain and S. K. Paul. 2011. Effect of row arrangement, age of tiller seedling and number of tiller seedlings per hill on performance of transplant aman rice. J. Agric. Sci. 6(2): 59-68.