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ORIGINAL RESEARCH ARTICLE

Evaluation of yield performance and establishment methods of drought tolerant rice genotypes under rainfed condition in drought prone areas of Bangladesh

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ABSTRACT

Two field experiments were carried out at farmer's field of Rajshahi and Chapainawabgonj under the Department of Agronomy, BINA during aman season of 2017 and 2018 consecutively to evaluate the drought tolerant rice varieties under different establishment methods in rain fed condition. First experiment (E1) was conducted to find out the performance of varieties and second experiment (E2) was to find out the suitability of method of transplanting/sowing in combination with short duration aman varieties. Different methods were as direct seeding, puddled and un-puddled transplanting and cultivars were used to cultivate BRRI dhan56, Binadhan-7, Binadhan-17 (except in second experiment) and Huttra (local cultivar). The experiment was laid out in a randomized complete block design with three replications. The recommended fertilizer doses applied for the experiment were 80 kg N ha^{-1}, 15 kg P ha^{-1}, 50 kg K ha^{-1}, 20 kg S ha^{-1} and 2 kg Zn ha^{-1}. Nitrogen, phosphorus, potassium, sulphur and zinc were supplied from urea, TSP, MoP, gypsum and zinc sulphate monohydrate respectively while urea was applied in three equal splits. Among the cultivar Binadhan-17 produced statistically higher grain yield (5.62 t ha^{-1}) at Chapainawabgonj. Among methods Binadhan-7 statistically higher grain yield 5.32 t ha^{-1} and 5.21 t ha^{-1}, respectively) in puddle transplanting method both Chapainawabgonj and Rajshahi region during 2017. Among the cultivar Huttra (local) produced statistically higher grain yield (5.43 t ha^{-1}) at Chapainawabgonj. Among methods, BRRI dhan56 statistically higher grain yield 6.37 t ha^{-1} and 6.19 t ha^{-1}, respectively) in puddle transplanting method bothat Rajshahi and Chapainawabgonj during 2018. Overall results indicates that BRRI dhan56, Binadhan-7, Binadhan-17 performed better in puddled transplanting, Huttra (local) in direct seeding method in drought prone region of Bangladesh.

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INTRODUCTION

Drought is an important limiting factor for rice productivity in Barind area of Bangladesh. Increasing irrigation area generally not economically viable option for alleviating drought problems in rainfed rice-growing systems. The impact of drought has recently become a major research topic, stressed by the rapid change of climatic parameters that creates pressure on agro-ecosystem in Bangladesh. Climate change is predicted to increase the frequency and severity of drought, which will likely result in increasingly serious constraints to rice production worldwide (Wassmann *et al.*, 2009). Majority of freshwater withdrawals for agricultural purposes, water sources being drawn down faster than they are being replenished in Barind tract of Bangladesh. Utilization of rain waters strategic approaches to improving agricultural water management. Developing regions where irrigation is occurring, many aspects of industrial agriculture in the first world are unsustainable (Horrigan *et al.*, 2002). Evaluation of water management in agricultural development must account for inevitable negative

impacts on the environment (Wichelns *et al.*, 2006). Sustainable irrigation practices are site specific, depends on climate, soil topography, and water table, while energy costs and groundwater depletion are concerned issues for rice production in Bangladesh. Improvements in crop water productivity may decreases in water use because agriculture accounts for the largest quantity of water use. With water use efficiency ranging between 10% and 30% for rainfed and between 40% and 95% for irrigated agriculture (Laraus, 2004; Causapé *et al.*, 2006; Falkenmark *et al.*, 2006) there is nearly always opportunity for improvement. At the national or global scale, agricultural water use efficiency can be improved by growing more food in high water productivity regions and exporting to less productive regions (Yang *et al.*, 2006). Drought can occur at any stage of the rice crop in any year in rainfed areas which causes a significant yield reduction. Higher leaf rolling, reduction in spikelet fertility, and reduction in grain yield are some of the major phenotypic changes in rice plants under drought stress (Bhattarai and Subudhi 2018). The main agricultural challenges have already target for agronomic management is indeed influencing utilization of rain water for drought prone areas during aman season in Bangladesh. Enhance food security through the sustainable and productive management of water in agriculture is critically issues. Selection of appropriate genotypes for drought on maximum extraction of available soil moisture, nutrients and its efficient use in crop stand establishment and growth to maximize biomass and yield. Methods for improved on-farm agricultural water management include supplementing rainfed crops, irrigation scheduling, and efficient irrigation methods (Scanlon *et al.*, 2007). Therefore the present investigation was undertaken to compare the performance of some varieties (from research organizations *viz.*, BINA, BRRI) with popular local cultivar with various establishment methods in drought prone areas in Bangladesh.

MATERIALS AND METHODS

Experimental design and layout

The experiment was carried out at the farmer's field during aman season in 2017 and 2018. The location of the experiment was in Godagari Rajshahi (L_1) (Latitude 25.651544, Longitude 88.313313) and Amnura, Chapainawabgonj (L_2) (Latitude 24.462217, Longitude 88.332206). Experiment laid out in a factorial Randomized Complete Block Design with three treatment, combinations in three replications. The unit plot size was 5m × 4m. Row and hill spacing was 20cm × 15cm. As treatments, methods were used direct seeding(M_1), puddled transplanting (M_2) and un-puddled transplanting(M_3) and cultivars were BRRI dhan56(V_1), Binadhan-7(V_2), Binadhan-17(V_3) and local cultivar Huttra (V_4).

Soil and climate

The soil of the experimental sites are under "High Barind Tract" Agro ecological Zone (AEZ 26) (UNDP and FAO, 1988). The soils include paddled silt loam to silty clay loam in the top soils and porous silt loam with mottled plastic clay at varying depth. Deep Grey Terrace soils and Grey Valley soils are the major components of general soil types of this area. During the growing period of rice, minimum and maximum temperature 20 and 37°C respectively. The average relative humidity varied from 49 to 77% and rainfall condition is depicted on the Figure 1.

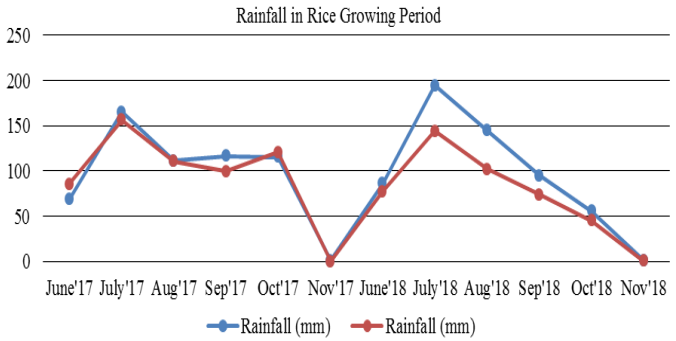

Figure 1. *Rainfall in rice growing period.*

Land preparation and fertilization

Direct seeded plot was only cross ploughed and laddered. For un-puddled plot, land was prepared by deep and cross ploughing with a tractor by disc and rotavetor followed by laddering. After two weeks the land was prepared with power tiller and level by a power tiller drawn leveler (puddle land). Ridges were made around each plot to restrict the lateral run-off of irrigation water. During final land preparation cow dung was incorporated into soil at the rate of 5 t ha^{-1}. A blanket fertilizer dose of 100 kg N ha^{-1}, 20 kg P ha^{-1}, 50 kg K ha^{-1}, 20 kg S ha^{-1} respectively Nitrogen, phosphorus, potassium, sulphur and zinc were supplied from urea, TSP, MoP and gypsum, respectively. One third of total urea and all other fertilizer were applied during final land preparation. The remaining amount of urea was applied as top dressing in two equal installments at vegetative (25 days after transplanting) and at after tillering stage (45 DAT).

Transplanting, intercultural operations and harvest

BRRI dhan 56 seeds were collected from GRS division, BRRI, Gazipur. Binadhan-7, Binadhan-17, Huttra (Local) from BINA and subjected to germination test. Seeds were soaked 24 hours before sowing. 25 days old rice seedling was transplanted, with two seedling $hill^{-1}$ on puddled soil and un-puddled soil. For direct seeded plot line sowing was done manually. Herbicide (Bensulfuron methyl 4% + Acetachlor 14%) were applied for preventing weed and manual weeding were completed at35DAT. Furadan (5G) was applied 10 kg ha^{-1} to control the infestation of stem borer at active tillering stage. After attaining 80% physiological maturity the rice varieties were harvested. The crops were threshed, cleaned, and processed. Yield and yield attributing characters data were recorded and analyzed by using statistical software "Statistix10".

Table 1. Evaluating the main effect of drought tolerant rice varieties in rain fed condition during aman season in 2017 and 2018.

Treatments	Plant height (cm)		Total tillers hill^{-1} (no)		Effective tillers hill^{-1} (no)		Panicle length (cm)		Filled grains panicle^{-1} (no.)		Unfilled grains panicle^{1} (no)		1000seed wt. (g.)		Grain yield (t ha^{-1})		Straw yield (t ha^{-1})	
	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
Locations																		
L_1	109.0	101.4	11.8	10.0	11.1	9.6	24.0	24.0	138.0	134.1	33.7	26.5	20.3	20.2	5.31	4.88	6.95	5.67
L_2	112.2	111.5	13.1	11.8	12.1	10.0	25.1	23.8	150.4	136.7	26.7	24.2	20.4	19.3	5.42	5.18	6.98	5.58
T value	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Varieties																		
V_1	123.6	110.0	11.5	10.7	10.7	8.4	24.5	24.9	107.1	134.6	24.1	18.7	20.9	19.6	4.86	4.89	6.53	5.56
V_2	108.0	99.3	14.6	12.3	13.4	12.2	26.5	25.1	104.8	103.5	29.0	17.1	19.5	21.2	5.21	4.91	6.91	5.55
V_3	103.3	102.0	10.7	10.7	10.2	9.6	24.1	23.1	149.4	123.3	33.8	33.0	20.5	18.8	5.46	5.09	7.09	5.79
V_4	107.5	114.5	13.0	9.0	8.6	8.1	23.2	22.7	195.3	180.2	33.7	32.6	20.5	19.5	5.29	5.25	7.32	5.61
$LSD_{0.05}$	2.8	6.8	3.4	1.5	2.9	1.2	1.3	1.1	18.1	31.1	9.0	13.1	1.0	2.7	0.27	0.30	NS	NS
CV%	2.1	5.4	22.1	11.3	20.3	10.7	4.3	3.8	10.2	18.5	24.2	14.1	4.1	11.3	4.10	12.6	4.43	7.4

N. B. Rajshahi (L_1), Chapainaw. (L_2), BRRI dhan56 (V_1), Binadhan-7 (V_2), Binadhan-17 (V_3), Huttra (V_4).

RESULTS AND DISCUSSION

Result of the experiment on performance of varieties (E1)

Plant height: There was a statistically significant difference in plant height among genotypes. The highest plant height (123.6 cm) was observed at BRRI dhan 56 and the lowest plant height (103.3 cm) at Binadhan-17 (for the experiment of 2017). In the experiment of 2018, the highest plant height (114.5 cm) was observed at Huttra and the lowest plant height (99.3 cm) at Binadhan-7 (Table 1). Hossain *et al.* (2014) found that, the variation in plant height was observed due to the variation in genetic variability and adaptability in studied area.

Total and effective tillers hill^{-1}: There were significantly difference of total tillers and effective tillers hill^{-1} among genotypes. The highest number of total tillers hill^{-1} 14.6 was observed at Binadhan-7 (Table 1). The highest number of effective tillers hill^{-1} 13.4 was observed at Binadhan-7 during 2017. The highest total tillers hill^{-1} 12.3 was observed at Binadhan-7 and the lowest total tillers hill^{-1} 9.0 at Huttra. The highest effective tillers hill^{-1} 12.2 was observed at Binadhan-7 and the lowest effective tillers hill^{-1} 8.1 at Huttraduring 2018. Effective tiller was more in modern varieties than local varieties. Thus, tillers hill^{-1} was less in Huttra. Jisan *et al.* (2014) concluded that, variation in number of tillers per hill might be due to varietal characters.

Panicle length: Maximum panicle length 26.5 cm was recorded at Binadhan-7 and the lowest panicle length 23.2 cm at Huttra during 2017 (Table 1). Panicle length was longer in modern varieties than local cultivars. The highest panicle length 25.1 cm was recorded at Binadhan-7 and the lowest panicle length 22.7 cm at Huttra during 2018.Thus, length of panicle was more in Binadhan-7, Binadhan-17, BRRI dhan56 and less in Huttra. This result is consistent with findings of Sarkar (2014) who reported that panicle length significantly varied among varieties.

Table 2. Evaluating the interaction effect (locations, varieties) of drought tolerant rice varieties in rain fed condition during aman season 2017 and 2018.

Treatments (Locations × Varieties)	Grain yield (t ha^{-1})	
	2017	2018
$L_1 \times V_1$	4.68	4.75
$L_1 \times V_2$	5.29	4.75
$L_1 \times V_3$	5.36	4.97
$L_1 \times V_4$	5.41	5.06
$L_2 \times V_1$	5.03	5.03
$L_2 \times V_2$	5.12	5.07
$L_2 \times V_3$	5.62	5.21
$L_2 \times V_4$	5.27	5.43
$LSD_{0.05}$	0.39	0.41
CV%	4.10	12.6

N. B. Rajshahi (L_1), Chapainaw. (L_2), BRRI dhan56 (V_1), Binadhan-7 (V_2), Binadhan-17 (V_3), Huttra (V_4).

Filled and unfilled grains panicle^{-1}: Significantly difference observed in filled and unfilled grain panicle^{-1} among genotypes. The highest unfilled grains panicle^{-1} 33.8 was recorded at Binadhan-17 during 2017.The highest unfilled grains panicle^{-1} 32.6 was recorded at Huttra and the lowest unfilled grains panicle^{-1} 17.1 at Binadhan-7 during 2018 (Table 1). The highest filled grains panicle^{-1} 180.2 was recorded at Huttra (local) and the lowest filled grains panicle^{-1} 103.5 at Binadhan-7 during 2017.The highest number of filled grains panicle^{-1} 195.3 was recorded at Huttra (local) and the lowest number of filled grains panicle^{-1} 104.8 at Binadhan-7 during 2018. Sarkar (2014) reported that number of filled grains/panicle influenced significantly due to variety.

Thousand seed weight: In 2017, there was no statistically significant difference of thousand seed weight of genotype but significant in 2018. Highest thousand seed weight 20.9 gm was recorded at BRRI dhan56 (Table 1). The highest thousand seed weight 21.2 gm was recorded at Binadhan-7 and the lowest thousand seed weight 18.8 gm at Binadhan-17. Lowest weight of Binadhan-17 was due to small sized fine grain during 2018. Roy *et al.* (2014) studied on 12 rice varieties and found difference in thousand weight of grains due to morphological and varietal variation.

Grain yield: Significantly higher grain yield 5.46 t ha^{-1} was recorded at Binadhan-17 and the lowest grain yield 4.86 t ha^{-1} was at BRRI dhan-56 (Table 1). Higher grain yield was produced at Chapai Nawabgonj 5.42 t ha^{-1} followed by Rajshahi 5.31 t ha^{-1}. The cultivarBinadhan-17 yielded 5.46 t ha^{-1} followed by Huttra 5.29 t ha^{-1} during 2017. The highest grain yield 5.25 t ha^{-1} was recorded at Huttra and the lowest grain yield 4.89 t ha^{-1} was at BRRI dhan-56. Higher grain yield was produced at Chapai Nawabgonj 5.18 t ha^{-1} during 2018. Yield differences due to varieties were recorded by Islam *et al.* (2014).

Straw yield: There was no statistically significant difference of straw yield. The highest straw yield 7.32 t ha^{-1} was recorded at Huttra and the lowest straw yield 6.53 t ha^{-1} was recorded at BRRI dhan56 (Table 1) during 2017. The highest straw yield 5.79 tha^{-1} was recorded at Binadhan-17 and the lowest straw yield 5.55 t ha^{-1} was recorded at Binadhan-7 during 2018.

Interaction of location and genotypes: There was a statistically significant difference of grain yield interaction effect of location and genotypes. The highest grain yield 5.62 t ha^{-1} was obtained at interaction of Binadhan-17 at Chapainawabganj and lowest grain yield 4.68 t ha^{-1}of BRRI dhan56 at Rajshahi during 2017 (Table 2). The highest grain yield 5.43 t ha^{-1} was obtained by Huttra which was followed by 4.68 t ha^{-1}at Binadhan-17 at Chapainawabganj. It might be due to the number of effective tillers hill^{-1}, filled grains panicle^{-1}, panicle length was yielded maximum during 2018.

Table 3. Evaluating the main effect of drought tolerant rice varieties under different establishment methods in rain fed condition during aman season 2017 and 2018.

Treatments	Plant height (cm)		Total tillers hill^{-1} (no)		Effective tillers hill^{-1} (no)		Panicle length (cm)		Filled grains panicle^{-1} (no.)		Unfilled grains panicle^{1} (no.)		1000 seed wt. (g.)		Grain yield (t ha^{-1})		Straw yield (t ha^{-1})	
	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
Locations																		
L_1	108.2	112.0	11.8	9.8	11.1	9.4	24.6	23.8	141.9	129.3	26.4	22.1	21.7	20.5	4.74	5.49	6.68	6.12
L_2	114.5	115.6	13.0	12.0	11.9	10.9	25.0	23.9	145.8	158.3	27.3	17.1	22.0	19.1	5.37	5.70	7.09	6.41
T value	*	NS	*	*	*	*	NS	NS	NS	*	NS	*	NS	*	*	*	*	*
Methods																		
M_1	109.8	113.6	11.8	11.1	10.7	10.2	24.6	24.0	133.4	138.3	30.2	20.9	21.8	19.7	4.91	5.52	7.01	6.36
M_2	111.9	113.0	12.9	11.2	12.0	10.7	25.2	24.0	150.6	152.3	24.7	18.1	22.0	19.7	5.19	5.71	6.85	6.18
M_3	112.2	114.8	12.5	10.3	11.8	9.6	24.8	23.7	147.7	140.8	25.6	19.7	21.9	20.1	5.05	5.55	6.79	6.25
$LSD_{0.05}$	2.3	4.3	0.9	1.2	0.8	1.1	0.9	1.0	17.8	29.5	5.0	8.1	0.3	0.3	0.28	0.23	0.32	0.35
Varieties																		
V_1	118.0	115.5	11.0	11.4	10.1	10.7	25.6	25.3	125.9	144.6	30.2	16.7	22.2	18.8	4.58	5.59	6.62	6.38
V_2	104.3	107.6	14.3	12.0	13.3	11.0	25.5	24.6	118.0	110.9	24.7	19.6	23.2	21.1	5.38	5.31	7.21	6.08
V_3	111.6	118.3	11.9	9.2	11.0	8.76	23.4	21.7	187.7	175.8	25.6	22.5	20.2	19.6	5.19	5.88	6.82	6.34
$LSD_{0.05}$	2.3	4.8	0.9	1.0	0.8	1.0	0.9	0.9	17.8	14.2	5.0	6.2	0.3	0.7	0.33	0.58	0.32	0.49
CV%	3.0	6.2	10.9	14.5	10.8	15.2	5.6	5.7	18.2	15.8	27.8	17.2	2.2	5.3	9.88	12.5	7.01	5.3

N. B. Rajshahi (L_1), Chapainaw. (L_2), Direct Seeding (M_1), Puddle Transplanting. (M_2), Unpuddled Transplanting (M_3),BRRI dhan56 (V_1), Binadhan-7 (V_2), Huttra (V_3).

Table 4. Evaluating the interaction effect of locations and establishment methods.

Treatments Location × Methods	Grain yield (t ha^{-1})	
	2017	2018
$L_1 \times M_1$	4.61	5.30
$L_1 \times M_2$	4.88	5.61
$L_1 \times M_3$	4.72	5.56
$L_2 \times M_1$	5.22	5.49
$L_2 \times M_2$	5.50	5.86
$L_2 \times M_3$	5.38	5.74
$LSD_{0.05}$	0.37	0.32

Table 5. Evaluating the interaction effect of location and genotypes.

Treatments Location × Variety	Grain yield (t ha^{-1})	
	2017	2018
$L_1 \times V_1$	4.32	5.63
$L_1 \times V_2$	5.26	5.18
$L_1 \times V_3$	4.63	5.65
$L_2 \times V_1$	4.85	5.56
$L_2 \times V_2$	5.75	5.44
$L_2 \times V_3$	5.50	6.10
$LSD_{0.05}$	0.47	0.38

Table 6. Evaluating the interaction effect of methods and genotypes

Treatments Methods × Variety	Grain yield (t ha^{-1})	
	2017	2018
$M_1 \times V_1$	4.44	5.76
$M_1 \times V_2$	5.70	5.25
$M_1 \times V_3$	4.30	5.67
$M_2 \times V_1$	4.68	5.73
$M_2 \times V_2$	4.91	5.14
$M_2 \times V_3$	4.57	6.12
$M_3 \times V_1$	4.63	5.18
$M_3 \times V_2$	5.24	5.55
$M_3 \times V_3$	5.07	5.83
$LSD_{0.05}$	0.58	0.53
CV%	7.01	5.3

N. B. Rajshahi (L_1), Chapainaw. (L_2), Direct Seeding (M_1), Puddle Transplanting. (M_2), Unpuddled Transplanting (M_3), BRRI dhan56 (V_1), Binadhan-7 (V_2), Huttra (V_3).

Result of experiment on suitability of methods

Main effect of rice varieties under different methods

Statistically higher grain yield 5.37 t ha^{-1} was obtained from Chapainawabgonj followed by Rajshahi 4.74 t ha^{-1} during 2017 (Table 3). Higher grain yield 5.70 t ha^{-1} was obtained from Chapainawabgonj followed by Rajshahi 5.49 t ha^{-1} 2018. Among different methods statistically higher grain yield 5.19 t ha^{-1} was obtained from puddled transplanting followed by un-puddled transplanting 5.05 t ha^{-1} and direct seeding method produced lowest yield 4.91 t ha^{-1} during 2017 (Table 3). The higher grain yield 5.71 t ha^{-1} was obtained from puddled transplanting followed by un-puddled transplanting 5.55 t ha^{-1} and direct seeding method produced lowest yield 5.52 t ha^{-1} during 2018. It was observed that weed infestation was more in unpuddled condition, direct seeding plot. It might be due to growth and development better in puddle transplanting plot and yielded higher. Among three genotypes, Binadhan-7 produced statistically higher grain yield 5.38 t ha^{-1} which was contributed by higher number of grains panicle^{-1}. Huttra produced second highest grain yield 5.19 t ha^{-1} during 2017. It might be due to more number of tillers hill^{-1}, thousand seed weight and early maturity escaping of terminal drought and yielded higher in Binadhan-7. Huttra produced statistically higher grain yield 5.88 t ha^{-1} which was contributed by higher number of grains panicle^{-1} followed by BRRI dhan56 produced 5.59 t ha^{-1} during 2018. It might be due stature of plant, higher root shoot ration in Huttra growth in drought condition not hampered compared to modern varieties BRRI dhan56, Binadhan-7 and Binadhan-17.

Interaction of location and methods: Interaction effect locations and methods showed that statistically higher grain yield 5.5 t ha^{-1} and 5.38 t ha^{-1}, respectively was obtained by puddle and unpuddled transplanting method in Chapainawabgonj region 2017 (Table 4). Interaction effect locations and methods showed that statistically higher grain yield 5.86 t ha^{-1} and 5.74 t ha^{-1}, respectively was obtained by puddle and unpuddled transplanting method in Chapainawabgonj region during 2018.

Interaction of location and genotypes: Interaction effect location and varieties showed that statistically higher grain yield 5.75 t ha^{-1} was obtained by Binadhan-7 in Chapainawabgonj region (Table 5). It might be due nutritional availability more in Chapainawabganj soil than Rajshahi and weather parameters remaining same both location. Interaction effect location and varieties showed that statistically higher grain yield 6.1 t ha^{-1} was obtained by Huttra in Chapainawabgonj region during 2018.

Interaction of methods and genotypes: Interaction effect methods and varieties showed that statistically higher grain yield 5.70 t ha^{-1} and 5.24 t ha^{-1}, respectively was obtained by direct seeding andun-puddled transplanting method (Table 6). The interaction showed that statistically higher grain yield 6.12 t ha^{-1} and 5.83 t ha^{-1}, respectively was obtained by un-puddle transplanting method in Chapainawabgonj region during 2018.

Interaction of locations, methods and genotypes: The interaction showed that statistically higher grain yield 5.32 t ha^{-1} and 5.21 t ha^{-1}, respectively was obtained by Binadhan-7 in puddle transplanting method Chapainawabgonj and Rajshahi during 2017 (Table 7). The interaction showed that statistically higher grain yield 6.37 t ha^{-1} and 6.19 t ha^{-1}, respectively was obtained by BRRI dhan56 in puddle transplanting method Chapainawabgonj and Rajshahi during 2018. It might be due to more number of effective tillers hill^{-1}, filled grains panicle^{-1}, panicle length resulted higher yield.

Table 7. Evaluating the interaction effect (location×method×varieties) drought tolerant rice varieties under different establishment methods in rain fed condition during aman season 2017 and 2018.

Treatments	Plant height (cm)		Total tillers hill^{-1} (no)		Effective tillers hill^{-1}(no)		Panicle length (cm)		Filled grains panicle^{-1} (no.)		Unfilled grains panicle^{1} (no.)		1000 seed wt. (g.)		Grain yield (t ha^{-1})		Straw yield (t ha^{-1})	
	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
Location × Methods × Varieties																		
$L_1×M_1×V_1$	110.6	116.0	11.1	10.8	9.5	10.5	25.9	25.5	131.47	130.6	25.6	17.0	23.1	18.2	4.63	5.48	7.19	6.46
$L_1×M_1×V_2$	98.1	107.0	15.2	11.0	12.6	10.5	25.2	24.7	113.2	118.0	29.7	20.6	22.4	22.9	5.07	5.30	8.73	5.99
$L_1×M_1×V_3$	104.0	114.0	9.3	8.9	8.8	8.6	23.0	21.0	187.0	131.3	31.7	24.0	20.3	20.5	4.04	5.90	6.14	6.27
$L_1×M_2×V_1$	115.6	117.0	11.2	11.6	9.5	11.3	25.3	26.0	125.6	134.1	26.2	24.0	22.9	18.5	4.63	6.37	6.31	6.14
$L_1×M_2×V_2$	101.1	112.0	11.8	10.5	10.8	9.9	25.6	23.7	122.6	84.4	21.8	21.6	22.8	23.2	5.21	4.87	6.18	5.85
$L_1×M_2×V_3$	108.6	109.7	11.8	7.9	9.3	7.6	23.4	22.4	160.8	154.6	26.3	18.4	20.7	19.8	4.31	5.59	6.68	6.33
$L_1×M_3×V_1$	117.6	115.7	9.4	10.3	8.8	9.5	25.4	24.7	126.4	141.0	25.8	15.5	23.2	19.2	4.50	5.18	5.66	6.47
$L_1×M_3×V_2$	107.2	107.6	16.6	11.7	15.3	10.9	25.0	24.3	120.1	130.8	24.9	18.6	22.4	20.7	5.08	5.55	6.96	6.09
$L_1×M_3×V_3$	111.0	121.0	10.2	8.8	9.5	8.4	23.2	22.0	195.3	185.1	26.0	25.1	20.4	20.3	4.96	5.83	6.28	6.19
$L_2×M_1×V_1$	123.8	113.0	11.2	11.9	10.8	10.0	25.9	25.2	129.4	162.6	28.2	15.6	23.4	18.8	5.05	5.05	6.40	6.45
$L_2×M_1×V_2$	106.9	108.3	14.8	12.6	14.2	11.0	24.1	26.2	109.8	100.3	34.2	22.0	21.6	18.9	5.13	5.20	7.07	6.28
$L_2×M_1×V_3$	115.4	123.3	13.4	11.4	9.8	10.2	23.4	21.2	185.4	187.0	32.2	26.4	20.1	18.7	4.57	5.35	6.54	6.70
$L_2×M_2×V_1$	120.8	115.7	12.8	13.2	9.3	12.6	25.2	25.8	117.4	158.6	26.1	13.0	23.5	18.8	4.74	6.19	7.24	6.27
$L_2×M_2×V_2$	105.8	102.7	12.0	14.8	11.1	13.1	27.2	24.3	122.6	101.4	23.3	16.0	21.9	20.3	5.32	5.42	7.17	6.16
$L_2×M_2×V_3$	119.9	121.0	11.2	9.4	9.7	9.26	24.3	21.9	151.3	211.6	25.2	16.0	20.0	17.9	5.03	5.75	7.55	6.33
$L_2×M_3×V_1$	119.8	115.7	10.3	10.3	9.1	9.5	25.8	24.7	125.4	141.0	23.2	15.5	23.3	19.2	4.76	5.18	6.94	6.47
$L_2×M_3×V_2$	106.7	107.6	15.6	11.7	13.4	10.9	25.9	24.3	119.6	130.8	24.5	18.6	22.0	20.7	4.89	5.55	7.12	6.09
$L_2×M_3×V_3$	110.7	121.0	15.5	8.8	8.4	8.4	23.1	22.0	186.6	185.1	29.3	25.1	20.0	20.3	4.44	5.83	7.76	6.19
$LSD_{0.05}$	5.6	11.7	2.2	2.6	2.0	2.6	2.3	2.3	43.6	36.2	12.4	15.7	0.8	1.8	0.82	1.18	NS	0.53
CV%	3.0	6.2	10.9	14.5	10.8	15.2	5.6	5.7	18.2	15.8	27.8	17.2	2.2	5.3	9.88	12.5	7.01	5.3

N. B. Rajshahi (L_1), Chapainaw. (L_2), Direct Seeding (M_1), Puddle Transplanting. (M_2), Unpuddled Transplanting (M_3),BRRI dhan56 (V_1), Binadhan-7 (V_2), Huttra (V_3).

Conclusion

It is concluded that in the first year (2017), Binadhan-17 produced statistically higher grain yield (5.62 t ha^{-1}) at Chapainawabgonj.In puddle transplanting method, Binadhan-7 statistically higher grain yield 5.32 t ha^{-1} and 5.21 t ha^{-1}, respectively) both Chapainawabgonj and Rajshahi.In the second year (2018), Huttra (local) produced statistically higher grain yield (5.43 t ha^{-1}) at Chapainawabgonj.In puddle transplanting method, BRRI dhan56 statistically higher grain yield 6.37 t ha^{-1} and 6.19 t ha^{-1}, respectively) in puddle transplanting method bothat Rajshahi and Chapainawabgonj. Overall results showed that, under puddle transplanting method BRRI dhan56, Binadhan-17, Binadhan-7, Huttra (local) may perform better in drought prone area of Bangladesh in rain fed condition.

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