Variation of Growth and Yield of Boro Rice Influenced by Transplanting Method and Gypsum Rate in the Salinity Affected Area of Noakhali in Bangladesh

Abstract

Field experiment was carried out in Moddhochar Jabbar of Noakhali, Bangladesh during *Boro* season (December-April) 2018 to investigate the ameliorative effect of application of gypsum and transplanting method on the yield of BRRI dhan28 (V_1) and BINAdhan-10 (V_2)under salinity stress. The experiment comprised 3 factors; Transplanting method, Variety and Gypsum. This variety was evaluated under two transplanting methods i.e., Furrow transplanting (T_1) and Conventional transplanting (T_2) and four levels of gypsum with control G0: control, G_1: 50 kg ha^{-1},G_2: 100 kg ha^{-1} and G_3: 150 kg ha^{-1}.The experiment was laid out in a Latin Square Design (LSD) with three replications. Salinity level had significant negative effect on plant characters and yield of rice. Gypsum (@ 150 kg/ha) exerted positive significant effect on most of the plant parameters except number of non-effective tillers. Furrow transplanting method (T_1) had positive significant effect on most of the plant parameters except panicle length and harvest index. Binadhan-10 shows better performance than BRRI dhan28 in case of yield and all yield contributing characters in the prevailing condition. The highest grain yield (6.63 t ha^{-1}) found from $T_1V_2G_3$ (combination of furrow transplanting method, Binadhan-10 and gypsum @ 150 kg/ha) and lowest (4.26 t ha^{-1}) in$T_2V_1G_0$ (combination of conventional transplanting method, BRRI dhan28 and gypsum @ 0 kg ha^{-1}). It was calculated that the straw yield highest (8.14 t ha^{-1}) in $T_1V_2G_2$ (combination of furrow transplanting method, Binadhan-10 and gypsum @ 100 kg/ha) and lowest (5.61 t ha^{-1}) in $T_2V_1G_0$ (combination of conventional transplanting method, BRRI dhan28 and gypsum @ 0 kg/ha).

Keyword: Gypsum rate, Binadhan-10, Saline soil, Furrow transplanting

1 Introduction

Rice (*Oryza sativa* L.) is rated as one of the major food crops in the world, but is also considered extremely salt-sensitive [1]. Salinity is a major threat for sustainable rice production in Bangladesh as well as in the world. Out of 2.86 million hectares of the coastal and offshore areas of Bangladesh about 1.06 million ha of arable lands are affected by varying degrees of salinity [2]. It has been observed that the coastal cultivable lands are not being used for crop cultivation, mostly due to the soil salinity; rising soil salinity retards crop growth and reduce the ultimate production [3]. The area under salinity is increasing with time (from 0.83 m ha to 1.056 m ha in 36 years) [4] due to rise in sea water level with increased global temperature. At present in Bangladesh, cultivation of rice is seriously hampered or sometimes impossible due to presence of excess soluble salt in the coastal areas of the world as toxic salt ions reduce or obstruct the growth and development of cultivated crop plant. To~~For~~ mitigate this problem two salt tolerant rice varieties have been tested and released by BINA. The varieties are BINA dhan8 and BINA dhan10 which can tolerate soil salinity level up to 8 - 10 dS/m, but EC value of soil in many areas are much

higher [5]. BRRI Dhan 28 is a clean rice medium slender and white, which was developed in 1994 by Bangladesh Rice Research Institute (BRRI). Gypsum is widely used amendment for saline soil reclamation, due to the application of the gypsum in saline-sodic soil removes the greatest amount of sodium ion from the soil particle and reduces the soil electrical conductivity [6]. Application of gypsum in saline soil increases rice yield by 9.8 to 25.3% compared with the control treatment [7]. Gypsum application increases the infiltration rate of toxic sodium ions and method of furrow transplanting accumulates most of the salts in the upper side of ridge. In conventional methods,accumulation of salts are found in~~remain all part of the~~ rice plot with irrigation water however,~~and~~ gypsum fertilizer replaces the salt ion. Thus gypsum making the root zone area free from salts. Method of furrow transplanting is a technology where rice is transplanted is more salt free zone than conventional method. In recent times, some efforts have been taken to develop salt-tolerant rice cultivars. But no attention has been given so far for amelioration of salinity stress effects in rice through agronomic management practices especially by furrow and conventional method of transplanting, gypsum application and their interaction with rice varieties. Therefore the experiment was conducted to find out the effect of gypsum rate and transplanting method on growth and yield of boro rice in saline condition.

2 Materials and Methods

The experiment was conducted in the area of Moddhochar Jabbar in Noakhali (22.366^0 N latitude and 91.125^0 E longitude) during Boro season 2018 (December to April). The site belongs to the non-calcareous dark grey floodplain soil under the Young Meghna Estuarine Floodplain Agro ecological Zone (AEZ 18) (UNDP and FAO, 1988). The field was a medium high land with well drained silty-loam texture having pH value of 6.5, low in organic matter content (1.67%).The salinity value of initial soil was 6.2 dsm^{-1}. The experiment was laid out in a Latin square design with three replications, where two transplanting method and four Gypsum application rates were assigned in main plots. The size of unit plot was 4.0 m × 2.5 m. Treatment T_1: Furrow transplanting T_2: Conventional transplanting and Gypsum levels were assigned viz. G0: 0 kgha^{-1}~~ha-1~~, G1: 50 kgha-1, G2: 10 kgha-1 and G3: 150 kgha-1. The test rice variety was BRRI dhan 28 (V_1) (as check variety) and Binadhan-10 (V_2)

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2.1 Initial soil status of experimental field at Noakhali, Bangladesh

Chart: Physical properties and Chemical properties

Physical properties		Chemical properties(0-15 cm depth)	
Sand (%) (0.0-0.02 mm)	14	pH(soil : water= 1 : 2.5	6.00
Silt (%) (0.02-0.002 mm)	45	Organic matter (%)	0.93

Clay (%) (<0.002 mm)	9	Total nitrogen (%)	0.13
Soil textural class	Silty loam	Available sulphur (mg kg^{-1})	15.6
Particle density (g/cc)	2.60	Available phosphorous (mg kg^{-1})	2.94
Bulk density (g/cc)	1.42	Exchangeable potassium (cmol kg^{-1})	0.43
Porosity (%)	44.7		

The land was puddled thoroughly by repeated ploughing and cross ploughing with a tractor and subsequently leveled by laddering. At the time of final land preparation, respective unit plots were fertilized with different levels of urea, TSP, MOP and gypsum according to treatments. Urea was applied in three equal splits at 15, 30 and 45 days after transplanting (DAT). Gypsum was applied in 0 $kgha^{-1}$, 50$kgha^{-1}$,100$kgha^{-1}$, 150 $kgha^{-1}$ respectively. Three seedlings were transplanted in each hill with a spacing of 25 cm × 15 cm. Intercultural operations were done as when required. The yield parameters - plant height, panicle length, number of plant hill-1^{-1}, and number of grains per panicle and grain and straw yield data were recorded at maturity during rice harvest. The analysis of variance for various crop characters was done following the F-statistics. Mean comparisons of the treatments were made by Duncan Multiple Range Test (DMRT) test.

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Climate and weather

The climatic parameters during the growing period of boro rice are presented in figure 1 & 2. It was observed that the cropping season through December to April. During the growing period of boro rice, minimum and maximum temperature 13.4 and 33.6°C respectively. The average relative humidity varied from 74.8 to 85%.

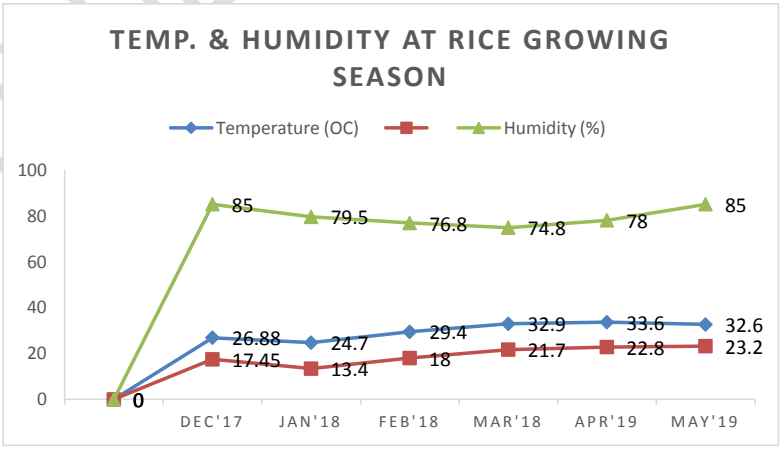

Fig. 1: Temperature & Humidity during crop growing period

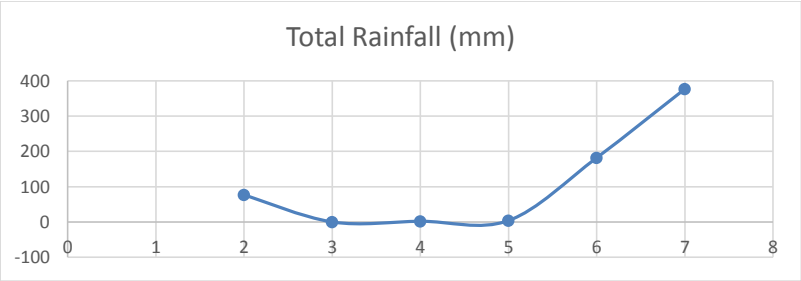

Fig. 2: Rainfall distribution during crop growing period

3 Results and Discussion

3.1 Effect of transplanting method on the yield and yield contributing characters of *Boro* rice

In case of the effect of transplanting method on the yield and yield contributing characters of *Boro* rice, all the parameters showed statistically significant except panicle length and harvest index (Table 1). Furrow transplanting (T_1) showed superiority in all the yield contributing characters with highest amount of grain (5.66 tha^{-1}>4.9 tha^{-1}), straw yield (7.23 t ha^{-1}) and biological yield than Conventional transplanting (T_2).In case of furrow transplanting method, it accumulated most of the salts in the upper side of ridge and furrow water became salt free. In this way the capacity to reduce the harmful effect of salinity problem to a great extent and increased all the ~~all~~ yield contributing characters.

3.2 Effect of variety on the yield and yield contributing characters of *Boro* rice.

In aspect of the effect of variety on the yield and yield contributing characters of rice, all the parameters showed ~~statistically~~ significant differences except number of non-effective tiller $hill^{-1}$, panicle length and harvest index (Table 2). The variety Binadhan-10 showed superiority in all the yield contributing characters with highest amount of grain(5.49 t ha^{-1}) , straw yield (7.08 t ha^{-1}) and biological yield than BRRI dhan28 which might be for its individual genetic potential or for its inherent capacity to reduce the harmful effect of salinity problem to a great extent.

3.3 Effect of gypsum on the yield and yield contributing characters of *Boro* rice

The effect of gypsum on the yield and yield contributing characters of *Boro* rice, all the parameters showed statistically significant differences except number of non-effective tiller

hill^{-1} and panicle length (Table 3). Application of Gypsum 150 kgha^{-1}removed high amount the salts ion and showed superiority in all the yield contributing characters.

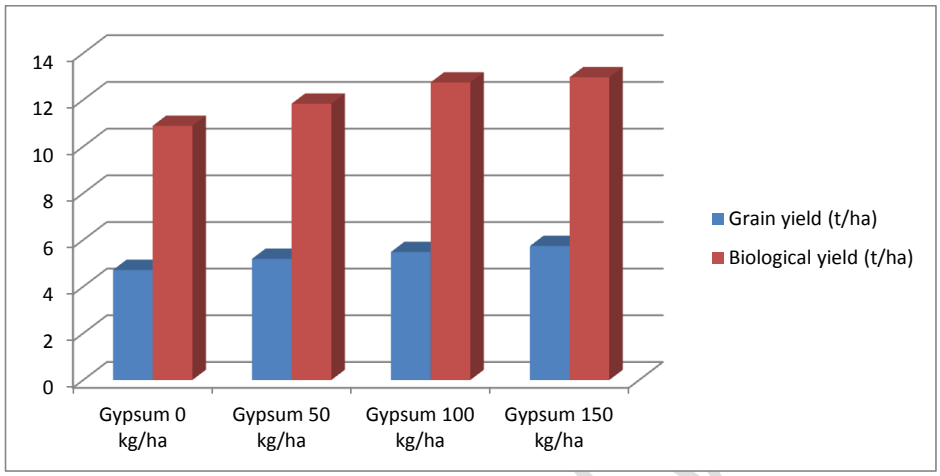

Fig3: Effect of gypsum on the grain yield and biological yield of *Boro* rice.

3.4 Effect of interaction between transplanting method and gypsum on the yield and yield contributing characters of *Boro* rice

The effect of interaction between transplanting method and gypsum on the yield and yield contributing characters of *Boro* rice, all the parameters showed statistically significant differences except number of plant height, number of non-effective tiller hill^{-1}, panicle length and 1000 grain weight (Table 4). The interaction T_1G_3 (Furrow transplanting method with Gypsum @ 150 kgha^{-1}) showed superiority in all the yield contributing characters with highest amount of grain yield, straw yield, biological yield than other interaction (T_1G_0,T_1G_1,T_1G_2,T_2G_0,T_2G_1,T_2G_2 andT_2G_3). The furrow ridge was accumulated salts due to evaporation pull and the furrow water lowest in salts ion. Gypsum (@ 150 kgha^{-1}) removed high amount the salts ion and increases the all yield contributing characters.

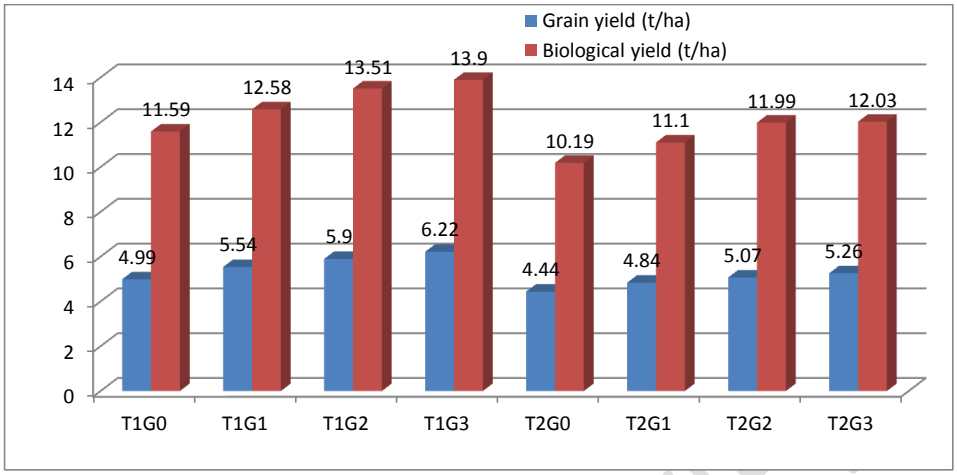

Fig 4: Effect of interaction between transplanting method and gypsum on the grain yield and biological yield of *Boro* rice.

3.5 Effect of interaction among transplanting method, variety and gypsum on the yield and yield contributing characters of *Boro* rice

The interaction effects~~combination~~ among furrow transplanting method, Binadhan-10 and gypsum 150 kgha^{-1}($T_1V_2G_3$) showed superiority in all yield contributing characters with highest amount of grain yield and other yield contributing characters except straw yield than other interactions.

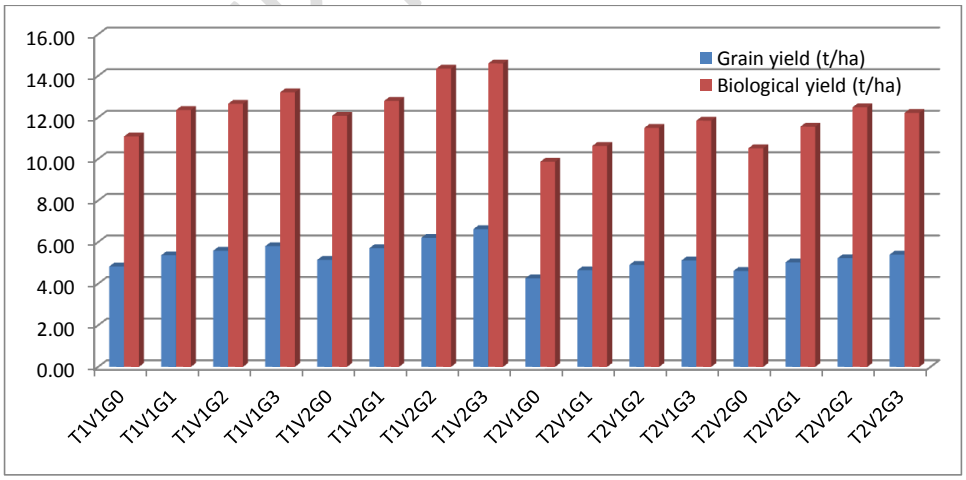

Fig 5: Effect of interaction among transplanting method, variety and gypsum on the grain yield and biological yield of *Boro* rice.

Table 5. Interaction among transplanting method, variety and gypsum on the yield of *Boro* rice.

Interaction	Plant Height (cm)	No. of total tiller hill^{-1}	No. of effective tiller hill^{-1}	No. of non effective tiller hill^{-1}	Panicle length (cm)	Grains panicle^{-1}	Sterile spikelet panicle^{-1}	1000-grain weight	Grain yield (t/ha)	Straw yield (t/ha)	Biological yield (t/ha)	Harvest Index (%)
$T_1V_1G_0$	91.29	10.09	8.070 m	1.12 a	23.73	76.71 k	11.88 d	22.49	4.83 k	6.26 j	11.09 m	43.55 cdef
$T_1V_1G_1$	95.42	12.14	11.17 g	0.82	23.73	82.33 f	11.75 d	22.85	5.37 f	6.99 fg	12.36 g	43.45 def
$T_1V_1G_2$	96.07	13.04	12.63 d	0.63	24.33	85.49 d	11.93 d	22.63	5.59 e	7.07 ef	12.66 e	44.16 bc
$T_1V_1G_3$	97.01	13.51	13.13 c	0.72	24.02	88.73 b	11.08 e	22.88	5.81 c	7.40 c	13.21 c	43.98 bcd
$T_1V_2G_0$	92.74	11.85	10.12 i	0.99	25.18	79.15 h	10.29 f	22.59	5.15 h	6.93 g	12.08 i	42.63 g
$T_1V_2G_1$	95.28	12.52	12.14 e	0.79	22.12	87.83 c	9.157 g	22.50	5.71 d	7.09 e	12.80 d	44.61 b
$T_1V_2G_2$	97.10	14.39	13.53 b	0.64	24.37	89.16 b	10.11 f	23.51	6.21 b	8.14 a	14.35 b	43.28 efg
$T_1V_2G_3$	96.44	14.81	13.73 a	1.16	25.06	90.21 a	8.037 h	23.70	6.63 a	7.97 b	14.60 a	45.41 a
$T_2V_1G_0$	89.42	8.977	7.370 p	0.95	24.24	76.14 l	16.11 a	21.98	4.26 m	5.61 l	9.870 p	43.16 fg
$T_2V_1G_1$	93.63	9.553	7.830 n	1.14	24.46	76.76 k	14.02 b	22.70	4.65 l	5.98 k	10.63 n	43.74 cdef
$T_2V_1G_2$	93.67	10.47	9.040 l	1.34	24.00	77.65 j	13.71 bc	22.42	4.91 j	6.59 i	11.50 l	42.70 g
$T_2V_1G_3$	95.96	10.52	9.770 j	0.89	24.94	79.35 h	13.32 c	22.67	5.12 h	6.73 h	11.85 j	43.21 fg
$T_2V_2G_0$	92.70	10.08	7.720 o	1.22	25.31	76.52 kl	14.12 b	22.19	4.62 l	5.90 k	10.52 o	43.91 bcde
$T_2V_2G_1$	95.12	11.05	9.580 k	0.93	23.07	78.48 i	12.23 d	22.33	5.03 i	6.53i	11.56 k	43.51 cdef
$T_2V_2G_2$	94.68	12.39	11.71 f	0.91	24.50	80.09 g	11.85 d	22.89	5.23 g	7.26 d	12.49 f	41.87 h
$T_2V_2G_3$	94.96	11.79	10.57 h	1.56	25.18	84.20 e	12.05 d	22.60	5.40 f	6.82 h	12.22 h	44.19 bc
Level of significance	NS	NS	**	NS	NS	**	**	NS	**	**	**	**
LSD value	1.245	0.805	0.092	0.5167	8.315	0.483	0.663	0.47	0.075	0.092	0.053	0.698
CV (%)	0.78	4.08	0.56	30.90	20.33	0.35	3.29	1.23	0.91	0.86	0.32	0.95

4 CONCLUSION

Gypsum combinations of transplanting methods along with two different cultivars have significant effect on growth and yield of rice in saline area of Noakhali district, Bangladesh. Binadhan-10 showed superiority for enhancing the growth and yield. Combination of furrow transplanting method, Binadhan-10 and gypsum @ 150 kg/ha showed the highest performance on plant height (96.44 cm), number of total tiller hill^{-1} (14.81), number of effective tiller hill^{-1} (13.73), grains panicle^{-1} (90.21) , weight of 1000 grain (23.70 g), grain yield (6.63 t ha^{-1}), straw yield (8.14 t ha^{-1}), biological yield (14.60 t ha^{-1}) respectively while combination of conventional transplanting method, BRRI dahn28 and gypsum @ 0 kg ha^{-1} showed lowest performance. The farmers of saline affected areas can be economically benefited by following this practice which will also enrich their social and economical condition.

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Abbreviation

BINA = Bangladesh Institute of Nuclear Agriculture

BRRI= Bangladesh Rice Research Institute

Annex

Table 1. Effect of transplanting method on the yield of *Boro* rice.

Transplanting Method	Plant Height (cm)	No. of total tiller hill^{-1}	No. of effective tiller hill^{-1}	No. of non effective tiller hill^{-1}	Panicle length (cm)	Grains panicle^{-1}	Sterile spikelet panicle^{-1}	1000-grain weight	Grain yield (t/ha)	Straw yield (t/ha)	Biological yield (t/ha)	Harvest Index (%)
Furrow Transplanting (T_1)	95.17a	12.79a	11.81a	0.86b	24.07	84.95a	10.53b	22.89a	5.66a	7.23a	12.89a	43.88
Conventional Transplanting (T_2)	93.77b	10.60b	9.19b	1.12a	24.46	78.65b	13.43a	22.47b	4.90b	6.42b	11.33b	43.29
Level of significance	**	**	**	**	NS	**	**	**	**	**	**	NS
LSD value	0.3535	0.784	0.0481	0.083	0.952	0.502	0.920	0.4053	0.083	0.152	0.173	0.638
CV (%)	0.24	4.06	0.31	5.53	2.58	0.41	50.05	1.17	1.04	1.46	0.94	0.96

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194 **Table 2. Effect of variety on the yield of *Boro* rice.**

Variety	Plant Height (cm)	No. of total tiller hill^{-1}	No. of effective tiller hill^{-1}	No. of non effective tiller hill^{-1}	Panicle length (cm)	Grains panicle^{-1}	Sterile spikelet panicle^{-1}	1000-grain weight	Grain yield (t/ha)	Straw yield (t/ha)	Biological yield (t/ha)	Harvest Index (%)
BRRI dhan28 (V_1)	94.06b	11.04b	9.87b	0.9542	24.18	80.39b	12.98a	22.58b	5.06b	6.57b	11.65b	43.49
Binadhan-10 (V_2)	94.88a	12.36a	11.14a	1.028	24.35	83.21a	10.98b	22.79a	5.49a	7.08a	12.58a	43.68
Level of significance	**	**	**	NS	NS	**	**	**	**	**	**	NS
LSD value	0.483	0.405	0.062	0.301	2.892	0.279	0.503	0.116	0.069	0.062	0.116	0.246
CV (%)	0.52	3.52	0.61	30.94	12.14	0.35	4.27	0.52	1.34	0.93	0.98	0.58

195 **Table 3 Effect of gypsum fertilizer on the yield of *Boro* rice.**

Treatment	Plant Height (cm)	No. of total tiller hill^{-1}	No. of effective tiller hill^{-1}	No. of non effective tiller hill^{-1}	Panicle length (cm)	Grains panicle^{-1}	Sterile spikelet panicle^{-1}	1000-grain weight	Grain yield (t/ha)	Straw yield (t/ha)	Biological yield (t/ha)	Harvest Index (%)
G_0	91.54 c	10.25 c	8.320 d	1.07	24.61	77.13 d	13.10 a	22.31 c	4.715 d	6.175 c	10.89 d	43.31 c
G_1	94.86 b	11.32 b	10.18 c	0.92	23.35	81.35 c	11.79 b	22.59 b	5.190 c	6.648 b	11.84 c	43.83 b
G_2	95.38 b	12.57 a	11.73 b	0.88	24.30	83.10 b	11.90 b	22.86 a	5.485 b	7.265 a	12.75 b	43.00 c
G_3	96.09 a	12.66 a	11.80 a	1.08	24.80	85.62 a	11.12 c	22.96 a	5.740 a	7.230 a	12.97 a	44.20 a
Level of significance	**	**	**	NS	NS	**	**	**	**	**	**	**
LSD value	0.623	0.402	0.046	0.258	4.158	0.241	0.338	0.235	0.038	0.046	0.027	0.349
CV (%)	0.78	4.08	0.56	30.90	20.33	0.35	3.29	1.23	0.91	0.86	0.32	0.95

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Table 4. Effect of interaction between transplanting method and gypsum on the yield of *Boro* rice.

Interaction	Plant Height (cm)	No. of total tiller hill^{-1}	No. of effective tiller hill^{-1}	No. of non effective tiller hill^{-1}	Panicle length (cm)	Grains panicle^{-1}	Sterile spikelet panicle^{-1}	1000-grain weight	Grain yield (t/ha)	Straw yield (t/ha)	Biological yield (t/ha)	Harvest Index (%)
T_1G_0	92.01 d	10.97 c	9.095 f	1.06 ab	24.45	77.93 f	11.08 c	22.54 b	4.990 f	6.595 f	11.59 f	43.09 c
T_1G_1	95.35 b	12.33 b	11.65 c	0.80 bc	22.93	85.08 c	10.45 d	22.67 b	5.540 c	7.040 c	12.58 c	44.03 b
T_1G_2	96.59 a	13.71 a	13.08 b	0.63 c	24.35	87.32 b	11.02 c	23.07 a	5.900 b	7.605 b	13.51 b	43.72 b
T_1G_3	96.72 a	14.16 a	13.43 a	0.94 abc	24.54	89.47 a	9.560 e	23.29 a	6.220 a	7.685 a	13.90 a	44.70 a
T_2G_0	91.06 e	9.528 e	7.545 h	1.08 ab	24.77	76.33 g	15.11 a	22.08 c	4.440 h	5.755 h	10.19 h	43.54 bc
T_2G_1	94.38 c	10.30 d	8.705 g	1.04 ab	23.77	77.62 f	13.12 b	22.51 b	4.840 g	6.255 g	11.10 g	43.63 b
T_2G_2	94.18 c	11.43 c	10.38 d	1.12 ab	24.25	78.87 e	12.78 b	22.65 b	5.070 e	6.925 d	11.99 e	42.28 d
T_2G_3	95.46 b	11.15 c	10.17 e	1.22 a	25.06	81.78 d	12.68 b	22.63 b	5.260 d	6.775 e	12.03 d	43.70 b
Level of significance	NS	**	**	NS	NS	**	**	NS	**	**	**	**
LSD value	0.880	0.569	0.065	0.365	5.88	0.341	0.469	0.332	0.053	0.065	0.038	0.494
CV (%)	0.78	4.08	0.56	30.90	20.33	0.35	3.29	1.23	0.91	0.86	0.32	0.95