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HETEROSIS OF YIELD AND ITS CONTRIBUTING CHARACTERS OF T-AMAN RICE (*Oryza sativa* L)

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ABSTRACT

The investigation was undertaken to study heterosis over better parent, heterosis over mid parent, reciprocal effects in eight crosses, their reciprocals and parents of T-Aman rice genotypes. Maximum traits showed heterosis in desirable direction of which the hybrid FR-13A × Arman sarder performed the best towards shorter stature, yield components like tiller number, panicle length, filled grains per panicle and 100-grain weight. The hybrid FR-13A × PJT (st) showed significant and positive heterosis over better parent for plant height, number of tillers per hill, grains per panicle and yield per hill which performed the best in terms of both physical as well as yield contributing traits. Considering heterosis over mid parent, the hybrid FR-13A × Arman Sarder performed the best showing heterosis in desirable direction on maximum number of traits namely tiller number, panicle length, filled grains per panicle, harvest index and yield per tiller. Most of the hybrids showed maternal effects but the cross FR-13A × PJT (st) had no maternal effects for 100 grains weight.

Key words: Rice, heterosis, better parent, mid parent, reciprocal effect

INTRODUCTION

Rice occupies about 75% of the total cropped area and constitutes 94% of cereals production. In Bangladesh total production area of rice is 64.63 lac ha and total production is 125.55 million M tones. Bangladesh is an over populated country and population is increasing day by day at rapid rate. At present, the rice growing areas are gradually decreased due to industrialization, housing and expansion of urban areas. The present population of 145 million will increase to 233 million by 2030 requiring 48 million tons of extra food grain (Karim *et al.* 1990). Under such conditions, all the additional production must come from higher yield due to non-availability of lands for expansion of rice. It is not possible to increase the production of rice horizontally due to lack of land. On the contrary, among the three types of rice Aus, Aman and Boro; Aman is fully dependent on natural condition. It is required for the rainy season but flood or submergence condition can hampered the expected production. Sometimes, rice plants may be damaged due to submergence for long time which affects the production of rice. So we should improve the production of rice vertically utilizing every resources and opportunity judiciously. Hybrid rice technology offers considerable opportunity for Bangladesh to increase the productivity of rice. Therefore, efficient and economic seed production package is one of the pre-requisites for the exploitation of heterosis on

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commercial scale. Considering these problems, an experiment was conducted to evaluate the yield related characteristics of nine parents and their F_1 generation obtained by crossing some submergence tolerant rice genotype.

MATERIALS AND METHODS

The experiment was carried out at the experimental farm of Bangabandhu Sheikh Mujibur Rahman Agricultural University, Salna, Gazipur during July 2007 to January 2009. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Five rows of 4 m each constituted the experimental unit. Twenty five treatments were distributed in the experimental unit through randomization by using the IRRISTAT programme. Nine genotypes were used as parent material. Eight crosses and their reciprocals were made during first year (July 2007 to December 2007) of the experiment. In this case, the genotype FR-13A was used as both male and female for crossing with other genotypes. Then the experiment was conducted in the next year (July 2008 to January 2009) using eight crosses, their reciprocals and parents. Healthy seedlings of 30 days old were transplanted in separate strips of the experimental field. In each strip 20 cm × 20 cm spacing between plant to plant and row to row, respectively were maintained. The overall mean value for each parent or hybrid in all the three replications for each character was taken for the estimation of heterosis. Heterosis was calculated as percent deviation of the F_l hybrid from the mid parental value between two corresponding parents (Liang *et al.* 1971). The magnitude of heterosis was expressed as heterosis over better parent (BP) and heterosis over mid parent (MP) for 15 traits.

RESULTS AND DISCUSSION

Heterosis over better parent

Among the 16 hybrids, 10 had the significant negative heterosis for days to 50% flowering and days to maturity which is highly desirable (Table 1). Young and Virmani (1990) similarly observed negative mean heterosis, heterobeltiosis and standard heterosis for days to 50% flowering. On the other hand, Patnaik *et al.* (1990) had not found any hybrid, earlier than the earliest parents. The heterosis of plant height ranged from 40.05 to 0.88%. Among the 16 hybrids, 12 of them exhibited highly significant and positive heterosis over the better parent except FR-13A × Chamara. The mean heterosis over better parent was 34.34 %. Patnaik *et al.* (1990) did not find any hybrids, which was shorter than the shortest parent while studying different CMS lines. Young and Virmani (1990) mentioned that heterosis for plant height did not change the plant type of hybrids from semi-dwarf to tall because the parents possessed semi dwarfing gene. For number of tillers per hill all the hybrids showed significant positive heterosis effect at 5% level except four hybrids. Lokaprakash *et al.* (1992) pointed out the importance of heterosis of productive tillers on heterosis of yield. For panicle length nine crosses showed significant effect at 1% level while three hybrids showed significant at 5% level and the rest were non-significant. Among the 16 hybrids, majority (9) of them exhibited positive heterosis over the better parent. Seven hybrids had the negative heterosis. Among the 16 , few hybrid exhibited negative heterosis over the better parent and only 5 hybrid, had the positive heterosis. Heterosis over better parent was significant (1%) for the trait secondary branches per panicle. Among the 16 hybrids, only six exhibited positive heterosis over the better parent. Majority (9) of them had the negative heterosis. The cross FR-13A × PJM (st) showed positive non-significant heterosis.

Table 1. Estimation of heterosis over better parent in 16 crosses in T. Aman rice

Hybrids	Days to first flowering	Days to 50% flowering	Days to 100% flowering	Days to maturity	Plant height (cm)	No. of tillers per hill	Panicle length (cm)	Primary branches per panicle	Secondary branches per panicle	Yield per hill (g)	Yield per tiller(g)	Harvest index	Filled grain	Spikelet sterility	Wt.of 100 grain (g)
FR-13A × BR-22	-3.58ns	-5.64**	-13.4 ns	-9.55**	31.64**	113.4*	12.2*	-5.05 ns	33.61**	-20.3**	-64.7 **	-60.7 **	-24.2**	351.0**	-10 ns
FR-13A × BR-23	1.30 ns	-0.31 ns	1.465 ns	-0.89**	30.56**	53.84*	2.28ns	5.59 ns	23.41**	105. **	46.8 **	-51.3**	44.01**	4.76 ns	-23. ns
FR-13A × PJM (st)	-1.30 ns	-3.1**	-6.15 ns	-8.14**	5.70 ns	-6.02 ns	-2.62ns	0.62 ns	0.48ns	-4.4 **	-5.2 ns	360.0 **	16.76**	10.57 ns	15.6 ns
FR-13A × PJT (st)	-13.0 ns	-10.6**	-11.37 ns	-9.68 ns	38.62**	139.0*	7.214*	6.67 ns	-4.38ns	181. **	15.3ns	-64.06 **	-35.2**	171.5**	-20 ns
FR-13A × Chamara	0	-2.19 ns	-4.39 ns	-0.89 ns	-4.37	-35.5*	-0.57**	-16.4**	-8.09ns	-31.3**	-5.4ns	29.41ns	-5.57 ns	97.23 ns	6.66 ns
FR-13A × Heachua	-3.06 ns	1.306**	2.57 ns	0	13.47**	103.1*	-4.42**	-21.6**	-3.94ns	109. **	-16.8 **	26.47ns	48.99**	-25.10**	30 ns
FR-13A × Khaiyamota	-9.12 ns	-5.95**	-10.52 ns	-8.08**	29.87**	82.25*	4.93**	-16**	-6.72ns	97.3 **	-23.6 **	-47.3 **	-36.0**	299.0 ns	-10 ns
FR-13A × Arman sarder	-10.7 ns	-10.0**	-11.8 ns	-12.38**	33.59**	82.97*	5.46**	11.8**	40.05**	164**	83.9 **	90.2 **	68.3**	-36.0 ns	20 ns
BR-22 × FR-13A	-5.86 ns	-5.9**	-13.2 ns	-6.37**	29.82**	103.1*	8.44**	-2.24**	38.6**	-14.9**	-64. **	57.04 **	-39.0**	299.3**	-16. ns
BR-23 × FR-13A	0.65 ns	-1.56 ns	-5.42 ns	-3.47**	40.05**	98.29*	14.22**	11.8 ns	80.0**	-43. **	-77. **	57.69 **	31.7**	166.1**	-51. ns
PJM (st) × FR-13A	0.977 ns	-0.31 ns	2.057 ns	0.46 ns	0.88 ns	-10.3 ns	-7.01**	-10.4**	-34.0**	-32. **	-17.1 **	-40.4 **	-19.6**	4.17 ns	9 ns
PJT (st) × FR-13A	-12. ns	-11.3**	-10.75 ns	-10.22**	30.84**	115.2*	-3.90*	-14**	-14.3**	114**	6.74 **	-76.5 **	-60.0**	101.4*	-20 ns
Chamara × FR-13A	2.606 ns	-8.14**	-1.73 ns	-0.44 ns	5.37 ns	55.03*	1.63ns	-18.8**	-7.22ns	43.0 **	-12.8ns	2.94ns	-44.5**	87.56 ns	-10 ns
Heachua × FR-13A	4.4 ns	1.96 ns	2.56 ns	8.91**	17.34**	57.44*	-6.16**	-11.6**	-6.89ns	43.7 **	-17.1*	0	6.70 ns	-7.62 ns	16.6 ns
Khaiyamota × FR-13A	-8.794 ns	-9.40**	-9.93 ns	-9.74**	17.46**	57.01*	10.7**	-9.33*	-17.2**	49.3 **	-25.2 **	-39.5 **	-18.9**	311.5 ns	33.3 ns
Arman sarder × FR-13A	-4.88 ns	-5.6**	-9.67 ns	-6.17**	19.73**	15.95 ns	-1.43ns	-3.94 ns	14.03**	-31. **	-25.0 **	45ns	-50.0**	56.1 ns	-10 ns
Mean heterosis	-6.24	-7.72	-10.9	-7.63	34.34	64.06	2.56	-5.82	7.96	45.6	-12.6	43.0	-7.31	189.1	-2.4
No. of positive heterosis	5	2	4	2	15	13	9	5	7	9	4	8	6	13	7
No. of negative heterosis	10	14	12	13	1	3	7	11	9	10	12	7	10	3	9

*indicates significant at 5% level and ** indicates significant at 1% level

Heterosis over mid parent

Among the 16 hybrids, only one exhibited positive heterosis over the mid parent. Majority (15) of them had the negative heterosis. Majority of the hybrids showed significant effect at 1% level, only two hybrids showed non-significant effect. The range of the heterosis was 0.10 to 13.26% with a mean of -6.09 %. Among the 16 hybrids, all exhibited the negative heterosis. Only two hybrids showed non-significant effect, another showed significant effect at 1% level. The heterosis of plant height ranged from -1.67 to 26.65% (Table 2). Among the 16 hybrids, 12 of them exhibited significant positive heterosis over the mid parent. Young and Virmani (1990) mentioned that heterosis for plant height did not change the plant type of hybrids from semi-dwarf to tall because the parents possessed semi dwarfing gene. Among the 16 hybrids, half (8) of them exhibited positive heterosis over the mid parent and half (8) of them had the negative heterosis for filled grains per panicle. Yolanda and Das (1996) observed considerable heterosis in the six quantitative traits especially in grains per panicle. Mishra and Pandey (1998) also reported that most of the higher yielding hybrids manifested positive heterosis for filled grains per panicle. The heterosis of yield per hill ranged from -2.86 to 128.4%.

Reciprocal effects

In case of days to 50% flowering reciprocal effect was observed for all the crosses (Table 3). Only 4 crosses showed negative reciprocal effects but the cross BR-23 × FR-13A, FR-13A × PJM (st) and FR-13A × Arman sarder showed positive effects. Reciprocal effect for days to 100% flowering was observed for all the crosses studied. Among the crosses, six cross combinations (BR-23 × FR-13A, FR-13A × PJM (st), Chamara × FR-13A , Heachua × FR-13A, FR-13A × Khaiyamota and FR-13A × Arman Sarder) had positive effect while in other two crosses the effect was negative. This might be happened due to cytoplasmic maternal effect in either direction. Both negative and positive reciprocal effect was observed for days to maturity. The cross Heachua × FR-13A and FR-13A × Khaiyamota showed negative reciprocal effects but the cross FR-13A × BR-22, BR-23 × FR-13A, FR-13A × PJM (st), PJT (st) × FR-13A, FR-13A × Arman Sarder and Chamara × FR-13A showed positive effects. Among the crosses, five pairs of combination had positive effect while in other three crosses the effect was negative for plant height. This might be happened due to cytoplasmic maternal effect in either direction. Reciprocal effect for panicle length was observed for all the crosses studied. Among the crosses, four pairs of combination had positive effect while in other four crosses the effect was negative. This might be happened due to cytoplasmic maternal effect in either direction. Both negative and positive reciprocal effect was observed for the trait number of primary branches per panicle. Most of the cross showed negative reciprocal effects. The crosses BR-23× FR-13A, FR-13A × PJM (st), Chamara × FR-13A , Heachua × FR-13A and FR-13A × Arman Sarder showed negative reciprocal effects but the crosses FR-13A X BR-22, FR-13A × Khaiyamota and PJT (st) × FR-13A, showed positive effects. For number of tillers per plant, the cross FR-13A X BR-22, BR-23 × FR-13A, FR-13A × PJM (st), Heachua × FR-13A, FR-13A × Khaiyamota and FR-13A × Arman Sarder showed negative reciprocal effects but the cross PJT (st) × FR-13A and Chamara × FR-13A, showed positive effects. In case of yield per hill reciprocal effect was observed for all the crosses. All the crosses showed reciprocal effects.The crosses FR-13A × PJM (st), FR-13A × Khaiyamota and FR-13A×Arman Sarder showed negative reciprocal effects but the crosses FR-13A× BR-22, BR-23 × FR-13A, Heachua × FR-13A, PJT (st) × FR-13A and Chamara × FR-13A showed positive effects. Both negative and positive reciprocal effect was observed for the trait harvest index. All the crosses showed reciprocal effects.

Table 2. Estimation of heterosis over mid parent in 16 crosses in T. Aman rice

Hybrids	Days to first flowering	Days to 50% flowering	Days to 100% flowering	Days to maturity	Plant height (cm)	No. of tillers per hill	Panicle length (cm)	Primary branches per panicle	Secondary branches per panicle	Yield per hill (g)	Yield per tiller (g)	Harvest index	Filled grains per panicle	Spikelet sterility (%)	Wt.of 100 grains (g)
FR-13A × BR-22	-4.97 ns	-7.8**	-11.4**	-9.76 ns	18.7**	147**	14.2**	3.05ns	36.4**	-3.73**	-59.9**	-56.0**	-21.8**	235.6**	10. ns
FR-13A × BR-23	-0.47 ns	-3.6**	-2.26 ns	-1.48**	19.3**	73.0**	7.37**	9.32**	24.1**	164.3**	82.36**	-41.1*	51.51**	-2.87 ns	-13.ns
FR-13A × PJM (st)	-2.88 ns	-5.06**	-8.17 ns	-8.43**	3.02 ns	5.31 ns	-0.58 ns	4.49 ns	9.69*	33.51**	27.31**	618.3**	19.85**	6.9 ns	19.35 ns
FR-13A × PJT (st)	-13.4 ns	-10.8**	-12.2*	-10.7**	31.6**	156.1**	10.0 ns	14.28**	4.30 ns	219.0**	30.82**	-53.0**	-26.5**	149.2 ns	-17.ns
FR-13A × Chamara	-2.38 ns	-3.10**	-8.29 ns	-1.89**	-5.8 ns	-20 ns	3.03**	-12.7**	-7.5 ns	-6.84**	19.58 ns	41.93 ns	1.39 ns	8.79 ns	14.28 ns
FR-13A × Heachua	-5.15 ns	-0.80 ns	-2.1 ns	-5.14**	11.8**	106.4**	0.54**	-16.5 ns	4.27 ns	128.4**	-2.94*	79.16*	53.40**	-57.57**	59.18 ns
FR-13A × Khaiyamota	-10.71 ns	-6.68**	-13.7*	-8.95**	24.0**	96.96**	15.9**	-0.78**	48.3**	116.8**	-14.8**	-24.*	-20.3**	40.6 ns	-1.81*
FR-13A × Arman Sarder	-13.5 ns	-11.0**	-14.9 ns	-13.2**	26.5**	85.94**	7.81**	12.58**	52.3**	195.3**	107.1**	558.**	78.48**	-27.7 ns	28. ns
BR-22 × FR-13A	-7.2 ns	-8.1**	-11.7 ns	-6.58**	17.1*	135.9**	10.4**	6.09**	41.6**	2.86**	-59.2**	75.9**	-37.1**	197.1**	2.04ns
BR-23 × FR-13A	-1.11 ns	-4.84**	-9.03*	-4.01**	27.9**	123.0**	19.9**	15.75**	81.1**	-27.9**	-71.8*	90.69**	38.57**	146.79**	-44.9*
PJM (st) × FR-13A	-0.64 ns	-2.30**	-0.14**	-0.10 ns	-1.6 ns	0.47 ns	-5.07**	-7.04**	-28.**	-5.73**	11.31*	-7.09 ns	-17.4**	0.74 ns	12.90*
PJT (st) × FR-13A	-12.47 ns	-11.4**	-11.7*	-11.4**	24.2**	130.6**	-1.38 ns	-7.85**	-6.5 ns	142.9**	21.01*	-69.3**	-54.7**	84.85**	-17.ns
Chamara × FR-13A	0.15 ns	-9.00**	-5.76 ns	-1.47**	3.79 ns	92.5**	5.32**	-15.2**	-6.68 ns	94.04**	10.16 ns	12.90 ns	-40.4**	3.42 ns	-3.5 ns
Heachua × FR-13A	2.16 ns	-0.15 ns	-2.14 ns	-3.35**	15.6**	59.9**	-1.28 ns	-5.91*	1.068 ns	56.60**	-3.32 ns	41.66 ns	9.86*	-47.6**	42. ns
Khaiyamota × FR-13A	-10.40 ns	-10.1**	-13.1*	-10.6**	12.2**	69.6**	22.47**	7.09*	31.6**	64.07**	-16.5*	-13.3 ns	1.00 ns	45.08 ns	45. ns
Arman Sarder × FR-13A	-7.8 ns	-6.66**	-12.9*	-7.15**	13.4**	17.8 ns	0.76 ns	-3.31 ns	24.0**	-23.2**	-15.5*	61.63*	-47.0**	76.30**	-3.5 ns
Mean heterosis	-5.69	-6.35	-8.75	-6.09	15.13	80.12	6.85	0.20	19.38	71.92	4.09	82.23	-0.71	53.73	8.34
No. of positive heterosis	2	1	0	0	14	15	12	8	12	11	8	9	8	12	9
No. of negative heterosis	14	15	16	16	2	1	4	8	4	5	8	7	8	4	7

*indicates significant at 5% level and **indicates significant at 1% level

Table 3. Reciprocal effect on eight crosses in T. Aman rice

Parameter	FR-13A × BR-22	BR-22 × FR-13A	Effects		BR-23 × FR-13A	FR-13A × BR-23	Effects		FR-13A × PJM (st)	PJM (st) × FR-13A	Effects		PJT (st) × FR-13A	FR-13A × PJT (st)	Effects	
Days to first flowering	98.66	96.33	-2.33	-ve	103	103.66	0.66	+ve	101	103.33	2.33	+ve	90	89	-1	-ve
Days to 50% flowering	100.33	100	-0.33	-ve	104.66	106	1.3	+ve	103	106	3	+ve	94	94.66	0.66	+ve
Days to 100% flowering	103	102.66	-0.33	-ve	107.33	115.33	8	+ve	106.66	116	9.33	+ve	99.33	98.66	-0.6	-ve
Days to maturity	141.66	146.66	5	+ve	151.33	155.33	4	+ve	143	156.33	13.3	+ve	137	138	1	+ve
Plant height (cm)	130.06	128.26	-1.8	-ve	141.73	132.13	-9.6	-ve	127.13	121.33	-5.8	-ve	142.26	150.73	8.46	+ve
No. of tillers per hill	17.93	17.06	-0.86	-ve	15.467	12	-3.46	-ve	7.267	6.93	-0.33	-ve	15.06	16.73	1.66	+ve
Panicle length (cm)	29.87	28.86	-1.01	-ve	30.4	27.22	-3.18	-ve	27.02	25.8	-1.22	-ve	25.57	28.53	2.96	+ve
Primary branches per panicle	11.26	11.6	0.33	+ve	12	11.33	-0.66	-ve	10.86	9.66	-1.2	-ve	8.6	10.66	2.06	+ve
Secondary branches per panicle	31.8	33	1.2	+ve	41.533	28.46	-13.0	-ve	27.53	18.06	-9.46	-ve	19.53	21.8	2.26	+ve
Yield per hill (g)	7.287	7.787	0.5	+ve	6.047	22.18	16.13	+ve	13.26	9.36	-3.9	-ve	12.85	16.88	4.02	+ve
Yield per tiller (g)	0.413	0.42	0.007	+ve	0.33	2.14	1.81	+ve	1.727	1.51	-0.21	-ve	0.95	1.027	0.07	+ve
Harvest index	0.17	0.68	0.51	+ve	0.82	0.253	-0.56	-ve	5.567	0.72	-4.84	-ve	0.15	0.23	0.08	+ve
Filled grains per panicle	82	65.96	-16.0	-ve	133.86	146.36	12.5	+ve	125.13	86.13	-39	-ve	40.56	65.76	25.2	+ve
Spikelet sterility (%)	86.6	76.66	-9.9	-ve	74.53	29.33	-45.2	-ve	33.53	31.6	-1.93	-ve	55.33	74.6	19.27	+ve
Wt. of 100 grains (g)	2.7	2.5	-0.2	-ve	1.9	3	1.1	+ve	3.7	3.5	-0.2	-ve	2.4	2.4	0	No effect

Table 3. Continued…………..

Parameter	FR-13A × Chamara	Chamara × FR-13A	Effects		Heachua × FR-13A	FR-13A× Heachua	Effects		FR-13A × Khaiyamota	Khaiyamota × FR-13A	Effects		FR-13A × Arman Sarder	Arman Sarder × FR-13A	Effects	
Days to first flowering	102.33	105	2.66	+ve	102.33	95	-7.33	-ve	93	93.33	0.33	+ve	91.33	97.33	6.0	+ve
Days to 50% flowering	104	97.66	-6.3	-ve	104	103.33	-0.67	-ve	100	96.33	-3.66	-ve	95.66	100.33	4.66	+ve
Days to 100% flowering	108.66	111.67	3	+ve	106.33	106.33	0	0	101.66	102.33	0.66	+ve	100.33	102.67	2.33	+ve
Days to maturity	155.33	156	0.66	+ve	154	141.333	-12.6	-ve	144	141.33	-2.66	-ve	137.33	147	9.66	+ve
Plant height (cm)	115	126.73	11.7	+ve	141.13	136.47	-4.66	-ve	156.2	141.26	-14.9	-ve	160.66	144	-16.6	-ve
No. of tillers per hill	6.4	15.4	9	+ve	9.867	12.73	2.86	+ve	13	11.2	-1.8	-ve	11.46	7.267	-4.2	-ve
Panicle length (cm)	26.46	27.07	0.58	+ve	27.73	28.27	0.51	+ve	27.97	29.48	1.56	+ve	29.34	27.47	-1.92	-ve
Primary branches/ panicle	9.133	8.867	-0.26	-ve	10.07	8.933	-1.13	-ve	8.4	9.06	0.66	+ve	11.33	9.733	-1.6	-ve
Secondary branches/panicle	21.2	21.4	0.2	+ve	25.2	26	0.8	+ve	21.26	18.86	-2.4	-ve	31.93	26	-5.93	-ve
Yield per hill (g)	8.66	18.03	9.38	+ve	10.3	15.02	4.72	+ve	14.40	10.9	-3.50	-ve	20.027	5.20	-14.8	-ve
Yield per tiller (g)	1.44	1.33	-0.11	-ve	1.03	1.037	0.001	+ve	0.857	0.84	-0.01	-ve	2.11	0.86	-1.25	-ve
Harvest index	0.44	0.35	-0.09	-ve	0.34	0.43	0.09	+ve	0.453	0.52	0.06	+ve	2.007	0.49	-1.51	-ve
Filled grains per panicle	111.26	65.33	-45.	-ve	115.06	160.67	45.6	+ve	64.97	82.33	17.3	+ve	193	57.27	-135.	-ve
Spikelet sterility(%)	24.33	23.13	-1.2	-ve	29.93	24.27	-5.6	-ve	27.66	28.53	0.86	+ve	20.73	50.6	29.8	+ve
Wt. of 100 grains (g)	3.2	2.7	-0.5	-ve	3.5	3.9	0.4	+ve	2.7	4	1.3	+ve	3.6	2.7	-0.9	-ve

The crosses BR-23 × FR-13A, FR-13A × PJM (st) , Chamara × FR-13A and FR-13A × Arman Sarder showed negative reciprocal effects but the crosses FR-13A × BR-22, Heachua × FR-13A, FR-13A × Khaiyamota and PJT (st) × FR-13A showed positive effects. Reciprocal effect was also effective for the trait grain per panicle. All the crosses showed reciprocal effects. Most of the crosses showed negative reciprocal effects. The crosses FR-13A × BR-22, BR-23 × FR-13A, FR-13A × PJM (st), Chamara × FR-13A and FR-13A × Arman sarder showed negative reciprocal effects but the crosses PJT (st) × FR-13A, Heachua × FR-13A and FR-13A × Khaiyamota showed positive effects. Reciprocal effect for yield per ha was observed for all the crosses studied. Among the crosses, four cross combinations had positive effect while other four crosses the effect was negative. This might be happened due to cytoplasmic maternal effect in either direction.

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