Electronic Journal of Plant Breeding, 2(4):543-548 (Dec 2011)
ISSN 0975-928X

Research Note

Studies on heterosis for grain yield and its component traits for developing new plant type hybrids in rice (*Oryza sativa* L.)

Shivam Soni and Deepak Sharma*
Department of Genetics & Plant Breeding, Indira Gandhi Krishi Vishwa Vidhyalaya, Raipur-492006 (Chhattisgarh), India.
*Email:deepakigkv@gmail.com

(Received: 12 Sep 2011; Accepted: 28 Oct 2011)

Abstract:
The heterosis and heterobeltiosis were estimated for 15 grain yield, and its component traits in 27 cross combinations to develop heterotic hybrids. The result revealed that grain yield and its component showed highly significant differences for all the traits. Among the 27 hybrids, five hybrids *viz.*, IR58025A /IRFAN-115, IR58025A/SR-6-SW-8, IR58025A /ET 1-13, APMS 6A /ET 1-12, and APMS 6A /NPTR-2 showed significant heterosis for grain yield and seven hybrids showed significant negative heterosis for earliness and three hybrids for plant height. These hybrids may be exploited for heterosis breeding and should be screened for yield stability.

Key words: Rice, heterosis, new plant type, yield, cms line

Hybrid rice is produced by cross-breeding different kinds of rice. The earliest high-yield rice was cultivated by Henry 'Hank' Beachell in 1966. The first generations of hybrid rice varieties are three-line hybrids and produced15 to 20 per cent higher yield than those of high-yielding varieties of the same growth duration.

Genetically, to achieve the goal of 15 ton per hectare. IRRI initiated work on super rice in 1988 through a "New Plant Type" concept including reduced tillering, large panicles, high grain density, longer grain filling period and resistance to major pests (Khush, 1995). IRRI scientists proposed modifications to the high-yielding indica plant type in the late 1980s and early 1990s. The characteristics features of improved NPT lines include, semi taller stature, fewer, tough, non lodging, and all effective culms, upright growth habits, fewer, thick, large, but stiff leaves able to maintain erect position, heavy panicles with limited intra plant variation for panicles yield, high fertile spikelet per panicle and a deep extensive root system.

Chhattisgarh is now recognized as potential area for hybrid rice cultivation in India the area under hybrid rice in the state is currently around 80,000 hectare. The first public based hybrid "Indira Sona" developed in Chhattisgarh itself was released during 2006. The adoption of rice hybrids in such areas, along with proper crop management practices, can increase rice productivity in the state (Anon, 2008).

Heterosis in rice was first reported by Jones (1926), Ramaiah (1933), who observed that some F_1 hybrids had more culms and higher yield than their parents. During the 1960s, suggestions for commercial exploitation of heterosis in rice were made in India (Richharia 1962), USA (Stansel and Craigmiles 1966), and China (Yuan 1966). Commercial exploitation of heterosis has been made possible by the use of cytoplasmic genetic male sterility and fertility restoration system. A number of cytosterile maintainer and restorer lines in rice have been developed in China and at IRRI, Philippines. Therefore the present piece of research work reports the results of magnitude of heterosis for yield and its attributing traits.

The present investigation was conducted at Research Farm, Department of Genetics and Plant Breeding, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, during *Rabi* 2009-2010 and *Kharif* 2010. The present study was an attempt to use New Plant Types in heterotic hybrid rice production.

The experimental material comprised 27 hybrids obtained crosses of three CMS lines (APMS 6A, IR 79156A, IR58025A) with nine testers (ET-1-10, TOX 981-11-2-3, SR-6-SW-8, IR64-SR-6, NPTR-2, ET 1-1, ET 1-12, ET 1-13, IRFAN-115).The set of hybrids were generated in line x tester pattern and evaluated along with parents in Randomized Complete Block Design with two replications. Twenty one days old seedlings of 27 hybrids and 9 parents were transplanted in the field. Single seeding per hill was transplanted. Recommended package of practices were followed. Observations were recorded on five randomly selected plants in both the replications for fifteen traits *viz*., days to 50% flowering, flag leaf length, flag leaf width, flag leaf area, plant height, productive tillers per plant, pollen fertility (%), sterile spikelet's per panicle, fertile spikelet's per panicle, total number of spikelet's per panicle, spikelet fertility (%), panicle length, thousand seed weight, grain yield per plant and head rice recovery (%).

Heterosis for each trait was worked out by utilizing the overall mean of each hybrid over replications for each trait. The mean data of isogenic maintainer lines (of respective CMS lines) were used as values for female parents. Relative heterosis was estimated as per cent deviation of hybrid value from its mid-parental value.

The analysis of variance (ANOVA) showed that grain yield and its component showed highly significant differences for all the traits. Heterosis of F_1 hybrids over their respective mid parents and better parents are presented in Table 1 The relative heterosis ranged from -81.75 (IR79156A /IR64-SR-6) to 78.89 (IR58025A /IRFAN-115) percent and heterobeltiosis ranged from -87.69 (IR79156A /IR64-SR-6) to 60.67 (IR58025A /IRFAN-115) for seed yield per plant.

Out of twenty seven hybrids studied seven cross combinations shows significant positive heterosis and better parent heterosis for seed yield per plant. Some of the crosses which recorded very highly significant positive heterosis for seed yield include IR58025A /IRFAN-115, IR58025A/SR-6-SW-8, IR58025A /ET 1-13, A7, and APMS 6A /NPTR-2. Similar results have been reported by Isaac (2007) and Vaithiyaligan and Nadarajan, (2010).

The magnitude of heterosis revealed that among twenty seven cross combination seven hybrids exhibited significant negative heterosis for days to 50% flowering in which five crosses *viz,* APMS6A/IR64-SR6, IR 79156A/SR6-SW8, IR58025A/SR-6-SW-8, IR58025A/ET 1-12 and IR58025A /IRFAN-115 showed highly significant negative heterosis. Early maturing hybrids are desirable in rice to fit well in multiple cropping (Tang *et al*. , 2002; Bhandarkar *et al.,* 2005; Chaudhry *et al.,* 2007). Similarly for plant height, four hybrids *viz*, APMS 6A /TOX 981-11-2-3, IR58025A/IR64-SR-6, IR79156A /ET-1-10 and IR58025A /ET 1-13 showed highly significant negative heterosis, which is preferable as it is less prone to lodging. Similar results have been reported by Khoyumthem *et al.* (2005) and Gawas *et al.* (2007). In rice, flag leaf area (length x breadth) had great contribution for high grain yield production. In the present study fifteen hybrids recorded significant positive heterosis and seven hybrids observed to be positively significant over better-parent for flag leaf area. The best four hybrids are APMS 6A /NPTR-2, IR79156A /ET 1-1, APMS 6A /ET-1-10, and IR58025A/IR64-SR-6. Chaudhry *et al*. (2007) also reported positive heterosis for flag leaf length rice.

Number of productive tiller per plant is generally associated with higher productivity. Among the hybrids the cross combination (IR58025A /ET 1-13) showed significant mid parents and better parents heterosis. Similar results have been reported by Ghosh (2002) and Soni *et al.* (2005).

Twenty two hybrids exhibited significant positive heterosis for pollen fertility .The hybrids *viz*, APMS 6A /ET-1-10, APMS 6A /ET 1-1, IR79156A /SR-6-SW-8, APMS 6A /ET 1-12, IR58025A /IRFAN-115 showing significant heterosis and the hybrid APMS 6A /ET-1-10 showing significant heterobeltiosis. The only hybrid APMS 6A /ET-1-10 showed highly significant heterosis over both mid parent and better parents respectively. Similarly for spikelet fertility highest significant mid parent and better parent heterosis was showed by IR79156A /IR64-SR-6 followed by IR 79156A/NPTR-2. Six hybrids showed significant positive heterosis for mid parent and three hybrids for better parent heterosis for spikelet fertility. Similar results have been reported by Soni *et al.*, (2005).

Longer panicle length is associated with higher number of spikelet per panicle, resulting in higher productivity. The estimates of heterosis and heterobeltiosis for panicle length were highly significant and positive for nine hybrids. The cross combinations *viz,* IR58025A/ET-1-10, IR58025A/SR-6-SW-8, APMS 6A /ET-1-10 and IR58025A /ET 1-1 showed positive significant heterosis and heterobeltiosis for number of spikelets per panicles. Similar results have been reported by Munisonnappa and Vidyachandra, (2007). Test weight is the most important yield attributing character among hybrids. Seven cross combinations showed positive significant heterosis over mid parents and heterobeltiosis , four desirable hybrid combinations were IR58025A /IRFAN-115, IR58025A/NPTR-2, APMS 6A /IRFAN-115 and IR79156A /ET 1-1. Three hybrids *viz,* IR58025A/TOX 981-11-2-3, IR79156A /TOX 981-

11-2-3 and IR79156A /ET 1-1 exhibited positive significant heterosis for head rice recovery.

Keeping in view mean performances, heterosis and heterobeltiosis estimates, three hybrids (IR58025A /IRFAN-115, IR58025A/SR-6-SW-8 and IR58025A /ET 1-13,) having better yield performance (along with earliness and semi tall plant stature) are recommended for heterosis breeding.

References

Anonymous, 2008. ICAR Adhoc Project Final Report (2004-08), pp.7. Development of rice hybrids adapted to shallow lowlands of Chhattisgarh. IGKV, Raipur.

Bhandarkar, S., Rastogi, N.K. and Kumar, A. 2005. Study of heterosis in rice (*Oryza sativa L.*). *Oryza*, **42**(3): 218-219.

Chaudhary, Anju, Sharma, Pankaj, Singh, Harpal, Pradhan SK and Pandey MP, 2007. Study on heterosis for yield and physiological characters in rice hybrids. Oryza, **44**: 7-13.

Gawas, Y.K., Bhave, S.G., Bendale, V.W., Sawant, S.S. and Jadhav, B.B. 2007. Nature and magnitude of heterosis for growth, yield and yield components in hybrid rice. *J. Maharashtra Agric. Univ.*, **32**(1): 52-56.

Ghosh, A. 2002. Studies on heterosis in upland rice. *Oryza,* **39**: 5-8.

Isaac, S. 2007. Heterosis for economic traits in early, mid early and very early rice cultivars for the cauvery delta zone. *Indian J. Agrl. Res.*, **41**(4): 249-255.

Jones, J.W. 1926. Hybrid vigour in rice. *J. American Soc. Agron.*, **18**:423-428.

Khoyumthem, P., Sharma, P.R., Singh, N.B. and Singh, M.R.K. 2005. Heterosis for grain yield and its component characters in rice (*Oryza sativa* L.). Environ. and Ecol., **23**: 687-691.

Khush, G.S. 1995. Breaking the yield frontier of rice. *Geo-J.,* **35**: 329–332.

Munisonnappa, S. and Vidyachandra, B. 2007. Standard heterosis in newly developed rice hybrids. *Karnataka J. Agrl. Sci.*, **20**(2): 379-380.

Ramaiah, K. 1933. Inheritance of flowering duration in rice. *Indian J. Agric. Sci.*, **3**: 341-377.

Richharia , R.H. 1962. Clonal propagation as a practical means of exploiting hybrid vigor in rice. *Nature*, Lond, 194: 598.

Soni, D.K., Arvind, Kumar, Sunil Nag and Lakeswar, Sahu. 2005. Study of heterosis by utilizing cytoplasmic-genetic male sterility system in rice (*Oryza sativa* L.). Pl. Arch., **5**: 617-621**.**

Stansel, J.W. and Craigmiles, J.P. 1966. Hybrid rice: problems and potentials. *Rice Journal* **69**(5): 14-15, 46.

Tang L, Xiao GY, Yuan LP and Deng XX, 2002. Studies on heterosis of Pei'ai 645/ Javanica rice. Human Agric. Sci. and Tech. Newsl 3: 4-10

Vaithiyalingan, M. and Nadarajan, N. 2010 . Heterosis for yield and yield contributing characters in inter sub-specific crosses of rice, *Elect. J. Pl. Breed.*, **1**(3): 305-310.

Yuan, L.P. 1966. A preliminary report on male sterility in rice. *Sci. Bul.,* **4**: 32-34.

Electronic Journal of Plant Breeding, 2(4):543-548 (Dec 2011)
ISSN 0975-928X

Table 1. Mid parent heterosis and Heterobeltiosis for different characters

Hybrids	Days to 50% flowering		Flag leaf length(cm)		Flag leaf wide(cm)		Flag leaf area(cm^2)		Plant height(cm)	
	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP
APMS 6A X										
ET-1-10	-2.77	-5.95 **	43.43 **	26.60 **	14.70 **	1.28	61.78 **	28.24**	17.73 **	11.18*
TOX 981-11-2-3	8.15 **	6.48 **	1.99	-13.48 **	-19.48 **	-24.39**	-18.78 **	-34.59**	-25.33 **	-36.76**
SR-6-SW-8	-9.97 **	-21.96 **	23.57 **	5.38 **	6.49	0.00	30.25 **	5.40	7.93 **	2.91
IR64-SR-6	-10.24 **	-14.86 **	10.74 **	-5.17 **	-3.77	-7.78	7.43	-4.59	12.22 **	-7.25**
NPTR-2	-2.89	-11.11 **	49.38 **	48.42 **	24.05 **	13.95 **	85.58 **	71.38**	7.87 **	-5.58**
ET 1-1	4.73 *	3.75	29.65 **	26.85 **	15.56 **	4.00	49.65 **	32.02**	9.71 **	-0.13
ET 1-12	-1.57	-3.09	11.72 **	-2.41	-7.78 *	-23.15 **	0.31	-24.90*	7.77 **	-0.47
ET 1-13	8.92 **	8.92 **	14.76 **	5.78 **	-25.00 **	-36.54 **	-15.18 **	-32.85**	14.03 **	6.55**
IRFAN-115	0.31	-1.23	14.29 **	8.06 **	-0.90	-7.78	12.85 *	-0.22	15.83 **	14.01**
IR 79156A X										
ET-1-10	7.98 **	4.76 *	6.91 **	1.07	-18.52 **	-29.79 **	-13.97 **	-30.54**	-11.20 **	-15.11**
TOX 981-11-2-3	9.38 **	8.02 **	-4.24 *	-15.06**	-1.33	-9.76 *	-6.58 *	-23.33**	3.27 *	-11.61**
SR-6-SW-8	-12.37 **	-23.83 **	-7.89 **	-17.83**	4.53	-4.39	-4.73	-21.43*	19.26 **	15.13**
IR64-SR-6	12.91 **	7.43 **	-38.55 **	-44.94**	-12.54 *	-13.82 *	-46.07 **	-51.05**	8.44 **	-9.45**
NPTR-2	14.70 **	5.29 **	-7.61 **	-12.77**	19.48 **	6.98	11.22 **	5.08	6.09 **	-6.09**
ET 1-1	13.21 **	12.50 **	27.15 **	23.37**	26.58 **	11.11 **	61.70 **	45.76**	8.42 **	-0.13
ET 1-12	1.25	0.00	11.92 **	2.41	4.77	-14.63 **	14.86 **	-12.58**	4.17 **	-2.63
ET 1-13	16.19 **	15.82 **	15.17 **	11.56**	1.16	-16.35 **	15.86 **	-6.58*	18.69 **	12.25**
IRFAN-115	-1.88	-3.09	23.08 **	10.89**	26.15 **	20.59 **	54.59 **	33.85**	3.32 *	0.41
IR58025A X										
ET-1-10	-8.65 **	-12.73 **	14.06 **	1.48	32.43 **	4.26	48.53 **	5.82	10.20 **	-0.51
TOX 981-11-2-3	9.67 **	2.99	19.08 **	-19.66**	-11.76 *	-26.83 **	-18.56 **	-41.23**	1.95	-16.97**
SR-6-SW-8	-23.21 **	-28.50 **	13.87 **	-12.48**	-5.29	-21.46 **	-5.13	-31.28**	13.06 **	3.01
IR64-SR-6	-4.87 **	-7.31 **	-9.03 **	-7.82**	50.00 **	36.36 **	60.83 **	25.73**	-16.97 **	-33.91**
NPTR-2	6.56 **	5.29 **	7.35 **	17.81**	3.71	-15.58 **	23.23 **	-0.50	6.36 **	-10.64**
ET 1-1	19.02 **	11.12 **	16.68 **	9.57**	13.89 **	-8.89 *	28.52 **	-0.08	-0.43	-13.17**
ET 1-12	-11.69 **	-17.07 **	-3.96 *	-21.69**	-6.17	-29.63 **	-19.05 **	-44.91*	1.34	-10.42**
ET 1-13	12.45 **	4.07 *	4.08 *	-2.59	-26.58 **	-44.23 **	-23.62 **	-45.64**	-1.95	-12.36**
IRFAN-115	-10.53 **	-15.98 **	9.19 **	9.63**	7.59	0.65	23.12 **	19.72**	10.88 **	7.34**

*=significant of p= 0.05 level, MP= Mid Parent Heterosis,
**= significant of p=0.01 level, BP= Better Parent Heterosis

Electronic Journal of Plant Breeding, 2(4):543-548 (Dec 2011)
ISSN 0975-928X

Table 1 Contd..

Hybrids	Productive tillers/Plant		Pollen fertility (%)		Sterile spikelets/Panicle		Fertile spikelets/Panicle		Spikelets No./Panicle	
	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP
APMS 6A X										
ET-1-10	-31.28 **	-41.74 **	127.51 **	13.94 **	106.02 **	98.20 **	111.82 **	81.53 **	110.82 **	86.32 **
TOX 981-11-2-3	-20.00 *	-30.43 **	29.35 **	-35.23 **	-37.65	-44.86 *	-38.34 *	-39.50 *	-38.18 *	-39.13 *
SR-6-SW-8	-14.44	-16.30	46.27 **	-26.77 **	78.44 **	-17.83	25.68	14.45	37.20 *	27.07
IR64-SR-6	2.00	-11.30	52.37 **	-23.71 **	6.29	76.01 **	73.91 **	25.39	51.19 **	30.53
NPTR-2	-25.95	-40.43 **	-99.69 **	-99.84 **	51.98 *	46.22	68.38 **	67.32 **	65.10 **	62.99 **
ET 1-1	-20.59	-41.30 **	63.78 **	-18.00 **	-17.41	-24.95	1.08	-0.76	-2.98	-6.39
ET 1-12	-41.71 **	-55.65 **	83.59 **	-8.08 **	87.49 **	71.54 **	51.22 **	46.07 **	59.02 **	51.79 **
ET 1-13	-42.33 **	-46.09 **	-75.03 **	-87.50 **	-34.68	-47.90 **	-57.25 **	-60.47 **	-51.81 **	-57.09 **
IRFAN-115	-11.71	-21.30 *	35.79 **	-32.00 **	-56.67 **	-67.36 **	-78.18 **	-81.30 **	-72.98 **	-77.58 **
IR 79156A X										
ET-1-10	-58.89 **	-68.10 **	67.00 **	-16.36 **	64.36 **	32.73	92.86 **	87.13 *	87.53 **	83.90 **
TOX 981-11-2-3	-14.78	-32.41 **	73.85 **	-12.95 **	58.74 **	48.11 *	14.69	-0.76	25.29	10.34
SR-6-SW-8	-36.47 **	-44.14 **	94.78 **	-2.47	-23.36	-36.87 *	-20.84	-35.74 **	-21.42	-36.00 **
IR64-SR-6	6.96	-15.17 *	10.16 *	-44.85 **	-58.64 **	-62.35 **	64.86 **	10.09	24.33	-4.50
NPTR-2	-24.65 **	-44.14 **	61.23 **	-19.27 **	-24.33	-38.90 *	39.69 **	22.20	26.02	8.32
ET 1-1	-17.00	-42.76 **	63.78 **	-18.00 **	94.73 **	76.63 **	-44.95 **	-50.80 *	-12.85	-21.84
ET 1-12	-32.68 **	-52.41 **	36.18 **	-31.82 **	92.22 **	73.20 **	-13.44	-21.47	10.44	0.04
ET 1-13	-42.86 **	-51.72 **	24.83 **	-37.50 **	-55.88 **	-58.21 **	-2.06	-7.25	-15.38	-17.70
IRFAN-115	-8.51	-25.86 **	-0.72	-50.29 **	61.62 **	42.33 **	9.84	6.61	22.68 *	16.13
IR58025A X										
ET-1-10	-14.67	-25.58 *	63.61 **	-18.18 **	39.74	36.25	-13.72	-18.24	-6.15	-10.71
TOX 981-11-2-3	-9.61	-19.07 *	-99.48 **	-99.74 **	11.23	-2.80	-35.24 **	-53.91 **	-26.49 *	-36.96 **
SR-6-SW-8	-0.69	-1.82	66.64 **	-16.67 **	57.19 *	57.19 *	-39.55 **	-47.70 **	-22.75	-38.56 **
IR64-SR-6	-29.87 **	-37.21 **	-2.08	-51.03 **	78.66 **	36.78 *	60.63 **	3.01	65.40 **	24.35
NPTR-2	-40.28 **	-50.70 **	61.43 **	-19.27 **	54.49 *	50.63	2.52	-16.38	10.88	-7.12
ET 1-1	-56.92 *	-67.44	97.97 **	-1.00	136.43 **	112.23 **	12.05	-6.81	34.28 **	17.18
ET 1-12	-29.55 **	-45.12 **	29.27 **	-35.35 **	-11.56	-20.08	-40.92 **	-50.20 **	-35.77 **	-43.40 **
ET 1-13	18.55 *	14.42	-27.01 **	-63.50 **	288.63 **	206.80**	-39.57 **	-47.03**	25.96 *	18.88
IRFAN-115	-16.96	-23.72 *	77.11 **	-11.43 **	-40.59 *	-55.66**	-64.84 **	-66.69**	-59.90 **	-60.88 **

*=significant of p= 0.05 level, MP= Mid Parent Heterosis,
**= significant of p=0.01 level, BP= Better Parent Heterosis

Table 1 Contd..

Hybrids	Spikelets fertility (%)		Panicle length(cm)		1000 Seed weight(g)		Grain yield/plant (g)		Head rice recovery (%)	
	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP
APMS 6A X										
ET-1-10	0.74	-2.78	24.09 **	21.59 **	8.16 **	-3.13	-41.28 **	-45.40 **	-14.52 **	-22.29 **
TOX 981-11-2-3	0.01	-3.33	5.76	-0.06	-0.08	-3.15	-17.18 **	-25.58 **	-19.78 **	-35.24 **
SR-6-SW-8	-8.13 **	-9.79 **	20.29 **	12.56	3.72	-2.40	-27.89 **	-40.15 **	-3.70	-6.84 *
IR64-SR-6	19.50 **	-3.89	14.07 **	5.54 **	22.81 **	10.94 **	5.05	-15.15 **	-18.24 **	-24.10 **
NPTR-2	2.03	1.33	12.67 **	4.89	6.58 *	4.88	36.03 **	33.57 **	-4.62	-15.86 **
ET 1-1	4.17 *	2.34	17.72 **	16.00 **	6.16 *	0.11	-16.81 **	-26.25 **	-15.26 **	-35.06 **
ET 1-12	-5.00 *	-6.10 **	18.28 **	-11.49 **	-14.38 **	-23.90 **	42.44 **	31.65 **	-47.49 **	-54.15 **
ET 1-13	-12.09 **	-15.60 **	-7.10 *	-18.94 **	-15.37 **	-26.23 **	-20.91 **	-37.22 **	-30.72 **	-33.17 **
IRFAN-115	-20.01 **	-23.01 **	20.33 **	12.98 **	33.73 **	31.33 **	-1.14	-9.26 **	-31.14 **	-49.99 **
IR 79156A X										
ET-1-10	2.61	-2.28	-0.03	-5.34	-16.99 **	-29.68 **	22.61 **	-8.85 **	2.41	-2.39
TOX 981-11-2-3	-8.22 **	-10.08 **	-5.06	-7.16	8.92 **	-0.70	-25.00 **	-35.85 **	33.99 **	12.61 **
SR-6-SW-8	0.83	0.37	20.87 **	9.49 *	17.57 **	17.25 **	-34.44 **	-54.96 **	-24.89 **	-26.18 **
IR64-SR-6	41.98 **	15.40 **	8.91 **	4.18	-21.09 **	-32.62 **	-81.75 **	-87.69 **	-34.10 **	-35.78 **
NPTR-2	10.44 **	8.20 **	-3.37	-6.97	-1.67	-9.07 **	-60.35 **	-69.35 **	-26.40 **	-32.04 **
ET 1-1	-36.83 **	-37.08 **	14.47 **	12.15 **	32.73 **	17.95 **	-1.91	-29.48 **	34.91 **	7.27 *
ET 1-12	-21.69 **	-21.86 **	9.98 **	7.25	-4.07	-19.31 **	17.81 **	-1.77	-33.33 **	39.11 **
ET 1-13	15.98 **	-12.85 **	7.66 *	-3.10	-6.37 **	-22.65 **	9.43 **	7.47 **	-47.32 **	-48.08 **
IRFAN-115	-10.25 **	12.45 **	8.47	-1.43	27.65 **	21.91 **	8.05 **	-20.40 **	-41.82 **	-56.33 **
IR58025A X										
ET-1-10	-8.05 **	-8.47 **	29.72 **	28.60 **	-18.91 **	-28.37 **	-48.81 **	-54.59 **	-6.86 *	-9.03 *
TOX 981-11-2-3	-10.81 **	-17.05 **	16.00 **	8.41 *	-11.66 **	-15.65 **	-30.38 **	-46.72 **	36.08 **	16.77 **
SR-6-SW-8	-20.61 **	-25.04 **	25.27 **	18.54 **	-47.94 **	-50.28 **	50.83 **	50.22 **	-53.12 **	-55.05 **
IR64-SR-6	6.10 **	-17.20 **	-7.12 *	-15.00 **	-75.72 **	-78.37 **	-53.85 **	-55.58 *	-21.40 **	-21.47 **
NPTR-2	-6.93 **	-9.98 **	4.37	-3.89	38.19 **	33.92 **	32.35 **	11.86 **	-8.82 *	-13.81 **
ET 1-1	-15.89 **	-20.55 **	21.11 **	17.96 **	-10.55 **	-16.88 **	-33.93 **	-38.53 **	20.94 **	-1.98
ET 1-12	-7.44 **	-12.05 **	2.91	-4.07	-5.55 *	-17.20 **	-77.71 **	-82.56 **	13.46 **	6.07
ET 1-13	-51.76 **	-55.43 **	-2.17	-15.49**	-16.89 **	-28.51 **	49.36 **	3.88 *	-56.99 **	-58.63 **
IRFAN-115	-12.61 **	-19.05 **	25.28 **	-18.95**	38.73 **	38.37 **	78.89 **	60.67 **	-26.96 **	-44.22 **

*=significant of p= 0.05 level, MP= Mid Parent Heterosis,
**= significant of p=0.01 level, BP= Better Parent Heterosis