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Estimation of heterosis for quality traits in rice

PK Bhati*, SK Singh, Rajesh Singh and Amita Sharma

Institute of Agricultural Sciences, Banaras Hindu University, Varanasi - 221005, (U.P.) India

****Email: bhatipradeep5@gmail.com***

ABSTRACT

Heterobeltiosis and standard heterosis were studied in 32 hybrids generated by crossing 16 pollen parents with two CMS lines used as female parent. Result indicated that Out of 32 hybrids , five hybrids viz., *IR 79156A x IET22228, IR 79156A x Danteswari, IR 79156A x IET 22202, IR 79156A x Sarjoo-52 and Pusa 6A x Akshaya Dhan exchibited significant desirable heterosis over better parent, standard variety and standard hybrid for most of the quality traits* viz., *hulling recovery, kernel length, kernel breadth, kernel length breadth ratio, kernel length after cooking, kernel breadth after cooking, elongation ratio, alkali spread value and amylose content. Top two crosses for quality traits on the basis of significant positive standard heterosis over SV and SH were IR 79156A x IET22228 and IR 79156A x Danteswari. Cross combination, IR 79156A x IET 22228 showed significant negative standard heterosis over better parent (-22.61%), Standard variety (-3.60%) and Standard hybrid (-23.45%) for kernel breadth after cooking and average heterosis for kernel breadth whereas IR 79156A x Danteswari was found very low for quality traits* viz., *kernel breadth, kernel breadth after cooking.*

Key words: *Heterosis, Oryza sativa L., rice hybrid, WA-CMS and quality traits*

Rice is one of the most important staple crops of India. It contributes to total food grain and cereal production of the country to nearly 43% and 46% respectively (Bhati *et al.*, 2014). The productivity of rice has now stagnated. The present world rice area, production and productivity is 161.6 mha, 480.7 mt and 2.97 t/ha, respectively. In India, it is being grown in 44.00 mha area with production of 106.0 mt and productivity of 2.41 t/ha It contributes 25% to agricultural GDP (USDA, Rice Outlook, 2014). Hybrid rice technology is one of the most practically feasible tools to break the yield barriers. In China, the first hybrid rice variety for commercial cultivation was released by Yuan Long Ping in 1976. India also started this programme in 1989 and released 65 hybrid rice varieties till 2014 (Singh *et al.*, 2015). Therefore, the present study was undertaken to assess the hybrids for *per se* performance and heterosis with respect to quality traits to identify best hybrid combinations for commercial utilization.

MATERIALS AND METHODS

The experimental material consisting of 32 F_1 hybrids obtained by line x tester mating along with their 16 pollen parent, 2 maintainer lines of IR79156A and Pusa6A and 2 checks (BPT 5204 and Arize 6444) were grown in single row of 3.0 m with three replications in Randomized Block Design with spacing of 20 x 15 cm^2 during wet season2013 at Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, India by adopting standard agronomic practices. Observations were recorded on five randomly selected plants for estimation of magnitude of heterosis with respect to quality traits *viz.*, hulling recovery (%), milling recovery (%), head rice recovery (%), kernel length (mm), kernel breadth (mm), kernel length breadth ratio, kernel length after cooking(mm), kernel breadth after cooking(mm), kernel elongation ratio, alkali spread value and amylose content (%). The character means of each replication was subjected for analysis of variance (Panse and Sukhatme,

1967) and estimation of heterosis over better parent, standard variety and standard hybrid (Fonseca and Patterson, 1968).

RESULT AND DISCUSSION

All crosses showed marked variations in the expression of heterobeltiosis and standard heterosis for quality traits Table1. Heterobeltiosis and standard heterosis were studied in 32 hybrids generated by crossing 16 pollen parent with two CMS lines used as female parent. Result indicated that Out of 32 hybrids , five hybrids *viz.*, IR 79156A x IET22228, IR 79156A x Danteswari, IR 79156A x IET 22202, IR 79156A x Sarjoo-52 and Pusa 6A x Akshaya Dhan were found significant desirable heterosis over better parent, standard variety and standard hybrid for most of the quality traits *viz.*, hulling recovery, kernel length, kernel breadth, kernel length breadth ratio, kernel length after cooking, kernel breadth after cooking, elongation ratio, alkali spread value and amylose content. Top two crosses for quality traits on the basis of significant positive standard heterosis over SV and SH were IR 79156A x IET22228 and IR 79156A x Danteswari. Cross combination, IR 79156A x IET 22228 showed significant negative standard heterosis over better parent (-22.61%), Standard variety (-3.60%) and Standard hybrid (-23.45%) for kernel breadth after cooking and average heterosis for kernel breadth whereas IR 79156A x Danteswari was found very low for quality traits *viz.*, kernel breadth, kernel breadth after cooking. The present study showed that superior performance for all characters was not expressed in a single hybrid combination. However, different cross combinations were found to be superior for various quality characters. These finding are in accordance with those of Sharma and Roy (1996), Singh and Haque (1999), Binodh *et al* (2006), Eradasappa *et al* (2007), Saravanan *et al* (2008), Vaithiyalingan and Nadarajan (2010), Adilakshmi and Reddy (2011), Krishna *et al* (2011) Kumar *et al* (2012), Singh *et al.* (2013) and Sharma *et al* (2013).

The present study suggests that the top heterotic crosses for quality characters, IR 79156A x IET22228 and IR 79156A x Danteswari may further be tested for the development of superior rice hybrids.

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Table 1. Anova for L x T analysis for different quality characters in rice

Source of Variations	df	Hulling recovery (%)	Milling recovery (%)	HRR (%)	Kernel Length (mm)	Kernel Breadth (mm)	Kernel L/B Ratio	KLAC (mm)	KBAC (mm)	ER	ASV	AC (%)
Replicates	2	11.52*	1.41	0.33	1.93	0.01	0.46	0.07	0.01	0.11	0.32	0.56
Treatments	49	44.98**	46.53**	40.17**	3.56**	0.08**	1.21**	9.06**	0.32**	0.21**	5.15**	17.55**
Parents	17	37.32**	42.96**	24.90**	2.48**	0.06**	0.92**	3.22**	0.30**	0.14*	6.78**	4.87**
Parents (Line)	1	40.50**	23.48*	11.01	0.00	0.03	0.20	2.88	0.00	0.05	6.00**	4.16*
Parents (Testers)	15	38.91**	42.15**	27.25**	2.74**	0.04*	0.74**	3.10**	0.33**	0.16**	6.72**	5.23**
Parents (L vs T)	1	10.18	74.44**	3.48	1.05	0.45**	4.36**	6.32*	0.19*	0.00	8.61**	0.08
Parents vs Crosses	1	1.15	0.06	15.83	27.51**	0.15*	4.85**	126.02**	0.07	0.17	5.25**	252.20**
Crosses	31	50.59**	49.98**	49.34**	3.39**	0.09**	1.24**	8.47**	0.33**	0.25**	4.25**	16.94**
Error	98	3.11	4.92	4.72	0.71	0.02	0.20	0.67	0.04	0.05	0.40	0.83
Total	149	16.99	18.56	16.32	1.66	0.04	0.54	3.42	0.13	0.10	1.96	6.33

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

Table 2. Estimates of *per se* performance, heterobeltosis and standard heterosis for different quality characters in 32 hybrids of rice

Characters	Hulling Recovery				Milling Recovery				Head Rice Recovery				Kernel Length (mm)			
Crosses	Mean	BP	BPT 5204	Arize 6444	Mean	BP	BPT 5204	Arize 6444	Mean	BP	BPT 5204	Arize 6444	Mean	BP	BPT 5204	Arize 6444
IR 79156A x IET 21519	77.98	3.50	1.12	2.54	70.75	0.28	-1.15	-2.38	62.72	1.60	5.41	0.13	7.87	20.16	64.12**	38.34**
IR 79156A x IET 22218	78.23	3.84*	1.45	2.87	69.50	-2.26	-2.89	-4.10	57.97	-6.81*	-2.57	-7.45*	8.29	26.58*	72.88**	45.72**
IR 79156A x IET 22228	83.85	9.83**	8.73**	10.26**	74.50	5.60*	4.10	2.80	61.36	1.68	3.13	-2.03	8.29	9.22	73.02**	45.84**
IR 79156A x IET 22202	80.89	7.36**	4.89*	6.36**	72.51	2.78	1.32	0.05	63.68	8.97**	7.04*	1.68	8.20	12.13	71.00**	44.14**
IR 79156A x IET 20524	77.23	-2.20	0.15	1.56	68.68	-2.65	-4.03	-5.23*	54.44	-7.49*	-8.50**	-13.09**	6.45	-12.68	34.56*	13.42
IR 79156A x IET 21542	79.69	4.12*	3.33	4.78*	70.58	-1.01	-1.38	-2.62	55.32	-10.35**	-7.01	-11.67**	7.41	6.82	54.59**	30.30*
IR 79156A x Vardhan	76.64	1.73	-0.61	0.78	72.66	2.99	1.52	0.25	58.64	0.34	-1.43	-6.37*	6.81	4.07	42.14**	19.81
IR 79156A x Akshaya Dhan	72.65	-8.15**	-5.79**	-4.47*	65.51	-7.15**	-8.47**	-9.61**	48.87	-17.67**	-17.86**	-21.97**	7.23	10.39	50.76**	27.08*
IR 79156A x Rajendra Kasturi	83.11	5.42**	7.77**	9.28**	73.29	3.88	2.40	1.12	61.93	5.96	4.08	-1.13	5.45	-16.80	13.63	-4.22
IR 79156A x Sarjoo- 52	70.68	-12.72**	-8.35**	-7.06**	61.50	-16.08**	-14.07**	-15.14**	52.43	-17.24**	-11.87**	-16.29**	5.56	-15.02	16.06	-2.17
IR 79156A x HUR-8-1	74.26	-2.56	-3.71	-2.36	67.61	-4.17	-5.53*	-6.71**	57.28	-2.00	-3.73	-8.55**	4.66	-28.82**	-2.78	-18.05
IR 79156A x BPT 5204	78.81	2.13	2.20	3.63	71.36	-0.66	-0.28	-1.53	58.26	-2.26	-2.07	-6.98*	5.36	-18.18	11.75	-5.80
IR 79156A x RPBIO-226	66.32	-17.41**	-14.00**	-12.80**	61.70	-15.40**	-13.79**	-14.87**	51.15	-16.51**	-14.03**	-18.34**	6.27	-4.28	30.74*	10.20
IR 79156A x Type-3	69.28	-12.04**	-10.17**	-8.91**	65.46	-7.22**	-8.54**	-9.68**	51.32	-12.19**	-13.75**	-18.07**	8.25	25.70*	72.11**	45.08**
IR 79156A x MTU-7029	79.60	-1.26	3.22	4.67*	75.84	4.28	5.97*	4.65	65.65	8.45**	10.34**	4.82	7.55	15.27	57.44**	32.71*
IR 79156A x Danteswari	78.28	3.53	1.51	2.93	73.28	2.29	2.39	1.11	62.52	6.98*	5.09	-0.18	7.13	6.31	48.82**	25.44
Pusa 6A x IET 21519	74.27	-7.79**	-3.70	-2.34	71.34	-4.25	-0.32	-1.57	60.44	-2.08	1.59	-3.50	6.39	-2.99	33.24*	12.31
Pusa 6A x IET 22218	73.14	-9.19**	-5.16**	-3.83	65.47	-12.13**	-8.52**	-9.66**	56.32	-9.46**	-5.34	-10.08**	8.61	30.84**	79.69**	51.47**
Pusa 6A x IET 22228	76.33	-5.23**	-1.02	0.37	63.04	-15.39**	-11.91**	-13.02**	54.45	-10.97**	-8.49**	-13.07**	8.09	6.58	68.85**	42.32**
Pusa 6A x IET 22202	72.99	-9.38**	-5.36**	-4.03*	70.28	-5.67*	-1.79	-3.02	60.68	-0.77	1.99	-3.12	8.62	17.88	79.76**	51.52**
Pusa 6A x IET 20524	79.31	-1.53	2.84	4.28*	68.64	-7.87**	-4.09	-5.29*	60.16	-1.62	1.11	-3.95	6.36	-13.90	32.68*	11.84
Pusa 6A x IET 21542	71.47	-11.26**	-7.32**	-6.02**	61.75	-17.12**	-13.72**	-14.80**	54.69	-11.39**	-8.08**	-12.69**	7.48	7.83	56.05**	31.54*
Pusa 6A x																

Vardhan	72.16	-10.40**	-6.43**	-5.12**	69.41	-6.84**	-3.01	-4.22	61.11	-0.07	2.71	-2.43	8.53	29.62**	78.03**	50.06**
Pusa 6A x Akshaya Dhan	78.67	-2.32	2.02	3.45	73.09	-1.90	2.13	0.85	60.95	-0.33	2.45	-2.68	7.80	18.53	62.80**	37.22*
Pusa 6A x Rajendra Kasturi	78.81	-2.15	2.20	3.63	69.33	-6.95**	-3.13	-4.34	61.05	-0.17	2.61	-2.53	6.26	-4.96	30.53*	10.02
Pusa 6A x Sarjoo- 52	79.99	-1.23	3.72	5.18**	71.85	-3.56	0.40	-0.86	58.97	-6.92*	-0.89	-5.85*	5.66	-13.97	18.15	-0.41
Pusa 6A x HUR-8-1	78.61	-2.39	1.94	3.37	68.54	-8.01**	-4.23	-5.43*	58.18	-4.86	-2.21	-7.10*	7.34	11.54	53.20**	29.13*
Pusa 6A x BPT 5204	80.87	0.41	4.87*	6.34**	69.67	-6.50**	-2.65	-3.87	58.42	-4.46	-1.80	-6.72*	7.11	7.95	48.26**	24.97*
Pusa 6A x RPBIO-226	80.81	0.34	4.79*	6.26**	75.50	1.33	5.49*	4.17	63.34	3.40	6.47*	1.13	6.07	-7.75	26.70	6.80
Pusa 6A x Type-3	78.98	-1.94	2.42	3.85*	70.66	-5.16*	-1.27	-2.50	60.37	-1.28	1.47	-3.61	6.58	-0.05	37.27*	15.71
Pusa 6A x MTU-7029	76.27	-5.40**	-1.10	0.29	61.95	-16.85**	-13.44**	-14.52**	54.88	-10.26**	-7.76*	-12.38**	6.99	6.13	45.76**	22.86
Pusa 6A x Danteswari	80.50	-0.05	4.39*	5.86**	70.76	-5.02*	-1.12	-2.36	61.32	0.27	3.06	-2.10	7.32	9.14	52.78**	28.78*
Mean	76.90	-2.63	-0.28	1.11	69.26	-4.88	-3.23	-4.44	58.40	-3.73	-1.83	-6.75	7.06	4.47	47.33	24.18
S. E.		1.44	1.44	1.44		1.82	1.82	1.82		1.78	1.78	1.78		0.69	0.69	0.69
Range	66.32 to 83.85	-17.41 to 9.83	-14.00 to 8.73	-12.80 to 10.26	61.5 to 75.84	-17.12 to 5.60	-14.07 to 5.97	-15.14 to 4.65	48.87 to 65.65	-17.67 to 8.97	-17.86 to 10.34	-21.97 to 4.82	4.66 to 8.62	-28.82 to 30.84	-2.78 to 79.76	-18.05 to 51.52

Characters		Kernel Breadth					Kernel L/B Ratio				KLAC			KBAC		
Crosses	Mean	BP	BPT 5204	Arize 6444	Mean	BP	BPT 5204	Arize 6444	Mean	BP	BPT 5204	Arize 6444	Mean	BP	BPT 5204	Arize 6444
IR 79156A x IET 21519	1.75	-8.87	13.91	-4.20	4.51	4.48	46.43**	44.24**	10.97	5.08	24.57**	-0.06	3.48	3.98	29.53**	2.86
IR 79156A x IET 22218	1.67	-13.17*	8.91	-8.41	4.98	15.37	61.69**	59.28**	11.24	6.14	27.64**	2.40	3.23	-5.64	20.35**	-4.43
IR 79156A x IET 22228	1.78	-5.16	15.87	-2.56	4.66	8.03	51.41**	49.15**	11.24	7.73	27.72**	2.46	2.59	-22.61**	-3.60	-23.45**
IR 79156A x IET 22202	1.84	1.65	20.22*	1.10	4.47	3.47	45.02**	42.86**	12.16	15.77*	38.13**	10.81	3.71	4.71	37.97**	9.56
IR 79156A x IET 20524	2.29	10.27	49.35**	25.59**	2.85	-33.90**	-7.36	-8.74	12.29	15.65*	39.61**	12.00	3.51	4.78	30.52**	3.65
IR 79156A x IET 21542	1.95	-4.56	27.39**	7.13	3.80	-12.05	23.27	21.43	10.65	2.04	20.98**	-2.95	3.26	-2.59	21.34**	-3.65
IR 79156A x Vardhan	1.91	-1.55	24.57**	4.75	3.55	-17.76*	15.26	13.54	13.32	27.63**	51.31**	21.39**	3.04	-9.16	13.15	-10.15
IR 79156A x Akshaya Dhan	2.40	25.65**	56.52**	31.63**	3.03	-29.73**	-1.52	-2.99	13.47	19.84**	53.01**	22.75**	3.04	-9.26	13.03	-10.25
IR 79156A x Rajendra Kasturi	1.85	0.54	20.65*	1.46	2.93	-32.12**	-4.87	-6.29	9.67	-7.38	9.81	-11.91	2.93	-12.35*	9.18	-13.30*
IR 79156A x Sarjoo- 52	1.93	-4.30	25.87**	5.85	2.87	-33.59**	-6.93	-8.32	10.24	-1.92	16.28*	-6.71	2.70	-19.32**	0.50	-20.20**
IR 79156A x HUR-8-1	1.94	6.61	26.30**	6.22	2.41	-44.25**	-21.86	-23.03	11.43	6.22	29.88**	4.19	2.76	-23.78**	2.61	-18.52**
IR 79156A x																

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BPT 5204	2.11	28.66**	37.61**	15.72*	2.53	-41.31**	-17.75	-18.98	11.41	9.29	29.57**	3.95	2.94	-12.25*	9.31	-13.20*
IR 79156A x RPBIO-226	1.80	5.66	17.61*	-1.10	3.49	-19.15*	13.31	11.62	11.51	10.25	30.71**	4.86	2.72	-18.73**	1.24	-19.61**
IR 79156A x Type-3	2.33	25.09**	51.74**	27.61**	3.56	-17.45*	15.69	13.97	14.38	23.62**	63.31**	31.01**	3.40	-2.11	26.67**	0.59
IR 79156A x MTU-7029	1.90	-6.72	23.70**	4.02	3.97	-8.11	28.79*	26.87	13.47	29.10**	53.05**	22.78**	3.40	-6.50	26.67**	0.59
IR 79156A x Danteswari	1.75	-1.69	13.91	-4.20	4.10	-5.10	33.01**	31.02*	13.63	19.25**	54.79**	24.18**	3.46	3.49	28.91**	2.36
Pusa 6A x IET 21519	1.81	-5.39	18.26*	-0.55	3.52	-10.97	14.18	12.47	9.47	-19.04**	7.54	-13.73*	2.81	-17.27**	4.59	-16.95**
Pusa 6A x IET 22218	1.78	-7.45	16.09*	-2.38	4.85	22.78*	57.47**	55.12**	12.42	6.19	41.05**	13.15*	2.88	-16.05**	7.07	-14.98**
Pusa 6A x IET 22228	2.04	8.90	33.04**	11.88	3.97	-1.98	28.79**	26.87*	12.77	9.24	45.10**	16.40**	3.43	0.88	27.54**	1.28
Pusa 6A x IET 22202	1.94	7.17	26.74**	6.58	4.49	11.60	45.78**	43.60**	14.46	23.69**	64.29**	31.80**	3.39	-4.14	26.30**	0.30
Pusa 6A x IET 20524	2.06	-0.80	34.35**	12.98	3.09	-21.86*	0.22	-1.28	12.66	8.30	43.85**	15.40*	3.49	2.65	29.78**	3.05
Pusa 6A x IET 21542	2.04	-0.33	33.04**	11.88	3.68	-6.92	19.37	17.59	10.74	-8.12	22.04**	-2.10	3.29	-3.24	22.33**	-2.86
Pusa 6A x Vardhan	2.08	7.22	35.65**	14.08*	4.09	3.54	32.79**	30.81*	11.64	-0.48	32.18**	6.04	2.81	-17.17**	4.71	-16.85**
Pusa 6A x Akshaya Dhan	2.05	7.33	33.70**	12.43	3.83	-3.12	24.24**	22.39	13.40	14.57*	52.18**	22.08**	2.44	-28.26**	-9.31	-27.98**
Pusa 6A x Rajendra Kasturi	1.88	2.36	22.83**	3.29	3.19	-19.32*	3.46	1.92	8.26	-29.39**	-6.21	-24.76**	2.95	-13.25*	9.68	-12.91*
Pusa 6A x Sarjoo- 52	1.74	-13.72*	13.48	-4.57	3.25	-17.81*	5.41	3.84	9.01	-22.95**	2.35	-17.89**	3.38	-0.49	25.81**	-0.10
Pusa 6A x HUR-8-1	1.82	0.00	18.48*	-0.37	4.03	2.03	30.84**	28.89**	10.55	-9.75	19.88*	-3.83	3.29	-8.94	22.58**	-2.66
Pusa 6A x BPT 5204	1.84	10.18	20.00*	0.91	3.86	-2.19	25.43**	23.56	12.70	8.64	44.30**	15.77*	3.07	-9.72	14.14*	-9.36
Pusa 6A x RPBIO-226	1.72	0.98	12.39	-5.48	3.53	-10.55	14.72	13.01	11.96	2.25	35.82**	8.96**	3.15	-7.36	17.12*	-7.00
Pusa 6A x Type-3	1.77	-4.66	15.65	-2.74	3.71	-6.08	20.45	18.66	14.62	25.03**	66.07**	33.23**	3.66	5.37	36.35**	8.28
Pusa 6A x MTU-7029	1.84	-9.67	19.78*	0.73	3.80	-3.88	23.27	21.43	13.90	18.90**	57.93**	26.70**	3.11	-14.47**	15.88*	-7.98
Pusa 6A x Danteswari	1.86	4.69	21.30*	2.01	3.94	-0.17	28.03*	26.12*	14.49	23.92**	64.60**	32.05**	3.68	8.24	36.85**	8.67
Mean	1.93	2.02	25.27	5.35	3.70	-10.25	20.25	18.45	12.00	7.47	36.35	9.38	3.16	-7.83	17.46	-6.72
S. E.		0.12	0.12	0.12		0.37	0.37	0.37		0.66	0.66	0.66		0.18	0.18	0.18
Range	1.67 to 2.4	-13.72 to 28.66	8.91 to 56.52	-8.41 to 31.63	2.41 to 4.98	-44.25 to 22.78	-21.86 to 61.69	-23.03 to 59.28	8.26 to 14.62	-29.39 to 29.10	-6.21 to 66.07	-24.76 to 33.23	2.44 to 3.71	-28.26 to 8.24	-9.31 to 36.85	-27.98 to 9.56

Characters	Kernel Elongation Ratio				Alkali Spread Value				Amylose Content			
Crosses	Mean	BP	BPT 5204	Arize 6444	Mean	BP	BPT 5204	Arize 6444	Mean	BP	BPT 5204	Arize 444
IR 79156A x IET 21519	1.45	-27.69**	-22.14*	-22.83*	6.33	-5.00	72.73**	0.00	22.67	15.25**	11.48**	6.25
IR 79156A x IET 22218	1.35	-17.31	-27.50*	-28.14**	6.67	0.00	81.82**	5.26	21.00	0.00	3.28	-1.56
IR 79156A x IET 22228	1.37	-14.02	-26.61*	-27.26*	4.33	-35.00**	18.18	-31.58**	23.00	6.15	13.11**	7.81*
IR 79156A x IET 22202	1.48	-6.90	-20.54	-21.24*	5.33	-27.27**	45.45**	-15.79	25.00	27.12**	22.95**	17.19**
IR 79156A x IET 20524	1.91	20.08	2.50	1.59	3.33	-50.00**	-9.09	-47.37**	24.67	10.45**	21.31**	15.63**
IR 79156A x IET 21542	1.45	-9.00	-22.32*	-23.01*	4.67	-30.00**	27.27	-26.32**	26.33	21.54**	29.51**	23.44**
IR 79156A x Vardhan	1.97	15.91	5.36	4.42	3.67	-45.00**	0.00	-42.11**	20.00	-4.76	-1.64	-6.25
IR 79156A x Akshaya Dhan	1.86	6.90	-0.36	-1.24	5.67	-15.00	54.55**	-10.53	19.00	-10.94**	-6.56	-10.94**
IR 79156A x Rajendra Kasturi	1.80	-0.55	-3.75	-4.60	6.33	-5.00	72.73**	0.00	26.00	32.20**	27.87**	21.88**
IR 79156A x Sarjoo- 52	1.86	16.95	-0.18	-1.06	5.33	-20.00*	45.45**	-15.79	23.33	4.48	14.75**	9.38**
IR 79156A x HUR-8-1	2.51	15.51	34.29**	33.10**	2.33	-65.00**	-36.36*	-63.16**	21.00	6.78	3.28	-1.56
IR 79156A x BPT 5204	2.16	30.38*	15.71	14.69	5.67	-15.00	54.55**	-10.53	25.00	22.95**	22.95**	17.19**
IR 79156A x RPBIO-226	1.90	17.01	1.96	1.06	3.33	-50.00**	-9.09	-47.37**	26.00	32.20**	27.87**	21.88**
IR 79156A x Type-3	1.74	-2.06	-6.61	-7.43	5.33	-20.00*	45.45**	-15.79	26.33	21.54**	29.51**	23.44**
IR 79156A x MTU-7029	1.79	-2.71	-3.93	-4.78	4.67	-30.00**	27.27	-26.32**	26.00	18.18**	27.87**	21.88**
IR 79156A x Danteswari	1.92	12.50	2.86	1.95	5.00	-25.00**	36.36*	-21.05*	25.00	27.12**	22.95**	17.19**
Pusa 6A x IET 21519	1.48	-26.37**	-20.71	-21.42*	6.67	0.00	81.82**	5.26	21.00	-1.56	3.28	-1.56
Pusa 6A x IET 22218	1.44	-19.10	-22.86*	-23.54*	4.67	0.00	27.27	-26.32**	19.67	-7.81*	-3.28	-7.81*
Pusa 6A x IET 22228	1.58	-11.42	-15.54	-16.28	7.00	31.25**	90.91**	10.53	21.67	0.00	6.56	1.56
Pusa 6A x IET 22202	1.70	-4.49	-8.93	-9.73	6.33	-13.64	72.73**	0.00	22.00	3.13	8.20*	3.13
Pusa 6A x IET 20524	2.02	13.67	8.39	7.43	4.33	-7.14	18.18	-31.58**	25.00	11.94**	22.95**	17.19**
Pusa 6A x IET 21542	1.45	-18.54	-22.32*	-23.01*	3.00	-35.71**	-18.18	-52.63**	23.00	6.15	13.11**	7.81*
Pusa 6A x Vardhan	1.37	-23.03*	-26.61*	-27.26*	3.67	-31.25**	0.00	-42.11**	22.67	6.25	11.48**	6.25
Pusa 6A x Akshaya Dhan	1.72	-3.37	-7.86	-8.67	4.67	0.00	27.27	-26.32**	20.33	-4.69	0.00	-4.69
Pusa 6A x Rajendra Kasturi	1.36	-24.91*	-27.32*	-27.96*	5.67	6.25	54.55**	-10.53	20.00	-6.25	-1.64	-6.25
Pusa 6A x Sarjoo- 52	1.62	-8.80	-13.04	-13.81	6.67	17.65	81.82**	5.26	22.33	0.00	9.84**	4.69
Pusa 6A x HUR-8-1	1.45	-33.33**	-22.50*	-23.19*	4.33	-7.14	18.18	-31.58**	26.33	23.44**	29.51**	23.44**
Pusa 6A x BPT 5204	1.86	4.31	-0.54	-1.42	4.33	-7.14	18.18	-31.58**	25.67	20.31**	26.23**	20.31**
Pusa 6A x RPBIO-226	1.99	11.80	6.61	5.66	3.67	-21.43	0.00	-42.11**	22.00	3.13	8.20*	3.13
Pusa 6A x Type-3	2.25	26.22*	20.36	19.29	5.33	14.29	45.45**	-15.79	25.33	16.92**	24.59**	18.75**
Pusa 6A x MTU-7029	2.00	8.68	7.32	6.37	5.00	7.14	36.36*	-21.05*	27.00	22.73**	32.79**	26.56**
Pusa 6A x Danteswari	1.98	11.24	6.07	5.13	4.33	-7.14	18.18	-31.58**	21.67	1.56	6.56	1.56
Mean	1.75	-1.32	-6.58	-7.41	4.93	-15.35	34.37	-22.20	23.32	10.17	14.65	12.40
S. E.		0.20	0.20	0.20		0.52	0.52	0.52		0.75	0.75	0.75
Range	1.35 to 2.51	-33.33 to 30.38	-27.50 to 34.29	-28.14 to 33.10	2.33 to 7	-65 to 31.25	-36.36 to 90.91	-63.16 to 10.53	19 to 27	-10.94 to 32.20	-6.56 to 32.79	-10.94 to 26.56

programme at Banaras Hindu University, Varanasi, Uttar Pradesh.

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