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Studies on Heterosis for yield and its Attributing Traits in Tomato (*Solanumlycopersicum* L.)

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Abstract

Twenty eight hybrids of tomato developed using eight parents (PusaRohini, PusaGaurav, Roma, Cherry Orange, Selection-1, Taiwan, N-5 and C-10-15-27-3) in half diallelfashion were studied for estimation of heterosis for yield and its attributing traits. Hybrids PusaGaurav x Taiwan, PusaRohini x PusaGaurav and PusaRohini x Roma were found most promising for yield and its contributing traits. These hybrid exhibited heterosis to the tune of 48.14%, 44.47% and 73.41% over better parents and 83.43%, 76.78% and 74.24%, respectively over the check cultivar for fruit yield per plant. The cross combination PusaGaurav x Taiwan expressed highest significant standard parent heterosis and SCA estimates for yield and its attributing traits and it was identified for evaluation in multilocation trail and commercial exploitation.

Highlights

- Hybrids *Viz*.PusaGaurav × Taiwan, PusaRohini × PusaGaurav and PusaRohini ×Roma were found to be betterheterotic combinations for yield.
- F_1 hybrid PusaGaurav × Taiwan expressed 83.43% heterosis for yield over standard parentmay be recommended for commercial exploitation.

Keywords: Diallel, Heterosis, Tomato, Yield attributing traits, *Solanumlycopersicum.*

Introduction

Tomato universally treated as “protective food” is being extensively grown as annual plant all over the world. In India, tomato is cultivated in about 0.87 million hectare in different parts and is well adapted in varied climatic conditions of the country. Its production is nearly 16.81 million ton and productivity is 19.5mt./ha. (Anonymous, 2011). In developed countries it is commonly consumed fresh; over 80% of the tomato consumption comes from processed products such as juice, paste, puree, ketchup and sauce. It has high nutritional value; one medium fresh tomato (135g) provides 47% Recommended Dietary Allowance (RDA) of vitamin C, 22% RDA vitamin A and 25 calories. The pulp and juice are digestible, a promoter of gastric secretion and blood purifier. It has antiseptic properties against intestinal infections. Tomato is a good appetizer and its soup is said to be a good remedy for patients suffering from constipation. It is one of the best vegetable which keeps our stomach and intestine in order.Various breeding techniques have been advocated considering the

breeding behaviour of crop species. Out of these hybrids breeding is prominent and used in the improvement of vegetable crops. Heterosis in tomato was first observed by Hedrickand Booth (1968) for higher yield and more number of fruits per plant. Choudhary*et al*. (1965) emphasized the extensive utilization of heterosis to step up tomato production. Heterosis manifestation in tomato is in the form of the greater vigour, faster growth and development, earliness in maturity, increased productivity (Yordanov, 1983).So a speedy improvement can be brought about by exploiting heterosis for various yield contributing traits as well as earliness.

Materials and Methods

Eight genetically diverse parental lines of tomato were used to develop 28 F_1s following a half diallel mating system, excluding reciprocals during winter, 2010. The parental lines used were PusaRohini, PusaGaurav, Roma, Cherry Orange, Selection-1, Taiwan, N-5 and C-10-15-27-3. The 28 F_1s along with their eight parents were evaluated during winter, 2011 at Research Farm of the Division of Vegetable Science, Indian Agricultural Research Institute, New Delhi. Parental line Roma considered as check during experiment. The experiment was laid out in a randomized block design (RBD) with three replications. Each plant was transplanted at a distance of 60cm between rows and 45cm between plants. Standard agronomic practices were followed to raise the crop. Observations were recorded on ten competitive plants selected at random for eight quantitative traits viz. days to first flowering, number of fruit per plant, average fruit weight, fruit length, fruit diameter, fruit size, days to first fruit harvest and yield/plant. The mean data obtained for quantitative traits on per plant basis were analysed statistically for heterosis as suggested by Fonseca and Patterson.

Results and Discussion

There were significant differences among the parental lines with respect to different characters studied including yield per plant. The mean performance of eight parental lines along with 28 F_1 hybrids is given in Table 1. With respect to days to first flowering range of heterosis varied from -10.64% to -11.20% over mid parent, -10.41% to -16.11% over better parent and -11.84% to -18.60% over standard parent.Out of 28 F_1 hybrids, 4 crosses showed negative heterosis over mid parent, 7 over better parent and 6 over mid parent for days to first flowering. The F_1 hybrid PusaRohini x Cherry Orange showed maximum heterosis over mid parent (-11.20%), F_1 hybrid PusaGaurav x Cherry Orange over better parent (-16.11%) and F_1 hybrid PusaGaurav x Selection-1 showed maximum heterosis over standard parent (-18.60%). In accordance with the present finding, Singh and Singh (1993), Baishya *et. al.* (2001) and Joshi and Thakur (2003)also observed earliness in heterotic combinations of tomato.For number of fruit per plant range of heterosis varied from 13.13% to 30.07% over mid parent, and 169.61% to 320.36% over standard parent. Six hybrid showed positive heterosis over mid parent, out of which PusaGaurav x Cherry Orange exhibited highest significant positive heterosis over mid parent (30.07%) and seven hybrids showed significant positive heterosis over standard parent, out of which Pusa Rohini x Cherry Orange exhibited highest significant positive heterosis over standard parent (309.81%). Similar observations were also made by Joshi and Thakur (2003), Baishya*et al*. (2001) and Kumar *et al.* (2012)with a different set of material in tomato.The extent of heterosis for average fruit weight varied from 9.96% to 14.79% over mid parent and 13.19% to 28.01% over standard parent. The highest significant heterosis was noted in four and six hybrids over mid parent and standard parent, respectively. The F_1 hybrid Pusa Rohini x N-5 showed maximum heterosis over mid parent (14.79%) and Pusa Gaurav x Taiwan showed maximum heterosis over standard parent (28.01%). These results are in consonance with Sundaram*et al*. (1994), Baishya *et al*. (2001) and Garg and Cheema (2010)in tomato.The extent of heterosis for average fruit length varied from -42.97% to 15.56% over mid parent, -65.00% to 13.92% over better parent and -66.84% to 11.03% over standard parent. Twenty eight hybrids showed positive heterosis over mid parent, out of which Roma x Taiwan expressed highest heterosis over mid parent (15.56%); twenty one hybrids showed positive heterosis over better parent, out of which PusaGaurav x C-10-15-27-3 exhibited highest heterosis over better parent (13.92%) and eighteen hybrids showed positive heterosis over standard parent, out of them Roma x Selection-1 exhibited highest heterosis over standard parent (11.03%).Dev*et al*. (1994) and Chattopadhyay and Paul (2012)also reported significant heterosis for fruit length in tomato.

For fruit diameter, range of heterosis varied from -56.43% to 14.38% over mid parent, -72.15% to 14.19% over better parent and -65.54% to 40.20% over standard parent. The highest significant positive heterosis was noted in twenty, ten and twenty one hybrids over mid parent, better parent and standard parent, respectively. The F_1 hybrid Pusa

Gaurav x Taiwan expressed maximum heterosis over mid parent (14.38%), better parent (14.19%) and standard parent (40.20%).Devi *et al*. (1994)also observed significant positive heterosis for fruit diameter in different cross combination of tomato.Heterosis for fruit size varied from -81.72% to 29.23% over mid parent and -88.68% to 52.43% over standard parent. Significant heterosis was recorded in ten crosses. However, only three crosses expressed significant heterosis in desirable direction. Maximum heterosis over mid parent recorded in PusaGaurav x Taiwan (29.23%). Significant heterosis over standard parent was observed in twenty crosses, out of which only thirteen crosses expressed positive heterosis. Maximum heterosis over standard parent recorded in PusaGaurav x Selection-1 (52.43%).With respect to days to first fruit harvest range of heterosis varied from -10.46%

Table 1: Mean performance of parents and F_1s for yield traits in tomato

	Days to first flowering	Number of fruit per plant	Average fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)	Fruit size (L x W)	Days to first harvest	Yield/ plant
PusaRohini	59.47	60.27	46.04	3.92	3.86	15.13	165.80	2.77
PusaGaurav	60.40	55.40	60.75	4.21	4.13	17.46	164.20	3.37
Roma	59.21	56.25	48.94	4.47	3.37	15.10	161.20	2.76
Cherry Orange	53.00	308.20	6.92	1.00	1.18	1.18	158.20	2.14
Selection-1	54.93	74.03	36.77	4.47	4.24	18.95	162.13	2.73
Taiwan	56.20	64.38	53.19	4.09	4.12	16.89	161.20	3.41
N-5	58.20	48.67	40.87	4.21	4.19	17.71	163.00	2.00
C-10-15-27-3	65.33	30.33	51.47	4.33	4.24	18.51	170.13	1.57
PusaRohini x PusaGaurav	55.13	86.07	56.52	4.46	4.25	19.08	148.67	4.87
PusaRohini x Roma	56.60	89.33	53.90	4.72	3.73	17.78	147.60	4.80
PusaRohini x Cherry Orange	49.93	230.53	15.31	1.57	1.19	1.86	146.47	3.50
PusaRohini x Selection-1	57.47	83.13	44.87	4.58	4.24	19.51	147.13	3.74
PusaRohini x Taiwan	55.13	82.27	53.94	4.47	4.11	18.39	149.07	4.43
PusaRohini x N-5	54.33	85.40	49.88	4.56	4.24	19.47	151.33	4.27
PusaRohini x C-10-15-27-3	63.27	50.40	47.50	4.57	4.40	20.15	156.27	2.40
PusaGaurav x Roma	55.87	86.20	55.39	4.85	3.88	18.90	148.20	4.79
PusaGaurav x Cherry Orange	50.67	236.47	17.93	1.51	1.16	1.77	147.20	4.27
PusaGaurav x Selection-1	54.40	83.47	45.80	4.90	4.67	23.02	149.07	3.83
PusaGaurav x Taiwan	52.87	80.47	62.64	4.73	4.72	22.20	151.40	5.06
PusaGaurav x N-5	54.47	83.47	48.71	4.62	4.25	19.75	150.20	4.07
PusaGaurav x C-10-15-27-3	57.60	48.67	56.36	4.94	4.37	21.70	155.20	2.75
Roma x Cherry Orange	54.20	231.13	14.55	1.74	1.17	2.05	143.00	3.34
Roma x Selection-1	51.00	78.47	43.65	4.97	3.88	19.34	147.40	3.43
Roma x Taiwan	53.87	75.60	56.63	4.95	4.02	19.94	146.40	4.29
Roma x N-5	53.93	53.07	49.46	4.83	4.00	19.39	148.07	2.62
Roma x C-10-15-27-3	61.73	44.47	52.76	4.89	4.11	20.07	155.07	2.34
Cherry Orange x Selection-1	48.20	226.07	10.40	1.56	1.28	1.99	145.00	2.36
Cherry Orange x Taiwan	50.47	221.47	16.61	1.48	1.16	1.71	146.13	3.70
Cherry Orange x N-5	52.20	201.87	13.09	1.49	1.17	1.73	147.07	2.66
Cherry Orange x C-10-15-27-3	58.84	151.67	14.79	1.67	1.18	1.96	154.13	2.26
Selection-1 x Taiwan	57.07	58.80	45.76	4.80	4.68	22.55	151.13	2.69
Selection-1 x N-5	55.67	56.47	43.53	4.80	4.62	22.39	150.20	2.46
Selection-1 x C-10-15-27-3	58.53	46.27	43.52	4.50	4.35	19.64	156.00	2.02
Taiwan x N-5	53.73	57.20	47.84	4.70	4.54	21.55	149.60	2.73
Taiwan x C-10-15-27-3	58.93	50.60	55.55	4.71	4.30	20.27	157.27	2.82
N-5 x C-10-15-27-3	61.47	39.47	46.88	4.55	4.41	20.14	156.47	1.86
Grand Mean	55.95	100.45	41.91	3.91	3.54	15.53	152.96	3.20
CD at 5%	5.63	9.45	3.69	0.43	0.47	3.34	2.36	0.42
CD at 1%	7.26	12.54	4.90	0.58	0.62	4.43	3.13	0.56
S.E.	2.74	4.74	1.85	0.22	0.23	1.67	1.18	0.21

Table 2: Estimates of mid parent (MP), better parent (BP) and standard parent heterosis for different yield contributing traits in tomato

Genotypes	Days to first flowering			Number of fruit per plant			Average fruit weight(g)			Fruit length(cm)		
	MP	BP	SP	MP	BP	SP	MP	BP	SP	MP	BP	SP
PusaRohini x PusaGaurav	-8.01	-8.72	-6.89	48.82	42.81	53.00	5.85	-6.97	15.49**	9.75**	5.93**	-0.22
PusaRohini x Roma	-4.62	-4.82	-4.41	53.34	48.23	58.81	13.51**	10.14	10.14	12.55**	5.59**	5.59**
PusaRohini x Cherry Orange	-11.20*	-16.03**	-15.67**	25.13**	-25.2**	309.81**	-42.17**	-66.74**	-68.71**	-36.04**	3.92**	-64.83**
PusaRohini x Selection-1	0.47	-3.36	-2.95	23.8	12.29	47.78	8.38	-2.53	-8.30	9.14**	2.46*	2.31*
PusaRohini x Taiwan	-4.67	-7.29	-6.89	32	27.79	46.24	8.72	1.41	10.22	11.56**	9.2**	-0.07
PusaRohini x N-5	-7.65	-8.63	-8.24	56.79	41.7	51.81	14.79**	8.34	1.92	12.21**	8.31**	2.01*
PusaRohini x C-10-15-27-3	1.39	-3.16	6.85	11.26	-16.37	-10.41	-2.58	-7.72	-2.94	10.74**	5.46**	2.16**
PusaGaurav x Roma	-6.59	-7.51	-5.65	54.41	53.24	53.24	1.00	-8.82	13.19*	11.67**	8.42**	8.42**
PusaGaurav x Cherry Orange	-10.64*	-16.11**	-14.43**	30.07**	-23.27**	320.36**	-47.01**	-70.49**	-63.36**	-41.94**	-64.08**	-66.17**
PusaGaurav x Selection-1	-5.66	-9.93	-8.13	28.97	12.74	48.38	-6.07	-24.60**	-6.40	12.83**	9.63**	9.46**
PusaGaurav x Taiwan	-9.32	-12.47*	-10.72	34.36	24.99	43.04	9.96*	3.12	28.01**	13.88**	12.26**	5.74**
PusaGaurav x N-5	-8.15	-9.82	-8.02	60.41	50.66	48.38	-4.14	-19.82**	-0.47	9.65**	9.65**	3.28**
PusaGaurav x C-10-15-27-3	-8.38	-11.84*	-2.72	13.53	-12.15	-13.49	0.45	-7.23	15.17**	15.52**	13.92**	10.36**
Roma x Cherry Orange	-3.40	-8.47	-8.47	26.84**	-25.01**	310.88**	-47.91**	-70.27**	-70.27**	-36.42**	-61.1**	-61.1**
Roma x Selection-1	-10.64*	-13.87*	-13.87*	20.45	5.99	39.49	1.86	-10.80	-10.80	11.11**	11.03**	11.03**
Roma x Taiwan	-6.65	-9.03	-9.03	25.34	17.43	34.39	10.89*	6.46	15.71**	15.56**	10.66**	10.66**
Roma x N-5	-8.13	-8.92	-8.92	1.16	-5.66	-5.66	10.15	1.07	1.07	11.28**	8.05**	8.05**
Roma x C-10-15-27-3	-0.87	-5.51	4.26	2.71	-20.95	-20.95	5.10	2.51	7.82	11.05**	9.31**	9.31**
Cherry Orange x Selection-1	-10.69*	-12.26*	-18.60**	18.29**	-26.65**	301.87**	-52.38**	-71.71**	-78.74**	-42.80**	-65**	-66.05**
Cherry Orange x Taiwan	-7.57	-10.20	-14.77**	18.88**	-28.14**	293.70**	-44.75**	-68.78**	-66.06**	-41.75**	-63.76**	-66.84**
Cherry Orange x N-5	-6.12	-10.31	-11.84*	13.13**	-34.5**	258.85**	-45.20**	-67.96**	-73.24**	-42.97**	-64.72**	-66.77**
Cherry Orange x C-10-15-27-3	-0.55	-9.94	-0.63	-10.4**	-50.79**	169.61**	-49.35**	-71.27**	-69.78**	-37.37**	-61.46**	-62.67**
Selection-1 x Taiwan	2.70	1.54	-3.63	-15.04	-20.58	4.53	1.73	-13.97**	-6.49	12.23**	7.54**	7.38**
Selection-1 x N-5	-1.59	-4.35	-5.99	-7.96	-23.73	0.38	12.12	6.51	-11.06	10.68**	7.54**	7.38**
Selection-1 x C-10-15-27-3	-2.66	-10.41*	-1.15	-11.34	-37.51	-17.75	-1.37	-15.45**	-11.08	2.2*	0.67	0.52
Taiwan x N-5	-6.06	-7.67	-9.25	1.2	-11.15	1.68	1.73	-10.05	-2.23	13.16**	11.55**	5.07**
Taiwan x C-10-15-27-3	-3.02	-9.80	-0.47	6.85	-21.4	-10.05	6.16	4.44	13.52*	11.79**	8.69**	5.29**
N-5 x C-10-15-27-3	-0.49	-5.92	3.81	-0.08	-18.9	-29.84	1.55	-8.91	-4.20	6.47**	5.00**	1.71

*, **Significant at 5 % and 1% level, respectively

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Table 3: Estimates of mid parent (MP), better parent (BP) and standard parent heterosis for different yield contributing traits in tomato

Genotypes	Fruit diameter(cm)			Fruit size (L x W)			Days to first fruit harvest			Yield/plant		
	MP	BP	SP	MP	BP	SP	MP	BP	SP	MP	BP	SP
PusaRohini x PusaGaurav	6.47**	2.90*	26.34**	17.10	9.28	26.35	-9.90**	-9.46**	-7.78**	58.65**	44.47**	76.78**
PusaRohini x Roma	3.28*	-3.28**	10.79**	17.62	17.51	17.72	-9.72**	-8.44**	-8.44**	73.82**	73.41**	74.24**
PusaRohini x Cherry Orange	-52.75**	-69.14**	-64.65**	-77.15**	-87.68**	-87.66**	-9.59**	-7.42**	-9.14**	42.61**	26.47**	27.09**
PusaRohini x Selection-1	4.69**	-0.08	25.94**	-14.51	2.97	29.2	-10.27**	-9.25**	-8.73**	35.8**	34.9**	35.55**
PusaRohini x Taiwan	2.97**	-0.32	21.98**	14.87	8.88	21.78	-8.83**	-7.53**	-7.53**	43.18**	29.69**	60.58**
PusaRohini x N-5	5.43**	1.27	25.94**	18.58	9.94	28.93	-7.95**	-7.16**	-6.12**	78.9**	54.03**	54.78**
PusaRohini x C-10-15-27-3	8.65**	3.78**	30.59**	19.79	8.84	33.41*	-6.97**	-5.75**	-3.06**	10.84**	-13.24**	-12.82**
PusaGaurav x Roma	3.47**	-6.13**	15.26**	16.09	8.25	25.16	-8.91**	-8.06**	-8.06**	56.17**	41.9**	73.64**
PusaGaurav x Cherry Orange	-56.34**	-71.94**	-65.54**	-81.05**	-89.88**	-88.30**	-8.68**	-6.95**	-8.68**	54.8**	26.58**	54.90**
PusaGaurav x Selection-1	11.5**	10.05**	38.71**	26.46*	21.5	52.43**	-8.64**	-8.06**	-7.53**	25.44**	13.54**	38.94**
PusaGaurav x Taiwan	14.38**	14.19**	40.20**	29.23*	27.12	46.98**	-6.95**	-6.08**	-6.08**	49.02**	48.14**	83.43**
PusaGaurav x N-5	2.24**	1.59	26.34**	12.31	11.52	30.79*	-8.19**	-7.85**	-6.83**	51.61**	20.75**	47.76**
PusaGaurav x C-10-15-27-3	4.58**	3.30*	30.00**	20.62	17.19	43.65**	-7.16**	-5.48**	-3.72**	11.34**	-18.48**	-0.24
Roma x Cherry Orange	-48.68**	-65.35**	-65.35**	-74.87*	-86.43**	-86.43**	-10.46**	-9.61**	-11.29**	36.46**	21.28**	21.28**
Roma x Selection-1	1.97	-8.56**	15.25**	13.57	2.04	28.03	-8.82**	-8.56**	-8.56**	25.08**	24.55**	24.5**
Roma x Taiwan	7.39**	-2.43	19.41**	24.62	18.01	32.00**	-9.18**	-9.18**	-9.18**	39.17**	25.78**	55.74**
Roma x N-5	5.91**	-4.46**	18.81**	18.19	9.48	28.40	-8.66**	-8.15**	-8.15**	10.3**	-4.84**	-4.84**
Roma x C-10-15-27-3	8.20**	-2.91*	22.18**	19.41	8.41	32.88*	-6.40**	-3.80**	-3.80**	8.1**	-15.24**	-15.24**
Cherry Orange x Selection-1	-52.67**	-69.76**	-61.88**	-80.2**	-89.48**	-86.80**	-9.47**	-8.34**	-10.04**	-3.08*	-13.54**	-14.27**
Cherry Orange x Taiwan	-56.23**	-71.84**	-65.54**	-81.08**	-89.88**	-88.68**	-8.50**	-7.63**	-9.35**	33.05**	8.3**	34.10**
Cherry Orange x N-5	-56.40**	-72.05**	-65.25**	-81.72**	-90.25**	-88.57**	-8.43**	-7.04**	-8.77**	28.4**	24.11**	-3.51
Cherry Orange x C-10-15-27-3	-56.43**	-72.15**	-64.95**	-80.13**	-89.43**	-87.05**	-6.11**	-2.57*	-4.38**	21.65**	5.29**	-18.14**
Selection-1 x Taiwan	11.92**	10.29**	39.01**	25.84*	19.01	49.33**	-6.52**	-6.24**	-6.24**	-12.47**	-21.19**	-2.42
Selection-1 x N-5	9.61**	8.88**	37.23**	22.14	18.15	48.25**	-7.61**	-7.36**	-6.82**	4.08**	-9.88**	-10.64**
Selection-1 x C-10-15-27-3	2.59*	2.51*	29.21**	4.87	3.65	30.06*	-6.10**	-3.78**	-3.23**	-6.2**	-26.22**	-26.84**
Taiwan x N-5	9.31**	8.44**	34.85**	24.52	21.64	42.66**	-7.71**	-7.20**	-7.20**	0.99	-19.92**	-0.85
Taiwan x C-10-15-27-3	2.91**	1.49	27.72**	14.5	9.49	34.21*	-5.07	-2.44*	-2.44**	13.12**	-17.48**	2.18
N-5 x C-10-15-27-3	4.79**	4.17**	31.09**	11.17	8.77	33.33*	-6.06	-4.01**	-2.94**	4.11*	-7.17**	-32.65**

*, **Significant at 5 % and 1% level, respectively

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to -6.10% over mid parent, -9.61% to -7.20% over better parent and -11.29% to -2.44% over standard parent. Twenty six hybrids showed desirable negative heterosis over mid parent, out of which Roma x Cherry Orange expressed highest heterosis over mid parent (-10.46%). All twenty eight hybrids exhibited significant desirable negative heterosis over better parent and standard parent. The F_1 hybrid Roma x Cherry Orange expressed maximum heterosis over better parent (-9.61%) and standard parent (-11.29%). Similar negative heterosis in desirable direction was observed by Joshi and Thakur (2003).With respect to yield/plant range of heterosis varied from 4.08% to78.90% over mid parent, 5.29% to 73.41% over better parent and 21.28% to 83.43% over standard parent. Twenty four hybrids showed positive heterosis over mid parent, out of which PusaRohini x N-5 exhibited highest significant positive heterosis over mid parent (78.90%), seventeen hybrids showed positive heterosis over better parent, out of which PusaRohini x Roma exhibited highest significant positive heterosis over better parent (73.41%) and fifteen hybrids showed positive heterosis over standard parent, out of which PusaGaurav x Taiwan exhibited highest significant positive heterosis over standard parent (83.43%). High heterosis for yield/plant was also reported by Wang *et al*. (1998), Chaudhary and Malhotra(2001), Dudi and Sanwal (2004), Gul*et al.* (2011) and Ahmad *et al*. (2011).

Conclusion

The crosses PusaGaurav x Taiwan, PusaRohini x PusaGaurav and PusaRohini x Roma were found to be best heterotic combinations as they exhibited significant heterosis percentage for yield per plant over the standard parent. The high yielding F_1 hybrid PusaGaurav x Taiwan was expressed 83.43% heterosis for yield over standard parent may be recommended for commercial exploitation.

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