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Estimation of heterosis for yield and yield related traits in tomato (*Solanum lycopersicum* L.) under polyhouse conditions

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Abstract

The present investigation was carried out at Vegetable Research Center of Govind Ballabh Pant University of Agriculture & Technology, Pantnagar, India. The experimental material comprised of eight genotypes of tomato and from these eight genotypes, 28 crosses were evolved in a diallel mating design (excluding reciprocals) which was further evaluated in a Randomized Block Design (RBD). The genotypes were studied for fifteen yield and yield related traits. Desirable significant negative heterosis in all three cases *i.e.*, over mid parent, better parent and standard parent were found for days to 50 per cent flowering, PBT-9 x PBT-5, PBT-5 x PBT-13, PBT-5 x PBT-4 and PBT-13 x PBT-10, for number of fruits per plant PBT-5 x PBT-4, for average fruit weight PPT-2 x PBT-9, PPT-2 x PBT-5, PPT-2 x PBT-2, PPT-2 x PBT-13, PPT-2 x PBT-10, PPT-2 x PBT-4, PBT-9 x PBT-5, PBT-5 x PBT-10, PBT-5 x PBT-4, PBT-13 x PBT-10 and PBT-13 x PBT-4, for fruit yield per plant and fruit yield per hectare PCT-1 x PBT-5, PPT-2 x PBT-9, PPT-2 x PBT-2, PBT-9 x PBT-4, PBT-5 x PBT-4, PBT-2 x PBT-13 and PBT-13 x PBT-10.

Keywords: Heterosis, relative heterosis, heterobeltiosis, standard heterosis, significant.

Introduction

Tomato (*Solanum lycopersicum* L.) is an important vegetable of Solanaceae family having chromosome number 2n=2x=24. It has originated from wild form in the Peru-Equador-Bolivia region of the Andes, South America and is grown in almost every corner of the world. Tomato universally treated as 'Protective Food' and is being extensively grown as annual plant all over the world. Tomato is one of the most highly praised vegetables consumed widely. It is a major source of vitamins, minerals and organic acids. Tomato is typical day neutral plant and mainly self-pollinated, but a certain percentage of cross-pollination (1% to 47%) also occurs (Rick 1949). Among vegetables, tomato is the first crop grown in polyhouse worldwide. Heterosis refers to the superiority of F_1 hybrid in one or more characters over its parents. In other words, heterosis refers to increase of F_1 in fitness and vigour over the parental values. Generally, positive heterosis is considered as desirable, but in some cases negative heterosis is also desirable (such as earliness, days to first flowering, days from flowering to first fruit setting, days from fruit setting to maturity). The first incidence of heterosis in tomato was observed by Hedrick and Booth (1907) for increased yield and number of fruits in tomato. Diallel analysis provides a sensitive approach for large scale studies of quantitative characters. The mating among selected parents may include reciprocal crosses too. Keeping all above facts into consideration, the present investigation was taken to estimate the extent of heterosis over its parents for yield and yield related traits in tomato under polyhouse condition.

Materials and Methods

The experiment was conducted at Vegetable Research Centre (V.R.C.), G.B.P.U.A. & T., Pantnagar, Uttarakhand during 2017-18. The experimental material for this study consists of 8 genotypes which were selected based on their diversity for various traits. From these 8 genotypes, 28 crosses were evolved in a half diallel mating design. The seeds were sown in plastic pro trays by using artificial soilless media inside the naturally ventilated polyhouse for raising healthy and vigorous seedlings of tomato. Combinations of three ingredients *viz*., cocopeat, vermiculite and perlite are used as rooting medium for raising the nursery. These ingredients are mixed in 3:1:1 (V/V) ratio. The seedlings were ready for transplanting after one month of sowing and were subsequently transplanted inside the naturally ventilated polyhouse equipped with drip irrigation system for efficient use of water and fertilizers for long duration cultivation of

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tomato crop. Healthy seedlings were transplanted at a planting distance of 60 x 45cm. Before transplanting of seedlings, soil wsa thoroughly prepared, and beds were made with the help of tractor rotavator. Five competitive plants from each entry in each replication were randomly selected before flowering and tagged for the purpose of recording observations on different quantitative traits and their average values were used in the statistical analysis.

The magnitude of heterosis was estimated in relation to mid-parent, better parent and standard parent. They were calculated as percentage increase or decrease of F_1s over the mid-parent (MP), better parent (BP) and standard parent (SP) using the methods of Turner (1953) and Hayes et al. (1956). The formula used for estimation of heterosis given by Fonseca and Patterson (1968) was used. For the characters like days to 50% flowering, first flower producing node, first fruit producing node and inter-nodal length, low scoring parent was considered as better parent in the estimation of heterobeltiosis. Whereas, high scoring parent was considered as a better parent for the rest of the traits. Heterosis for each trait was computed and the significance of F_1 heterosis values was tested by comparing them with critical difference (CD) values. The analysis for estimation of heterosis was done through STPR-11 software.

Results and Discussions

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 and estimation of relative heterosis, heterobeltiosis and standard heterosis for different yield and yield related traits are given in Table 2. The data represented in Table 2 showed that for days to 50 per cent flowering, seven cross combinations exhibited significant desirable negative relative heterosis. Among them top three crosses were PBT-13 x PBT-10 (-22.231%), PBT-5 x PBT-13 (-19.669%) and PBT-5 x PBT-4 (-15.928). However, out of all crosses, four crosses showed significant negative heterobeltiosis and top three were namely PBT-9 x PBT-5 (-13.889%), PBT-5 x PBT-4 (-13.635%) and PBT-13 x PBT-10 (-13.343%). Looking to standard heterosis, among the crosses, eleven cross combinations exhibited significant negative standard heterosis in desirable direction. Top three crosses which showed maximum negative heterosis over check parents were PCT-1 x PBT-4 (-19.485%), PBT-9 x PBT-2 (-19.485%) and PBT-13 x PBT-10 (-19.485). This result is counteracting with Sahu et al. (2016), Marbhal et al. (2016) and Kumar et al. (2017a). For days to first fruit ripening, out of twenty-eight crosses, four cross combinations showed significant negative relative heterosis and top three were PBT-2 x PBT-13 (-9.964%), PBT-9 x PBT-5 (-7.585%) and PBT-5 x PBT-13 (-6.924%). For heterobeltiosis two cross combinations *viz*., PBT-9 x PBT-5 (-6.908%) and PBT-9 x PBT-2 (-4.754%) showed significant negative heterosis over better parent. Out of all cross combinations, three crosses *i.e*., PCT-1 x PBT-5 (-7.852%), PBT-9 x PBT-5 (-7.439%) and PBT-9 x PBT-2 (-5.910%) showed negative standard heterosis over check parent. Significant negative heterosis for days to first fruit ripening was also reported by Hannan et al. (2007) in tomato.

For number of fruits per cluster, among all crosses, eight crosses exhibited desirable significant positive relative heterosis for the same traits. Top three cross combinations which showed significant positive relative heterosis were PBT-2 x PBT-13 (69.312%), PBT-5 x PBT-4 (55.156%) and PCT-1 x PBT-5 (48.000%). In case of heterobeltiosis among all crosses five cross combinations exhibited desirable significant positive heterosis over better parent and top three were PBT-2 x PBT-13 (63.543%), PBT-9 x PBT-4 (42.328%) and PBT-13 x PBT-4 (39.859). Out of all crosses four cross combinations showed significant positive standard heterosis and top three were PCT-1 x PBT-5 (77.671%), PCT-1 x PPT-2 (24.850%) and PBT-5 x PBT-4 (19.208%). Desirable significant positive heterosis for number of fruits per cluster in tomato was also reported by Gul et al. (2010) and Marbhal et al. (2016). For number of fruits per plant out of 28 crosses four hybrids namely PBT-5 x PBT-4 (139.171%), PBT-9 x PBT-4 (100.396%), PBT-2 x PBT-13 (73.178%) and PBT-2 x PBT-4 (69.882%) exhibited significant positive heterosis over mid parent while, four hybrids showed significant positive heterosis over better parent which were PBT-5 x PBT-4 (108.532%), PBT-9 x PBT-4 (100.00%), PBT-2 x PBT-4 (61.851%) and PBT-2 x PBT-13 (60.960%). In case of heterosis over check parent out of all cross combinations, four hybrids showed significant positive standard heterosis *i.e*., PCT-1 x PBT-5 (72.547%), PBT-5 x PBT-4 (54.397%), PCT-1 x PPT-2 (43.328%) and PCT-1 x PBT-4 (36.738%). Similar findings for number of fruits per plant were reported by Biswas et al. (2016), Sahu et al. (2016), Kumar et al. (2017b) and Gautam et al. (2018).

For average fruit weight, among all crosses, seventeen crosses exhibited desirable significant positive relative heterosis for same traits. Top three cross combinations which showed significant positive relative heterosis

Table 1: Mean performance of tomato genotypes for different yield related traits

S.N.	Genotypes	DFPF	DFFS	DFFR	NFC	NFRC	NFP	IL (cm)	AFW (g)
1	PCT-1	31.67	43.50	68.20	22.00	12.87	355.73	10.00	9.90
2	PPT-2	37.67	50.33	82.40	13.73	8.33	54.93	10.27	77.00
3	PBT-9	36.00	49.20	83.13	9.13	5.67	30.37	11.00	109.60
4	PBT-5	36.67	48.73	81.93	10.00	7.13	40.67	9.27	89.07
5	PBT-2	32.67	44.20	81.40	7.67	5.87	27.39	13.07	119.27
6	PBT-13	43.00	56.27	95.13	9.20	5.47	31.89	13.07	69.80
7	PBT-10	35.00	47.07	74.40	10.67	7.93	47.19	10.27	76.27
8	PBT-4	38.67	51.60	88.80	8.47	5.67	30.25	12.80	91.53
9	PCT-1 x PPT-2	33.00	47.67	84.13	15.13	10.40	78.73	10.53	77.00
10	PCT-1 x PBT-9	36.33	49.27	82.93	13.33	9.20	70.99	10.93	31.73
11	PCT-1 x PBT-5	31.00	43.33	75.93	26.40	14.80	94.78	11.20	71.73
12	PCT-1 x PBT-2	35.67	49.47	81.53	14.27	8.60	49.74	9.13	34.80
13	PCT-1 x PBT-13	38.00	52.07	86.20	15.87	8.13	56.60	9.67	43.40
14	PCT-1 x PBT-10	35.00	49.93	81.80	12.87	7.13	41.47	11.80	29.20
15	PCT-1 x PBT-4	30.33	43.00	79.93	15.47	9.33	75.11	11.00	69.07
16	PPT-2 x PBT-9	39.33	54.27	88.67	9.47	6.33	41.12	10.40	139.20
17	PPT-2 x PBT-5	39.67	54.40	90.67	9.80	6.40	38.38	8.53	107.60
18	PPT-2 x PBT-2	38.33	53.40	92.27	10.40	6.47	37.27	9.00	133.93
19	PPT-2 x PBT-13	43.67	57.47	92.93	10.13	5.87	33.50	11.20	121.27
20	PPT-2 x PBT-10	38.67	53.00	88.93	9.93	6.27	42.24	10.27	93.33
21	PPT-2 x PBT-4	39.00	52.53	86.60	9.80	6.47	34.03	9.40	125.93
22	PBT-9 x PBT-5	31.00	44.87	76.27	12.53	6.27	35.27	8.07	141.53
23	PBT-9 x PBT-2	30.33	43.53	77.53	11.33	6.53	33.27	8.87	68.47
24	PBT-9 x PBT-13	39.00	53.27	88.67	10.33	6.67	35.59	9.20	103.73
25	PBT-9 x PBT-10	39.67	54.00	90.20	11.27	5.87	32.09	11.27	109.07
26	PBT-9 x PBT-4	36.67	50.53	89.73	15.47	8.07	60.74	7.80	95.40
27	PBT-5 x PBT-2	32.67	46.00	81.73	11.20	6.73	41.49	9.07	64.00
28	PBT-5 x PBT-13	32.00	45.47	82.40	15.07	7.60	48.65	10.47	31.33
29	PBT-5 x PBT-10	31.67	44.40	81.73	9.87	5.80	35.75	8.80	106.27
30	PBT-5 x PBT-4	31.67	45.47	83.60	17.93	9.93	84.81	13.40	120.27
31	PBT-2 x PBT-13	33.67	46.67	79.47	13.00	9.60	51.33	12.40	123.80
32	PBT-2 x PBT-10	33.33	46.80	83.40	10.73	6.87	38.21	12.53	61.80
33	PBT-2 x PBT-4	32.33	48.00	82.33	11.07	6.60	48.96	12.93	91.87
34	PBT-13 x PBT-10	30.33	44.27	83.80	15.13	7.87	50.94	11.93	159.93
35	PBT-13 x PBT-4	38.00	52.27	90.40	14.67	7.93	39.65	11.60	106.40
36	PBT-10 x PBT-4	33.67	48.67	85.33	8.93	5.73	35.31	9.73	63.60
	GM	35.43	49.03	84.01	12.56	7.57	55.12	10.58	88.00
	Sem	1.34	1.27	0.98	0.508	0.299	5.17	0.52	3.76
	C.D. (1%)	5.03	4.70	3.67	1.90	1.12	19.33	1.96	14.06
	C.D. (5%)	3.79	3.54	2.77	1.44	0.85	14.56	1.48	10.59
	C.V.	6.57	4.44	2.02	7.01	6.84	16.22	8.57	7.39

DFPF – Days to 50 per cent flowering, DFFS – Days to first fruit set, DFFR – Days to first fruit ripening, NFC – Number of flowers per cluster, NFRC – Number of fruits per cluster, NFP – Number of fruits per plant, IL – Internodal length, AFW – Average fruit weight, FL – Fruit length, FW – Fruit width, FSI – Fruit shape index, PH – Plant height, SW – 100 seed weight, FYP – Fruit yield per plant and FYH – Fruit yield per hectare.

were PBT-13 x PBT-10 (118.977%), PCT-1 x PPT-2 (77.215%) and PPT-2 x PBT-13 (65.218%). In case of heterobeltiosis among all crosses, five cross combinations exhibited desirable significant positive heterobeltiosis and top three were PBT-13 x PBT-10 (109.689%), PPT-2 x PBT-13 (57.494%) and PPT-2 x PBT-4 (37.583%). Out of all crosses sixteen cross combinations showed desirable positive standard heterosis for average fruit weight and among them top three crosses were PBT-13 x PBT-10 (107.701%), PBT-9 x PBT-5 (83.805%) and PPT-2 x PBT-9 (80.779%). Similar findings for average fruit weight were reported by Biswas et al. (2016), Sahu et al. (2016), Amin et al. (2017), Kumar et al. (2017a) and Gautam et al. (2018). For fruit shape index among all crosses, two crosses *viz*., PBT-2 x PBT-4 (35.510%) and PBT-5 x PBT-10 (22.472%) exhibited desirable significant positive relative heterosis for same traits. In case of heterobeltiosis among all crosses, none of them exhibited desirable significant heterosis over better parent. Out of all crosses two cross combinations showed significant positive standard heterosis which were PBT-2 x PBT-4 (55.140%) and PPT-2 x PBT-4 (21.495%). Desirable significant heterosis for fruit shape index in tomato was also reported by Kurian *et al*. (2001).

S.N.	Genotypes	FL (cm)	FW (cm)	FSI	PH (cm)	SW (g)	FYP(kg)	FYH (t/ha)
1	PCT-1	2.11	1.83	1.17	409.07	0.13	3.71	130.44
2	PPT-2	5.37	5.04	1.07	403.20	0.35	4.06	142.97
3	PBT-9	5.41	4.96	1.09	316.47	0.38	3.28	115.31
4	PBT-5	4.46	5.07	0.89	338.13	0.36	3.20	112.50
5	PBT-2	4.62	5.40	0.86	411.67	0.40	3.10	108.97
6	PBT-13	5.15	4.40	1.18	351.93	0.37	1.34	47.27
7	PBT-10	5.01	5.62	0.89	330.40	0.38	3.59	126.30
8	PBT-4	6.55	4.14	1.59	236.87	0.29	2.48	87.15
9	PCT-1 x PPT-2	4.07	3.62	1.13	401.40	0.39	3.06	107.75
10	PCT-1 x PBT-9	3.14	3.44	0.92	438.33	0.33	2.04	71.71
11	PCT-1 x PBT-5	3.76	3.81	0.99	431.67	0.30	6.83	240.37
12	PCT-1 x PBT-2	3.21	3.24	0.99	405.73	0.39	2.46	86.46
13	PCT-1 x PBT-13	3.99	3.82	1.05	423.33	0.40	2.19	76.89
14	PCT-1 x PBT-10	3.65	3.76	0.97	411.40	0.36	2.08	73.11
15	PCT-1 x PBT-4	5.11	4.09	1.25	447.53	0.31	3.41	119.98
16	PPT-2 x PBT-9	6.10	5.42	1.13	372.07	0.37	5.45	191.93
17	PPT-2 x PBT-5	5.21	4.99	1.05	332.40	0.36	4.13	145.32
18	PPT-2 x PBT-2	5.46	5.31	1.03	397.87	0.36	4.93	173.34
19	PPT-2 x PBT-13	5.36	4.72	1.14	420.00	0.38	4.02	141.33
20	PPT-2 x PBT-10	4.38	4.03	1.09	434.40	0.35	3.85	135.53
21	PPT-2 x PBT-4	5.82	4.47	1.30	430.00	0.36	4.04	142.06
22	PBT-9 x PBT-5	5.73	6.28	0.92	355.87	0.36	4.83	169.97
23	PBT-9 x PBT-2	3.89	4.39	0.89	236.13	0.42	2.41	84.70
24	PBT-9 x PBT-13	4.41	4.77	0.93	427.33	0.34	3.47	122.21
25	PBT-9 x PBT-10	4.93	4.71	1.05	330.53	0.38	2.90	102.15
26	PBT-9 x PBT-4	5.15	4.43	1.17	381.73	0.35	5.72	201.31
27	PBT-5 x PBT-2	4.19	4.38	0.96	346.67	0.39	2.49	87.61
28	PBT-5 x PBT-13	3.17	3.26	0.98	373.20	0.33	2.29	80.53
29	PBT-5 x PBT-10	5.26	4.85	1.09	427.60	0.33	3.89	136.77
30	PBT-5 x PBT-4	5.30	5.06	1.05	361.00	0.32	5.71	200.79
31	PBT-2 x PBT-13	5.05	5.43	0.93	368.40	0.39	6.19	217.82
32	PBT-2 x PBT-10	4.23	4.14	1.03	406.53	0.39	2.92	102.90
33	PBT-2 x PBT-4	5.68	3.46	1.66	411.27	0.28	3.06	107.57
34	PBT-13 x PBT-10	6.05	6.35	0.95	448.67	0.39	5.52	194.33
35	PBT-13 x PBT-4	5.18	5.47	0.95	420.87	0.36	4.26	149.89
36	PBT-10 x PBT-4	4.89	4.67	1.05	386.13	0.39	3.09	108.68
	GM	4.75	4.52	1.07	384.05	0.35	3.67	129.00
	Sem	0.15	0.21	0.06	23.43	0.01	0.25	8.64
	C.D. (1%)	0.57	0.78	0.23	87.73	0.04	0.92	32.67
	C.D. (5%)	0.43	0.59	0.18	66.08	0.03	0.69	24.38
	C.V.	5.52	7.99	10.18	10.56	5.78	11.60	11.61

DFPF - Days to 50 per cent flowering, DFFS - Days to first fruit set, DFFR - Days to first fruit ripening, NFC - Number of flowers per cluster, NFRC - Number of fruits per cluster, NFP - Number of fruits per plant, IL - Internodal length, AFW - Average fruit weight, FL - Fruit length, FW - Fruit width, FSI - Fruit shape index, PH - Plant height, SW - 100 seed weight, FYP - Fruit yield per plant and FYH - Fruit yield per hectare.

For fruit yield per plant, among all crosses, twelve crosses exhibited desirable significant positive relative heterosis for same traits. Top three cross combinations which showed desirable significant positive relative heterosis were PBT-2 x PBT-13 (178.829%), PBT-13 x PBT-10 (123.935%) and PBT-13 x PBT-4 (123.037%). In case of heterobeltiosis among all crosses, nine cross combinations exhibited desirable significant positive heterosis over better parent and among them top three crosses were PBT-2 x PBT-13 (99.677%), PCT-1 x PBT-5 (84.013%) and PBT-5 x PBT-4 (78.438%). Out of all crosses, seven cross combinations showed significant positive standard heterosis for fruit yield per plant and top three hybrids which exhibited significant positive standard heterosis were PCT-1 x PBT-5 (68.227%), PBT-2 x PBT-13 (52.463%) and PBT-9 x PBT-4 (40.887%). Significant positive heterosis for fruit yield per plant has been reported by many researchers, some of them are Biswas et al. (2016), Jose et al. (2016), Kumar et al. (2016), Marbhal et al. (2016), Sahu et al. (2016), Amin et al. (2017) and Kumar et al. (2017a).

Conclusion

Based on the significance test of relative heterosis, heterobeltiosis and standard heterosis as well as the *per se* performance of the cross combinations, the most promising heterotic hybrids are identified. For days to 50 per cent flowering, cross PBT-13 x PBT-10 showed desirable significant negative heterosis over mid parent, better parent and standard parent while, PBT-5 x PBT-4 showed desirable significant negative heterosis over mid parent and better parent. In case of days to first fruit ripening PCT-1 x PBT-4 exhibited desirable significant negative heterosis over mid parent and check parent. PBT-9 x PBT-5 showed desirable significant negative heterosis over mid parent, better parent and standard parent for days to first fruit ripening whereas,

Table 2: Estimates of relative heterosis (RH), heterobeltiosis (Hb) and standard heterosis (SH) for different yield & yield related traits

S. N.	F_1 hybrid	Days to 50 per cent flowering			Days to first fruit set			Days to first fruit ripening			Number of flowers per cluster		
		RH (%)	Hb (%)	SH (%)	RH (%)	Hb (%)	SH (%)	RH (%)	Hb (%)	SH (%)	RH (%)	Hb (%)	SH (%)
1	PCT-1 x PPT-2	-4.817	4.200	-12.397*	1.609	9.586	-5.285	11.726**	23.358**	2.100	-15.309**	-31.227**	10.197
2	PCT-1 x PBT-9	7.374	14.714*	-3.557	6.300	13.264**	-2.106	9.602**	21.598**	0.643	-14.359**	-39.409**	-2.913
3	PCT-1 x PBT-5	-9.277	-2.116	-17.706**	-6.039	-0.391	-13.908**	1.152	11.334**	-7.852**	65.000**	20.000**	92.280**
4	PCT-1 x PBT-2	10.880	12.630	-5.309	12.816**	13.724**	-1.709	8.997**	19.545**	-1.056	-3.809	-35.136**	3.933
5	PCT-1 x PBT-13	1.781	19.987**	0.876	4.380	19.701**	3.457	5.553**	26.393**	4.612*	1.731	-27.864**	15.586*
6	PCT-1 x PBT-10	4.995	10.515	-7.088	10.257*	14.782**	-0.795	14.727**	19.941**	-0.728	-21.212**	-41.500**	-6.264
7	PCT-1 x PBT-4	-13.762*	-4.231	-19.485**	-9.569*	-1.149	-14.564**	1.822	17.199**	-2.998	1.543	-29.682**	12.673
8	PPT-2 x PBT-9	6.773	9.250	4.407	9.053*	10.305*	7.828	7.135**	7.609**	7.609**	-17.148*	-31.027**	-31.027**
9	PPT-2 x PBT-5	6.726	8.181	5.309	9.832*	11.636*	8.087	10.351**	10.668**	10.036**	-17.404**	-28.623**	-28.623**
10	PPT-2 x PBT-2	8.985	17.325*	1.752	12.980**	20.814**	6.100	12.662**	13.354**	11.978**	-2.804	-24.253	-24.253**
11	PPT-2 x PBT-13	8.268	15.928*	15.928*	7.824*	14.186**	14.186**	4.692**	12.779**	12.779**	-11.644	-26.220**	-26.220**
12	PPT-2 x PBT-10	6.426	10.486	2.655	8.830*	12.598**	5.305	13.431**	19.530**	7.925**	-18.607**	-27.677**	-27.677**
13	PPT-2 x PBT-4	2.174	3.531	3.531	3.071	4.371	4.371	1.168	5.097*	5.097*	-11.712	-28.623**	-28.623**
14	PBT-9 x PBT-5	-14.683**	-13.889*	-17.706**	-8.363*	-7.921	-10.848*	-7.585**	-6.908**	-7.439**	30.998**	25.300**	-8.740
15	PBT-9 x PBT-2	-11.664	-7.163	-19.485**	-6.788	-1.516	-13.511**	-5.756**	-4.754*	-5.910**	34.881**	24.096*	-17.480**
16	PBT-9 x PBT-13	-1.266	8.333	3.531	1.015	8.272	5.841	-0.516	6.664**	7.609**	12.711	12.283	-24.763**
17	PBT-9 x PBT-10	11.746*	13.343*	5.309	12.184**	14.723**	7.292	14.518**	21.237**	9.466**	13.838	5.623	-17.917**
18	PBT-9 x PBT-4	-1.781	1.861	-2.655	0.258	2.703	0.397	4.380*	7.939**	8.896**	75.795**	69.441**	12.673
19	PBT-5 x PBT-2	-5.769	0.000	-13.273*	-1.001	4.072	-8.603*	0.080	0.405	-0.813	26.769**	12.000	-18.427**
20	PBT-5 x PBT-13	-19.669**	-12.735*	-15.052*	-13.390**	-6.690	-9.656*	-6.924**	0.574	0.000	56.979**	50.700**	9.760
21	PBT-5 x PBT-10	-11.623*	-9.514	-15.928*	-7.307	-5.672	-11.782**	4.561*	9.852**	-0.813	-4.499	-7.498	-28.114**
22	PBT-5 x PBT-4	-15.928**	-13.635*	-15.928*	-9.359*	-6.690	-9.656*	-2.068	2.038	1.456	94.153**	79.300**	30.590**
23	PBT-2 x PBT-13	-11.008*	3.061	-10.619	-7.097	5.588	-7.272	-9.964**	-2.371	-3.556	54.120**	41.304**	-5.317
24	PBT-2 x PBT-10	-1.493	2.020	-11.521	2.553	5.882	-7.014	7.060**	12.097**	1.214	17.012*	0.562	-21.850**
25	PBT-2 x PBT-4	-9.364	-1.041	-14.176*	0.209	8.597	-4.629	-3.255	1.143	-0.085	37.175**	30.697**	-19.374**
26	PBT-13 x PBT-10	-22.231**	-13.343*	-19.485**	-14.322**	-5.949	-12.041**	-1.138	12.634**	1.699	52.290**	41.799**	10.197
27	PBT-13 x PBT-4	-6.943	-1.733	0.876	-3.087	1.298	3.855	-1.702	1.802	9.709**	66.044**	59.457**	6.846
28	PBT-10 x PBT-4	-8.592	-3.800	-10.619	-1.348	3.399	-3.298	4.571*	14.691**	3.556	-6.688	-16.307	-34.960**
Minimum		-22.231	-13.889	-19.485	-14.322	-7.921	-14.564	-9.964	-6.908	-7.852	-21.212	-41.500	-34.960
Maximum		11.746	19.987	15.928	12.980	20.814	14.186	14.727	26.393	12.779	94.153	79.300	92.280

PBT-9 x PBT-2 exhibited desirable significant negative heterobeltiosis and standard heterosis. PBT-13 x PBT-10 exhibited desirable significant positive heterosis over mid parent, better parent and standard parent whereas, PPT-2 x PBT-13 showed significant positive heterosis for relative heterosis and heterobeltiosis for average fruit weight. For fruit yield per plant and fruit yield per hectare cross PBT-2 x PBT-13 show desirable significant positive heterosis in all three cases while, PCT-1 x PBT-5 showed positive significant heterosis for heterobeltiosis and standard heterosis. It is concluded that the hybrids, PCT-1 x PBT-5, PBT-9 x PBT-5, PBT-9 x PBT-2 and PBT-2 x PBT-13 were found promising for earliness while, for fruit yield, PCT-1 x PBT-5, PBT-2 x PBT-13, PBT-9 x PBT-4 and PBT-5 x PBT-4 were found promising hybrids, hence these crosses could be utilized as commercial hybrids for earliness and high yielding, respectively.

सारांश

वर्तमान परीक्षण गोविन्द वल्लभ पंत कृषि और प्रौद्योगिकी विश्वविद्यालय, पंतनगर, झारखण्ड (भारत) के सब्जी अनुसंधान केन्द्र में की गयी। प्रायोगिक सामग्री में टमाटर के आठ जननद्रव्य शामिल थे और आठ जननद्रव्यों से 28 संकर एक डायएलिल युक्त अभिकल्पना (पारस्परिक को छोड़कर) द्वारा विकसित किए गए, जिसका मूल्यांकन यादृच्छिकी खण्ड अभिकल्पना (रैंडोमाइज्ड ब्लॉक डिजाइन) में किया गया। जननद्रव्यों का अध्ययन पन्द्रह उपज और उपज संबंधित लक्षणों के लिए किया गया। तीनों मामलों में वांछनीय महत्वपूर्ण नकारात्मक विषमता जैसे– मध्य जनक, बेहतर जनक और मानक जनक को 50 प्रतिशत पुष्पन हेतु–पी.बी.टी.–9 x पी.बी.टी.–5, पी.बी.टी.–5 x पी.बी.टी.–13, पी.बी.टी.–5 x पी.बी.टी.–4 और पी.बी.टी.–13 x पी.बी.टी.–10 प्रति पौध फलों की संख्या के लिए पी.बी.टी.–5 x पी.बी.टी.–4, फलों के औसत वजन के लिए पी.बी.टी.–2 x पी.बी.टी.–9, पी.बी.टी.–2 x पी.बी.टी.–5, पी.बी.टी.–2 x पी.बी.टी.–2, पी.बी.टी.–2 x पी.बी.टी.–13, पी.बी.टी.–2 x पी.बी.टी.–10, पी.बी.टी.–2 x पी.बी.टी.

S. N.	F_1 hybrid	Number of fruits per cluster			Number of fruits per plant			Internodal length			Average fruit weight		
		RH (%)	Hb (%)	SH (%)	RH (%)	Hb (%)	SH (%)	RH (%)	Hb (%)	SH (%)	RH (%)	Hb (%)	SH (%)
1	PCT-1 x PPT-2	-1.887	-19.192**	24.850**	-61.657**	-77.868**	43.328**	3.897	5.300	2.532	77.215**	0.000	0.000
2	PCT-1 x PBT-9	-0.755	-28.516**	10.444	-63.227**	-80.044**	29.237	4.095	9.300	6.426	-46.895**	-71.049**	-58.792**
3	PCT-1 x PBT-5	48.000**	14.996**	77.671**	-52.180**	-73.356**	72.547**	16.243*	20.820*	9.056	44.953**	-19.468**	-6.844
4	PCT-1 x PBT-2	-8.218	-33.178**	3.241	-74.034**	-86.017**	-9.448	-20.850**	-8.700	-11.100	-46.118**	-70.823**	-54.805**
5	PCT-1 x PBT-13	-11.341*	-36.830**	-2.401	-70.796**	-84.089**	3.040	-16.168*	-3.300	-5.842	8.908	-37.822**	-43.636**
6	PCT-1 x PBT-10	-31.442**	-44.600**	-14.406*	-79.415**	-88.342**	-24.504	16.428*	18.000	14.898	-32.227*	-61.715**	-62.078**
7	PCT-1 x PBT-4	0.647	-27.506**	12.005	-61.081**	-78.886**	36.738*	-3.509	10.000	7.108	36.192**	-24.538**	-10.299
8	PPT-2 x PBT-9	-9.571	-24.010**	-24.010**	-3.587	-25.141	-25.141	-2.210	1.266	1.266	49.196**	27.007**	80.779**
9	PPT-2 x PBT-5	-17.206**	-23.169**	-23.169**	-19.707	-30.129	-30.129	-12.692	-7.983	-16.943	29.584**	20.804**	39.740**
10	PPT-2 x PBT-2	-8.873	-22.329**	-22.329**	-9.451	-32.150	-32.150	-22.879**	-12.366	-12.366	36.475**	12.291*	73.935**
11	PPT-2 x PBT-13	-14.928*	-29.532**	-29.532**	-22.829	-39.013*	-39.013*	-4.027	9.055	9.056	65.218**	57.494**	57.494**
12	PPT-2 x PBT-10	-22.878**	-24.730**	-24.730**	-17.274	-23.102	-23.102	0.000	0.000	0.000	21.785**	21.208*	21.208*
13	PPT-2 x PBT-4	-7.571	-22.329**	-22.329**	-20.099	-38.048*	-38.048*	-18.509**	-8.471	-8.471	49.445**	37.583**	63.545**
14	PBT-9 x PBT-5	-2.031	-12.062	-24.730**	-0.704	-13.278	-35.791*	-20.375*	-12.945	-21.422*	42.477**	29.133**	83.805**
15	PBT-9 x PBT-2	13.172	11.244	-21.609**	15.201	9.549	-39.432*	-26.298**	-19.364*	-13.632	-40.167**	-42.592**	-11.078
16	PBT-9 x PBT-13	19.749*	17.637	-19.928**	14.327	11.602	-35.208*	-23.556**	-16.364	-10.419	15.641*	-5.356	34.714**
17	PBT-9 x PBT-10	-13.676*	-25.977**	-29.532**	-17.251	-31.998	-41.580*	5.971	9.737	9.737	17.362**	-0.484	41.649**
18	PBT-9 x PBT-4	42.328**	42.328**	-3.121	100.396**	100.000**	10.577	-34.454**	-29.091**	-24.051**	-5.136	-12.956*	23.896**
19	PBT-5 x PBT-2	3.538	-5.610	-19.208**	21.922	2.016	-24.468	-18.800**	-2.158	-11.685	-38.562**	-46.340**	-16.883*
20	PBT-5 x PBT-13	20.635**	6.592	-8.764	34.096	19.621	-11.433	-6.267	12.945	1.947	-60.559**	-64.825**	-59.312**
21	PBT-5 x PBT-10	-22.975**	-26.860**	-30.372**	-18.621	-24.242	-34.917*	-9.928	-5.070	-14.314	28.547**	19.311**	38.013**
22	PBT-5 x PBT-4	55.156**	39.271**	19.208**	139.171**	108.532**	54.397**	21.432**	44.542**	30.477**	33.189**	31.400**	56.195**
23	PBT-2 x PBT-13	69.312**	63.543**	15.246*	73.178**	60.960*	-6.554	-5.126	-5.126	20.740*	30.957**	3.798	60.779**
24	PBT-2 x PBT-10	-0.435	-13.367*	-17.527**	2.467	-19.029	-30.439	7.369	22.006*	22.006*	-36.790**	-48.185**	-19.740*
25	PBT-2 x PBT-4	14.385	12.436	-20.768**	69.882*	61.851*	-10.868	-0.039	1.016	25.901**	-12.837*	-22.973**	19.312*
26	PBT-13 x PBT-10	17.463*	-0.757	-5.522	28.832	7.947	-7.264	2.228	16.164	16.164	118.977**	109.689**	107.701**
27	PBT-13 x PBT-4	42.370**	39.859**	-4.802	27.615	24.334	-27.817	-10.321	-9.375	12.950	31.904**	16.246*	38.182**
28	PBT-10 x PBT-4	-15.735*	-27.743**	-31.212**	-8.807	-25.175	-35.718*	-15.648*	-5.258	-5.258	-24.195**	-30.515**	-17.403*
Minimum		-31.442	-44.600	-31.212	-79.415	-88.342	-41.580	-34.454	-29.091	-24.051	-60.559	-71.049	-62.078
Maximum		69.312	65.543	77.671	139.171	108.532	72.547	21.432	44.542	30.477	118.977	109.689	107.701

S. N.	F_1 hybrid	Fruit length			Fruit width			Fruit shape index			Plant height		
		RH (%)	Hb (%)	SH (%)	RH (%)	Hb (%)	SH (%)	RH (%)	Hb (%)	SH (%)	RH (%)	Hb (%)	SH (%)
1	PCT-1 x PPT-2	8.824	-24.209**	-24.209**	5.386	-28.175**	-28.175**	0.893	-3.419	5.607	-1.165	-1.874	-0.446
2	PCT-1 x PBT-9	-16.489**	-41.959**	-41.527**	1.325	-30.645**	-31.746**	-18.584*	-21.368*	-14.019	20.831*	7.154	8.714
3	PCT-1 x PBT-5	14.460*	-15.695**	-29.981**	10.435	-24.852**	-24.405**	-3.883	-15.385	-7.477	15.542	5.525	7.060
4	PCT-1 x PBT-2	-4.606	-30.519**	-40.223**	-10.373	-40.000**	-35.714**	-2.463	-15.385	-7.477	-1.129	-1.441	0.628
5	PCT-1 x PBT-13	9.917	-22.524**	-25.698**	22.632*	-13.182	-24.206**	-10.638	-11.017	-1.869	11.257	3.488	4.993
6	PCT-1 x PBT-10	2.528	-27.146**	-32.030**	0.940	-33.096**	-25.397**	-5.825	-17.094	-9.346	11.269	0.570	2.034
7	PCT-1 x PBT-4	18.014**	-21.985**	-4.842	37.018**	-1.208	-18.849*	-9.420	-21.384**	16.822	38.570**	9.404	10.995
8	PPT-2 x PBT-9	13.173**	12.754*	13.594**	8.400	7.540	7.540	4.630	3.670	5.607	3.400	-7.722	-7.722
9	PPT-2 x PBT-5	6.002	-2.980	-2.980	-1.286	-1.578	-0.992	7.143	-1.869	-1.869	-10.324	-17.560	-17.560
10	PPT-2 x PBT-2	9.309*	1.676	1.676	1.724	-1.667	5.357	6.736	-3.738	-3.738	-2.348	-3.352	-1.323
11	PPT-2 x PBT-13	1.901	-0.186	-0.186	0.000	-6.349	-6.349	1.333	-3.390	6.542	11.239	4.167	4.167
12	PPT-2 x PBT-10	-15.607**	-18.436**	-18.436**	-24.390**	-28.292**	-20.040**	11.224	1.869	1.869	18.430	7.738	7.738
13	PPT-2 x PBT-4	-2.349	-11.145**	8.380	-2.614	-11.310	-11.310	-2.256	-18.239**	21.495*	34.361**	6.647	6.647
14	PBT-9 x PBT-5	16.109**	5.915	6.704	25.224**	23.866**	24.603**	-7.071	-15.596	-14.019	8.728	5.244	-11.739
15	PBT-9 x PBT-2	-22.433**	-28.096**	-27.561**	-15.251*	-18.704**	-12.897	-8.718	-18.349	-16.822	-35.140**	-42.640**	-41.435**
16	PBT-9 x PBT-13	-16.477**	-18.484**	-17.877**	1.923	-3.831	-5.357	-18.062*	-21.186**	-13.084	27.868**	21.425	5.985
17	PBT-9 x PBT-10	-5.374	-8.872	-8.194	-10.964	-16.192*	-6.548	6.061	-3.670	-1.869	2.195	0.040	-18.022
18	PBT-9 x PBT-4	-13.880**	-21.374**	-4.097	-2.637	-10.685	-12.103	-12.687	-26.415**	9.346	37.976**	20.624	-5.324
19	PBT-5 x PBT-2	-7.709	-9.307	-21.974**	-16.332**	-18.889**	-13.095	9.714	7.865	-10.280	-7.531	-15.789	-14.021
20	PBT-5 x PBT-13	-34.027**	-38.447**	-40.968**	-31.151**	-35.700**	-35.317**	-5.314	-16.949	-8.411	8.163	6.043	-7.440
21	PBT-5 x PBT-10	11.088*	4.990	-2.048	-9.261	-13.701*	-3.770	22.472*	22.472	1.869	27.922**	26.459*	6.052
22	PBT-5 x PBT-4	-3.724	-19.084**	-1.304	9.881	-0.197	0.397	-15.323*	-33.962**	-1.869	25.565*	6.763	-10.466
23	PBT-2 x PBT-13	3.378	-1.942	-5.959	10.816	0.556	7.738	-8.824	-21.186*	-13.084	-3.510	-10.510	-8.631
24	PBT-2 x PBT-10	-12.150*	-15.569**	-21.229**	-24.864**	-26.335**	-17.857*	17.714	15.730	-3.738	9.568	-1.247	0.827
25	PBT-2 x PBT-4	1.701	-13.282**	5.773	-27.463**	-35.926**	-31.349**	35.510**	4.403	55.140**	26.830*	-0.097	2.001
26	PBT-13 x PBT-10	19.094**	17.476**	12.663*	26.747**	12.989*	25.992**	-8.213	-19.492*	-11.215	31.510**	27.486**	11.276
27	PBT-13 x PBT-4	-11.453**	-20.916**	-3.538	28.103**	24.318**	8.532	-31.408**	-40.252**	-11.215	42.957**	19.587	4.382
28	PBT-10 x PBT-4	-15.398**	-25.344**	-8.939	-4.303	-16.904*	-7.341	-15.323*	-33.962**	-1.869	36.138**	16.868	-4.233
Minimum		-34.027	-41.959	-41.527	-31.151	-40.000	-35.714	-31.408	-40.252	-16.822	-35.140	-42.640	-41.435
Maximum		19.094	12.754	13.594	37.018	24.318	25.992	35.510	22.472	55.140	42.957	27.486	11.276

S. N.	F_1 hybrid	100 seed weight			Fruit yield per plant			Fruit yield per hectare		
		RH (%)	Hb (%)	SH (%)	RH (%)	Hb (%)	SH (%)	RH (%)	Hb (%)	SH (%)
1	PCT-1 x PPT-2	62.500**	11.429*	11.429*	-21.236*	-24.631*	-24.631*	-21.181*	-24.635*	-24.635*
2	PCT-1 x PBT-9	29.412**	-13.158*	-5.714	-41.631**	-45.013**	-49.754**	-41.640**	-45.025**	-49.843**
3	PCT-1 x PBT-5	22.449**	-16.667**	-14.286*	97.685**	84.097**	68.227**	97.884**	84.276**	68.126**
4	PCT-1 x PBT-2	47.170**	-2.500	11.429*	-27.753*	-33.693**	-39.409**	-27.772*	-33.717**	-39.526**
5	PCT-1 x PBT-13	60.000**	8.108	14.286*	-13.267	-40.970**	-46.059**	-13.466	-41.053**	-46.219**
6	PCT-1 x PBT-10	41.176**	-5.263	2.857	-43.014**	-43.935**	-48.768**	-43.047**	-43.951**	-48.863**
7	PCT-1 x PBT-4	47.619**	6.897	-11.429*	10.178	-8.086	-16.010	10.281	-8.019	-16.080
8	PPT-2 x PBT-9	1.370	-2.632	5.714	48.501**	34.236**	34.236**	48.622**	34.245**	34.245**
9	PPT-2 x PBT-5	1.408	0.000	2.857	13.774	1.724	1.724	13.767	1.644	1.644
10	PPT-2 x PBT-2	-4.000	-10.000*	2.857	37.709**	21.429*	21.429*	37.604**	21.242*	21.242*
11	PPT-2 x PBT-13	5.556	2.703	8.571	48.889**	-0.985	-0.985	48.581**	-1.147	-1.147
12	PPT-2 x PBT-10	-4.110	-7.895	0.000	0.654	-5.172	-5.172	0.665	-5.204	-5.204
13	PPT-2 x PBT-4	12.500*	2.857	2.857	23.547*	-0.493	-0.493	23.466*	-0.636	-0.636
14	PBT-9 x PBT-5	-2.703	-5.263	2.857	49.074**	47.256**	18.966	49.221**	47.403**	18.885
15	PBT-9 x PBT-2	7.692	5.000	20.000**	-24.451*	-26.524*	-40.640**	-24.469*	-26.546*	-40.757**
16	PBT-9 x PBT-13	-9.333*	-10.526*	-2.857	50.216**	5.793	-14.532	50.338**	5.984	-14.521
17	PBT-9 x PBT-10	0.000	0.000	8.571	-15.575	-19.220	-28.571**	-15.442	-19.121	-28.551**
18	PBT-9 x PBT-4	4.478	-7.895	0.000	98.611**	74.390**	40.887**	98.864**	74.582**	40.806**
19	PBT-5 x PBT-2	2.632	-2.500	11.429*	-20.952	-22.188	-38.670**	-20.883	-22.124	-38.721**
20	PBT-5 x PBT-13	-9.589*	-10.811*	-5.714	0.881	-28.438*	-43.596**	0.807	-28.418*	-43.673**
21	PBT-5 x PBT-10	-10.811*	-13.158*	-5.714	14.580	8.357	-4.187	14.548	8.290	-4.337
22	PBT-5 x PBT-4	-1.538	-11.111*	-8.571	101.056**	78.438**	40.640**	101.142**	78.480**	40.442**
23	PBT-2 x PBT-13	1.299	-2.500	11.429*	178.829**	99.677**	52.463**	178.827**	99.890**	52.354**
24	PBT-2 x PBT-10	0.000	-2.500	11.429*	-12.706	-18.663	-28.079**	-12.526	-18.527	-28.027**
25	PBT-2 x PBT-4	-18.841**	-30.000**	-20.000**	9.677	-1.290	-24.631*	9.698	-1.285	-24.760*
26	PBT-13 x PBT-10	4.000	2.632	11.429*	123.935**	53.760**	35.961**	123.921**	53.864**	35.924**
27	PBT-13 x PBT-4	9.091	-2.703	2.857	123.037**	71.774**	4.926	123.017**	71.991**	4.840
28	PBT-10 x PBT-4	16.418**	2.632	11.429*	1.812	-13.928	-23.892*	1.832	-13.951	-23.984*
Minimum		-18.841	-30.000	-20.000	-41.631	-45.013	-49.754	-43.047	-45.025	-49.843
Maximum		62.500	11.429	20.000	178.829	99.677	68.227	178.827	99.890	68.126

S. N.	F_1 hybrid	100 seed weight			Fruit yield per plant			Fruit yield per hectare		
		RH (%)	Hb (%)	SH (%)	RH (%)	Hb (%)	SH (%)	RH (%)	Hb (%)	SH (%)
1	PCT-1 x PPT-2	62.500**	11.429*	11.429*	-21.236*	-24.631*	-24.631*	-21.181*	-24.635*	-24.635*
2	PCT-1 x PBT-9	29.412**	-13.158*	-5.714	-41.631**	-45.013**	-49.754**	-41.640**	-45.025**	-49.843**
3	PCT-1 x PBT-5	22.449**	-16.667**	-14.286*	97.685**	84.097**	68.227**	97.884**	84.276**	68.126**
4	PCT-1 x PBT-2	47.170**	-2.500	11.429*	-27.753*	-33.693**	-39.409**	-27.772*	-33.717**	-39.526**
5	PCT-1 x PBT-13	60.000**	8.108	14.286*	-13.267	-40.970**	-46.059**	-13.466	-41.053**	-46.219**
6	PCT-1 x PBT-10	41.176**	-5.263	2.857	-43.014**	-43.935**	-48.768**	-43.047**	-43.951**	-48.863**
7	PCT-1 x PBT-4	47.619**	6.897	-11.429*	10.178	-8.086	-16.010	10.281	-8.019	-16.080
8	PPT-2 x PBT-9	1.370	-2.632	5.714	48.501**	34.236**	34.236**	48.622**	34.245**	34.245**
9	PPT-2 x PBT-5	1.408	0.000	2.857	13.774	1.724	1.724	13.767	1.644	1.644
10	PPT-2 x PBT-2	-4.000	-10.000*	2.857	37.709**	21.429*	21.429*	37.604**	21.242*	21.242*
11	PPT-2 x PBT-13	5.556	2.703	8.571	48.889**	-0.985	-0.985	48.581**	-1.147	-1.147
12	PPT-2 x PBT-10	-4.110	-7.895	0.000	0.654	-5.172	-5.172	0.665	-5.204	-5.204
13	PPT-2 x PBT-4	12.500*	2.857	2.857	23.547*	-0.493	-0.493	23.466*	-0.636	-0.636
14	PBT-9 x PBT-5	-2.703	-5.263	2.857	49.074**	47.256**	18.966	49.221**	47.403**	18.885
15	PBT-9 x PBT-2	7.692	5.000	20.000**	-24.451*	-26.524*	-40.640**	-24.469*	-26.546*	-40.757**
16	PBT-9 x PBT-13	-9.333*	-10.526*	-2.857	50.216**	5.793	-14.532	50.338**	5.984	-14.521
17	PBT-9 x PBT-10	0.000	0.000	8.571	-15.575	-19.220	-28.571**	-15.442	-19.121	-28.551**
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Minimum		-18.841	-30.000	-20.000	-41.631	-45.013	-49.754	-43.047	-45.025	-49.843
Maximum		62.500	11.429	20.000	178.829	99.677	68.227	178.827	99.890	68.126

–4, पी.बी.टी.–9 x पी.बी.टी.–5, पी.बी.टी.–5 x पी.बी.टी.–10, पी.बी.टी.–5 x पी.बी.टी.–4, पी.बी.टी.–13 x पी.बी.टी.–10 और पी.बी.टी.–13 x पी.बी.टी.–4, प्रति पौध फल उपज और प्रति हेक्टेयर फल उपज के लिए पी.बी.टी.–1 x पी.बी.टी.–5, पी.बी.टी.–2 x पी.बी.टी.–9, पी.बी.टी.–2 x पी.बी.टी.–2, पी.बी.टी.–9 x पी.बी.टी.–4, पी.बी.टी.–5 x पी.बी.टी.–4, पी.बी.टी.–2 x पी.बी.टी.–13 एवं पी.बी.टी.–13 x पी.बी.टी.–10 उत्तम पाया गया।

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