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Studies of Heterosis for Yield related Traits in Tomato (*Solanum lycopersicum* L.)

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ABSTRACT: The phenomenon of heterosis breeding express in first generation which is result of crossing of inbred line. Generally heterosis is not fixable in homozygous population. Therefore the present investigation was carried out during 2017-18 and 2018-19 in the department of Horticulture, SHUATS, (formerly Allahabad Agriculture Institute), Prayagraj, Uttar Pradesh, by using eight parents for yield and its related traits in half diallel manner. The analysis of variance showed that significant difference among tomato genotype for all characters. The promising F_1 hybrid over mid parent for yield contributing traits was PBT-23×PBT-22 for days to 50 percent flowering, days to first fruit set, average fruit weight and fruit length and PBT-15×PBT-23 was a promising F_1 hybrid for days to first fruit ripening, number of fruit per cluster, yield per plant, yield per hectare, pH of fruit juice and ascorbic acid. The promising F_1 hybrid over better parent was PBT-15×PBT-23 for number of fruit per cluster, yield per plant, yield per hectare and pH of fruit juice. The promising F_1 hybrid over check parent was PBT-1×PBT-19 for days to first fruit ripening, number of flower per cluster, number of fruit per cluster, number of fruit per plant, yield per plant and yield per hectare. Therefore, these hybrids can be used for exploited for commercial cultivation.

Keywords: Heterosis, breeding, for yield related traits, analysis of variance,

INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is one of the important warm season vegetable grown throughout tropical and sub-tropical conditions of world in indoors and outdoors, having family Solanaceae and chromosome number 2n=2x=24.

Tomato is native of Peru Ecuador Bolivia region of Andes, South America (Rick, 1969). Tomato is also rich in mineral and vitamins. The total sugar content in ripe fruit is 2.5 percent, Ascorbic acid varies from 16-65mg/100g and total amino acid varies from 100-350mg/100g. India is second largest producer of tomato in world after china.

In India, Tomato is grown in area of 778000 ha with production of 19397000 MT and productivity of 24.93 which is very less than rest of world (NHB, 2019). Effort has been made to increase production and productivity by develop superior variety. However yield is complex character and depend on various factors involve in production.

Heterosis breeding provides an opportunity to break the yield barrier. Variation is pre-request for the improvement through the heterosis breeding. Heterosis in tomato was first reported by Hedrick and Booth (1907) for more number of fruit which consequently result in higher yield and productivity. Since then, heterosis is extensively used for breeding for yield and yield related traits in tomato.

MATERIAL AND METHOD

The present investigation was carried out in the department of horticulture, Naini Agriculture institute, Sam Higginbottom University of Agriculture and Technology science (SAUATS), Prayagraj, Uttar Pradesh. The experiment consists of eight parents for yield related traits by using half diallel method. Thirty six genotype of genotype consist twenty eight F_1 and eight parents were grown during 2017-18 and 2018-19 and standard check (PPT-2) was included with parent. The experiment was done in Randomized block Design (R.B.D.) with three replications at spacing of 60cm with rows and 45cm between plants. The recommended culture operation and plant protection method were followed. The observation was recorded for eighteen character *viz.*, Days to 50 percent flowering, Days to first fruit set, Days to first fruit ripening, Plant height (cm), Inter nodal length (cm), Number of flower per cluster, Number of fruit per cluster, Number of fruit per plant, Average fruit weight (g), Fruit length (cm), Fruit width (cm), Fruit yield per plant (kg), Fruit yield per hectare (q/ha), Number of locules per fruit, Pericarp thickness (cm), Total Soluble solid (^{o}Brix), pH of fruit and Ascorbic acid (g/100g). The data were compiled for analysis of variance of different traits using method suggested by Panse and Sukhatme (1967). Heterosis was estimated over the better parent and over check by using the formulae (Kempthorne, 1957).

Table 1: Genotype of tomato used for present investigation.

Sr. No.	Parent line	Source
1.	PBT-23	Deptt. of Horticulture, Rehovot, Israel
2.	PBT-22	Deptt. of Horticulture, Rehovot, Israel
3.	PBT-20	Deptt. of Horticulture, Rehovot, Israel
4.	PBT-19	Deptt. of Horticulture, Rehovot, Israel
5.	PBT-18	Deptt. of Horticulture, Rehovot, Israel
6.	PBT-15	Deptt. of Horticulture, Rehovot, Israel
7.	Pant Polyhouse Tomato-2 (PPT-2)	Pantnagar
8.	Pant Cherry Tomato-1 (PCT-1)	Pantnagar

RESULT AND DISCUSSION

The estimation of mean difference for all characters studied were highly significant indicating wide genetic difference among genotype was presented in Table 2. The data unveiled that high GCV and PCV were observed for many traits *viz.*, number of fruits per plant (97.64 and 98.98 %), number of flowers per cluster (30.37 and 31.17 %) and number of fruits per cluster (26.74 and 27.60 %), average fruit weight (40.64 and 41.31%), fruit yield per hectare (34.76 and 36.65 %) and fruit yield per plant (34.75 and 36.64 %). Similar finding was also found by Tripathi *et al.* (2020) and Karthick *et al.* (2019). Heterosis effect in F_1 generation over standard and better parent are presented in Table 3.

Out of 28 cross, PBT-23×PBT-22 (-22.231) showed minimum heterosis over mid parent, PBT-20×PBT-19 (-13.88) display lowest heterosis over better parent and PBT-23×PBT-22 (-19.48) display lowest heterosis over check parent for days to 50 percent flowering. Lowest heterosis is desirable in case of days to 50 percent flowering. The similar result was also reported by Soresa *et al.* (2020) for days to 50 per cent flowering. PBT-23×PBT-22 (-14.32) showed minimum heterosis over mid parent, PBT-20×PBT-19 (-7.92) display lowest heterosis over better parent and PBT-1×PBT-18 (-14.56) display lowest heterosis over check parent for days to first fruit set. Significant negative heterosis in tomato for days to first fruit set was also reported by Alsadon *et al.* (2021). PBT-19×PBT-13 (-9.96) showed minimum heterosis over mid parent, PBT-20×PBT-19 (-6.90) display lowest heterosis over better parent and PBT-1×PBT-19 (-7.85) display lowest heterosis over check parent for days to first fruit ripening. Significant negative heterosis for days to first fruit ripening was also reported by Alsadon *et al.* (2021) in tomato. PBT-19×PBT-18 (94.15) showed maximum heterosis over mid parent, PBT-19×PBT-18 (79.30) display highest heterosis over better parent and PBT-1×PBT-19 (92.28) display highest heterosis over check parent for number of flower per cluster. Alsadon *et al.* (2021) was also reported that heterosis for number of flower per cluster showed in desirable positive direction. PBT-19×PBT-13 (69.31) showed maximum heterosis over mid parent, PBT-19×PBT-13 (63.54) display highest heterosis over better parent and PBT-1×PBT-19 (77.67) display highest heterosis over check parent for number of fruit per cluster. Heterosis for number of fruits per cluster was also reported by Kumari *et al.* (2020) which showed desirable significant positive results in tomato. PBT-19×PBT-18 (139.17) showed maximum heterosis over mid parent, PBT-19×PBT-18 (108.53) display highest heterosis over better parent and PBT-1×PBT-19 (72.54) display highest heterosis over check parent for number of fruit per plant.

Table 2: Analysis of variance for different trait in tomato.

Sr .No.	Characters	Range	General Mean	GCV (%)	PCV (%)	ECV (%)	Heritability (%)	GA as % of mean
1.	D 50% F	29.33-44.67	34.43	9.50	11.62	6.37	65.05	16.29
2.	DFFS	43.00-57.47	49.03	7.80	8.93	4.34	75.57	13.97
3.	DFFR	68.20-95.13	84.01	6.63	6.94	2.02	89.51	13.08
4.	NFWPC	7.67-26.40	12.56	30.37	31.17	7.01	94.95	60.96
5.	NFPC	5.47-14.80	7.57	26.74	27.63	6.74	93.86	53.36
6.	NFPP	27.39-350.73	55.12	97.64	98.98	16.22	95.31	197.43
7.	IL (cm)	7.80-13.40	10.58	13.64	16.11	8.56	71.72	23.80
8.	AFW(g)	9.90-158.93	88.00	40.64	41.31	7.39	93.80	81.38
9.	FL (cm)	2.11-6.50	4.75	19.90	20.73	5.43	92.89	40.68
10.	FW (cm)	1.83-6.35	4.52	19.60	21.17	8.10	85.72	37.39
11.	PH (cm)	236.13-448.67	380.05	12.01	15.98	10.56	56.37	18.57
12.	FYPP (kg)	1.34-6.50	3.67	34.78	36.64	11.50	87.97	68.90
13.	FYPH (t/ha)	47.27-239.37	127.00	34.76	36.60	11.61	85.97	67.92
14.	NLPF	1.67-5.00	2.57	26.91	29.23	11.40	84.79	51.07
15.	PT (cm)	0.35-1.21	0.82	22.13	24.91	11.46	78.90	40.50
16.	TSS (%)	4.37-8.07	6.19	13.00	14.03	5.32	85.59	24.77
17.	pHFJ	4.25-4.91	4.59	3.67	4.69	2.92	61.16	5.94
18.	AA (mg/100g)	25.33-40.11	29.28	8.89	11.17	6.76	63.40	14.58

D 50% F-Days to 50 per cent flowering, **DFFS**-Days to first fruit set, **DFFR**-Days to first fruit ripening, **NFWPC**- Number of flowers per cluster, **NFPC**-Number of fruits per cluster, **NFPP**-Number of fruits per plant, **IL**- Internodal length (cm), **AFW**- Average fruit weight (g), **FL**-Fruit length (cm), **FW**- Fruit width (cm), **PH**-Plant height (cm), **FYPP**- Fruit yield per plant (kg), **FYPH**-Fruit yield per hectare (t/ha), **NLPF**-Number of locules per fruit, **PT**-Pericarp thickness (cm), **TSS**-Total soluble solids (%), **pHFJ**- pH of fruit juice, **AA**-Ascorbic acid (mg/100g)

Table 3: Heterosis for different qualitative trait in tomato.

Sr. No.	Character	Range of heterosis			Three superior cross based on Relative Heterosis	Three superior cross based on Heterobeltosis	Three superior cross based on Standard Heterosis
		Relative Heterosis	Heterobeltosis	Standard Heterosis			
1.	D 50% F	-22.23 to 11.74	-13.88 to 19.98	-19.48 to 15.92	PBT-23 x PBT-22 PBT-19 x PBT-23 PBT-19 x PBT-18	PBT-9 x PBT-5 PBT-5 x PBT-18 PBT-23 x PBT-22	PCT-1 x PBT-18 PBT-20 x PBT-15 PBT-23 x PBT-22
2.	DFFS	-14.32 to 12.98	-7.92 to 20.81	-14.56 to 14.18	PBT-23 x PBT-22 PBT-19 x PBT-23 PCT-1 x PBT-18	-	PCT-1 x PBT-18 PCT-1 x PBT-19 PBT-20 x PBT-15
3.	DFFR	-9.96 to 14.72	-6.90 to 26.39	-7.85 to 12.77	PBT-15 x PBT-23 PBT-20 x PBT-19 PBT-19 x PBT-23	PBT-20 x PBT-19 PBT-20 x PBT-15	PCT-1 x PBT-19 PBT-20 x PBT-19 PBT-20 x PBT-15
4.	NFWPC	-21.21 to 94.15	-41.50 to 79.30	-34.96 to 92.28	PBT-19 x PBT-18 PBT-20 x PBT-18 PBT-23 x PBT-18	PBT-19 x PBT-18 PBT-20 x PBT-18 PBT-23 x PBT-18	PCT-1 x PBT-19 PBT-19 x PBT-18 PCT-1 x PBT-23
5.	NFPC	-31.44 to 69.31	-44.60 to 65.54	-31.21 to 77.67	PBT-15 x PBT-23 PBT-19 x PBT-18 PCT-1 x PBT-19	PBT-15 x PBT-23 PBT-20 x PBT-18 PCT-23 x PBT-18	PCT-1 x PBT-19 PCT-1 x PPT-2 PCT-19 x PBT-18
6.	NFPP	-79.4 to 139.17	-88.34 to 108.53	-41.58 to 72.54	PBT-19 x PBT-18 PBT-20 x PBT-18 PBT-15 x PBT-23	PBT-19 x PBT-18 PBT-20 x PBT-18 PBT-15 x PBT-18	PCT-1 x PBT-19 PBT-19 x PBT-18 PCT-1 x PPT-2
7.	IL (cm)	-34.45 to 21.43	-29.09 to 44.54	-24.05 to 30.47	PBT-20 x PBT-18 PBT-20 x PBT-15 PBT-20 x PBT-23	PBT-20 x PBT-18 PBT-20 x PBT-15	PBT-20 x PBT-18 PBT-20 x PBT-19
8.	AFW(g)	-60.55 to 118.97	-71.04 to 109.68	-62.07 to 107.70	PBT-23 x PBT-22 PBT-19 x PBT-23 PCT-1 x PBT-18	PBT-23 x PBT-22 PPT-2 x PBT-23 PPT-2 x PBT-18	PBT-23 x PBT-22 PBT-20 x PBT-19 PPT-2 x PBT-20
9.	FL (cm)	-34.02 to 19.09	-41.95 to 12.75	-41.52 to 13.59	PBT-23 x PBT-22 PCT-1 x PBT-18 PBT-20 x PBT-19	PBT-23 x PBT-22 PPT-2 x PBT-20	PPT-2 x PBT-20 PBT-23 x PBT-22
10.	FW (cm)	-31.15 to 37.01	-40.00 to 24.31	-35.71 to 25.99	PCT-1 x PBT-18 PBT-23 x PBT-18 PBT-13 x PBT-22	PBT-23 x PBT-18 PBT-20 x PBT-19	PBT-23 x PBT-22 PBT-20 x PBT-19
11.	PH (cm)	-35.14 to 42.95	-42.64 to 27.48	-41.43 to 11.27	PBT-23 x PBT-18 PCT-1 x PBT-18 PBT-20 x PBT-18	PBT-23 x PBT-22 PBT-19 x PBT-22	-
12.	FYPP (kg)	-41.63 to 178.82	45.01 to 99.67	-49.75 to 68.22	PBT-15 x PBT-23 PBT-23 x PBT-22 PBT-23 x PBT-18	PBT-15 x PBT-23 PCT-1 x PBT-19 PBT-19 x PBT-18	PCT-1 x PBT-19 PBT-15 x PBT-23 PBT-20 x PBT-18
13.	FYPH (t/ha)	-43.04 to 178.82	-45.02 to 99.89	-49.84 to 68.12	PBT-15 x PBT-23 PBT-23 x PBT-22 PBT-23 x PBT-18	PBT-15 x PBT-23 PCT-1 x PBT-19 PBT-19 x PBT-18	PCT-1 x PBT-19 PBT-15 x PBT-23 PBT-20 x PBT-18
14.	NLPF	-24.95 to 100.00	-33.33 to 66.66	-16.50 to 150.00	PBT-15 x PBT-22 PBT-20 x PBT-19 PPT-2 x PBT-22	PBT-15 x PBT-22 PBT-20 x PBT-22 PPT-2 x PBT-22	PBT-15 x PBT-22 PBT-15 x PBT-23 PBT-20 x PBT-19
15.	PT (cm)	-35.26 to 80.76	-38.55 to 52.70	-26.08 to 75.36	PCT-1 x PPT-2 PCT-1 x PBT-19 PPT-2 x PBT-18	PPT-2 x PBT-18 PBT-20 x PBT-15 PBT-15 x PBT-18	PBT-20 x PBT-15 PBT-15 x PBT-18 PPT-29 x PBT-18
16.	TSS (%)	-25.14 to 9.24	-37.67 to 4.25	-37.30 to 6.60	PBT-20 x PBT-15 PCT-1 x PBT-20	-	-
17.	pHFJ	-12.28 to 1.82	-11.08 to 4.50	-8.40 to 5.17	PBT-15 x PBT-23 PCT-1 x PBT-15 PBT-15 x PBT-18	PBT-15 x PBT-23 PCT-1 x PBT-15 PCT-1 x PPT-2	PBT-15 x PBT-23 PCT-1 x PPT-2 PCT-1 x PBT-15
18.	AA (mg/100g)	-15.05 to 18.67	-28.82 to 15.70	-12.23 to 11.30	PBT-15 x PBT-23 PPT-2 x PBT-18 PBT-20 x PBT-19	PBT-20 x PBT-19 PBT-15 x PBT-23	-

Similar findings were reported by, Soresa *et al.* (2020) for number of fruits per plant. PBT-20×PBT-18 (-34.45) showed minimum heterosis over mid parent, PBT-20×PBT-18 (-29.09) display lowest heterosis over better parent and PBT-20×PBT-18 (-24.05) display lowest heterosis over check parent for intermodal length. Also, Alsadon *et al.* (2021) for intermodal length. PBT-23×PBT-22 (118.97) showed maximum heterosis over mid parent, PBT-23×PBT-22 (109.68) display highest heterosis over better parent and PBT-23×PBT-22 (107.70) display highest heterosis over check parent for average fruit weight. Similar findings were reported by Kumari *et al.* (2020) for average fruit weight. PBT-23×PBT-22 (19.09) showed maximum heterosis over mid parent, PBT-2×PBT-20 (12.75) display highest heterosis over better parent and PBT-2×PBT-20 (13.59) display highest heterosis over check parent for fruit length. Similar findings were reported by Soresa *et al.* (2020) for fruit length. PBT-1×PBT-18 (37.01) showed maximum heterosis over mid parent, PBT-23×PBT-18 (24.31) display highest heterosis over better parent and PBT-23×PBT-22 (25.99) display highest heterosis over check parent for fruit width. Similar findings were reported by Soresa *et al.* (2020) for fruit width. PBT-23×PBT-18 (42.95) showed maximum heterosis over mid parent, PBT-23×PBT-22 (27.48) display highest heterosis over better parent and PBT-23×PBT-22

(11.27) display highest heterosis over check parent for plant height. Similar findings were reported by Kumari *et al.* (2020) for plant height. PBT-19×PBT-13 (178.82) showed maximum heterosis over mid parent, PBT-19×PBT-13 (99.67) display highest heterosis over better parent and PBT-1×PBT-19 (68.22) display highest heterosis over check parent for yield per plant. Similar findings were reported by Alsadon *et al.* (2021) for yield per plant. PBT-19×PBT-13 (178.82) showed maximum heterosis over mid parent, PBT-19×PBT-13 (99.89) display highest heterosis over better parent and PBT-1×PBT-19 (68.12) display highest heterosis over check parent for yield per hectare. Similar findings were reported by Soresa *et al.* (2020) for yield per hectare.

PBT-19×PBT-10 (100.00) showed maximum heterosis over mid parent, PBT-19×PBT-10 (66.66) display highest heterosis over better parent and PBT-19×PBT-10 (150.00) display highest heterosis over check parent for number of locules per fruits. Chapagain *et al.* (2020) reported similar findings for number of locules per fruit. PBT-1×PBT-2 (80.76) showed maximum heterosis over mid parent, PBT-2×PBT-18 (52.70) display highest heterosis over better parent and PBT-20×PBT-15 (75.36) display highest heterosis over check parent for pericarp thickness. Significant positive heterosis for pericarp thickness was also reported by Chapagain *et al.*, (2020). PBT-1×PBT-20 (9.24) showed maximum heterosis over mid parent, PBT-20×PBT-19 (4.25) display highest heterosis over better parent and PBT-1×PBT-2 (6.60) display highest heterosis over check parent for T.S.S. Chapagain *et al.* (2020) had also reported significant positive heterosis for TSS in tomato. PBT-20×PBT-18 (1.82) showed maximum heterosis over mid parent, PBT-20×PBT-15 (4.50) display highest heterosis over better parent and PBT-19×PBT-18 (5.17) display highest heterosis over check parent for pH of fruit juice. PBT-19×PBT-13 (18.67) showed maximum heterosis over mid parent, PBT-20×PBT-19 (15.70) display highest heterosis over better parent and PBT-2×PBT-18 (11.30) display highest heterosis over check parent for ascorbic acid. Significant positive heterosis for pH in fruit juice and ascorbic acid was also reported by Chapagain *et al.* (2020).

CONCLUSION

The promising F_1 hybrid over mid parent for yield traits was PBT-23×PBT-22 for days to 50 percent flowering, days to first fruit set, average fruit weight and fruit length and PBT-15×PBT-23 was a promising F_1 hybrid for days to first fruit ripening, number of fruit per cluster, yield per plant, yield per hectare, pH of fruit juice and ascorbic acid. The promising F_1 hybrid over better parent PBT-15×PBT-23 for number of fruit per cluster, yield per plant, yield per hectare and pH of fruit juice. The promising F_1 hybrid over check parent was PBT-1×PBT-19 for days to first fruit ripening, number of flower per cluster, number of fruit per cluster, number of fruit per plant, yield per plant and yield per hectare. Therefore, these hybrids can be used for exploited for commercial cultivation.

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