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Heterosis and Combining Ability Analysis in Tomato Using Line × Tester Model

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The experiment entitled Heterosis and combining ability studies for yield and yield attributing trait in Tomato (*Lycopersicon esculentum)* in Bundelkhand Region was carried out during *Rabi* 2021-22 and 2022-23 at the Experimental, Organic Research farm Kargunwa ji, Jhansi, Department of Horticultural Sciences, Institute of Agricultural Sciences, Bundelkhand University Jhansi (Uttar Pradesh). The present experiment was design under Randomized block design with three replication with plot size - 3×3m and number of rows per plant – 5 rows per plant accommodating spacing (60×60) cm. All F_{1s} (50) along with parents were raised in RBD in 3 replications and population size were 30 plants per treatment with standard spacing. All 17 parents (5 lines and 12 testers) were raised in separate plots along with a check grown in RBD in three replications to study the combining ability, to estimate the magnitude or percentage of heterosis in the crosses, for

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identification of the best F_1 hybrid and correlation among different traits. Since, Line × tester analysis provides information of potential parents the hybrid line. The three best combinations for line parents *viz*., H-88-78-5, Kashi Aman, H-88-78-5 and their F_1 hybrid *viz*., H-88-78-1x Kashi Chaya,VRT-67 × Kashi Chaya,H-88-78-5×VRT-50 performed significantly better amongst rest of the other treatment.

Keywords: Heterosis; line; tomato; Lycopersicon esculentum L.; tester.

1. INTRODUCTION

The solanaceae family include tomato *Solanum lycopersicum* L., which is asexually reproduce annual herbaceous vegetable crops. One of the most extensively grown vegetable crops it has 2n=2x=24 chromosomes is a diploid species. According to Rick [1], the tomato is said to have originated in Peru Ecuador. The Portuguese introduce it to the Indian *pennelli, L. hirsutum, L. chinese and L. peruvianum* species. According to Esquinas-Alcazar [2] the genus Lycorpersicon has9 closely related species, including *L. esculentum, L. pimpinefolium, L. cheesmaniae, L. perviflorum, L. chnielewskii*and L. species. The word tomato in English derived from the Tomate which itself derived from the Mexican word *Tomatal*. Tomato output is second only to the potato production world wide [3]. India is the world second largest producer of the tomatoes, right after China.

According to India 3rd estimate of production figure, 778000 hectares produced over 19397000 Metric Tonnes in 2018-19 (*nhb.gov.in*) the total tomato production in India in the major tomato growing states of Karnataka, Odissa, Madhya Pradesh, West Bengal, Chhattisgarh, Gujrat and Telangana, Bihar Uttar Pradesh, Tamil Nadu. The output of tomato fruits in the years 2022-23 is anticipated to be 3.8% greater than in prior year, according to the first advance estimate. After maize, wheat and cotton, it ranks fifth in terms of crop value at the moment [4].

According to Kempthorne [5], the line x Tester mating design is essentially a important for development of top cross analysis in that multiple testers are used as opposed to just one in top cross. Together and individually, they all contribute a shared genetic background that the inbreds' genotype is measured against. A line is tested due to the utilization of several testers in vegetable crops. The first design that simultaneously gives both full sibling (FS) and half sibling (HS) relationships is the line x tester mating design (top cross and poly cross design only supply HS). Half-siblings are people with one parent in common and a different parent. Therefore, a group of half-siblings is one person's offspring. Therefore, a group of half-sibs is the offspring of one person who mated with a random group of the other person and had one child by each mate. Full siblings, on the other hand, share both parents, and as a result, the mean genotypic value of a full sibling group is equal to the average breeding value of two parents [6]. Thus, FS/HS analysis is another name for line x tester.

2. MATERIALS AND METHODS

The experiment entitled “Heterosis and combining ability studies for yield and yield attributing trait in Tomato (*Lycopersicon esculentum)* in Bundelkhand Region” was carried out during *Rabi* 2021-22 and 2022-23 was carried at the Experimental, Organic Research farm Kargunwa ji, Jhansi, Department of Horticultural Sciences, Institute of Agricultural Sciences, Bundelkhand University Jhansi (Uttar Pradesh).The present experiment was conducted in a Randomized block design (RBD) with three replication to appraise the performance of 17 parents (5 lines and 12 testers) which were selected based upon their performance for various traits. The characteristics features of the parents involved in the study are given below in Randomized block design with three replication.

2.1 Hybridization Program

Each of the 5 lines was crossed with 12 testers to produce 60 hybrids and F_{1S} was allowed to selfing to produce $F_{2S.}$ The healthy flower buds from new flush, which were due to open next day, were selected emasculation and pollination. The selected buds were emasculated by hand using forceps in the evening hours between 4:00pm to 5:30 pm. Emasculated flowers were covered with cotton to avoid contamination by foreign pollen. Pollination of the emasculated flowers was done by next day after the anthesis time (8:30am to 9:00 am). Well opened flowers with dehisced anthers were collected from male parents, the cotton was removed carefully and the stigma was touched with dehisced anthers of

the male flowers. The female flowers were covered with white colour butter paper bag immediately for easy identification and further avoiding the contamination from other pollen. The pedicel of each pollinated flowers was tied with the label, bearing information of female and male parents and date of crossing for identification.

3. RESULTS

3.1 Mean Performance of F_1-Hybrids of Genotypes and their Crosses

Mean performance of parents with respect to plant height as presented in (Tables 1a and 1b) in F_1 hybrids Line 97.34 cm (H-88-78-5), tester 90.26 cm (Kashi Aman) with their crosses 98.11cm under (H-88-78-1× Kashi Chaya). Number of branches per plant as in F_1 hybrids Line 18.89 (H-88-78-1), tester 18.93 (Kashi Chaya) with 98.11cm (H-88-78-1×Kashi Chaya). The number of fruits per plant as in F_1 hybrids Line 15.16 (H-88-78-5), tester 14.06 (VRT-30) with 98.11cm (H-88-78-1×Kashi Chaya). Days to 50% flowering was as in F_1 hybrids Line 54.23 (TOLev-32), tester 49.10 (VRT-30) with 44.98 (VRT-19 × Kashi Chaya). Number of cluster per plant as in F_1 hybrids Line 7.37 (TOLev-32), tester 7.17 (Vaibhav) with 7.37 (H-88-78-1× Kashi Chaya). Number of flower per cluster was as in F_1 hybrids Line 7.77 (H-88-78-1), tester 7.40 (VRT-30) with cross 7.83 (H-88-78-1 × Kashi Chaya). The number of fruit per cluster as in F_1 hybrids Line 13.18 (TOLev-15), tester 11.54 (Kashi Aman) with 7.10 (VRT-67× Kashi Chaya). The number of fruit per cluster was in F_1 hybrids Line 6.75 (H-88-78-5), tester and 6.40 (Vaibhav) with 6.80 (H-88-78-1×Kashi Chaya). Days to first fruit harvest was as in F_1 hybrids Line 55.95 (H-88-78-1), tester 54.92 (VRT-50) with 54.10 (VRT-67 × Kashi Chaya). Fruiting duration was as in F_1 hybrids Line 55.47 days (TOLeV-32), tester 54.77 days (VRT-30) with 93.83 (H-88-78-1× Kashi Chaya). For fruit length was as in F_1 hybrids Line 7.69 (H-88-78-1), tester 7.37 (Kashi Chaya) with 8.40 (H-88-78-1× Kashi Chaya). For fruit width was as in F_1 hybrids Line 8.27 (H-88-78-5), tester 7.33 (Kashi Aman) with 8.00 (VRT-67 × Kashi Chaya) with. Lycopene content was as in F_1 hybrids Line 11.31 (VRT-67), tester 10.51 (Kashi Chaya) with 12.56 (VRT-51× VRT-50). Yield per plant (g) was as in F_1 hybrids Line 113.57 (H-88-78-1), tester 106.10 (Kashi Chaya) with 124.86 (VRT-67 × Kashi Chaya).

4. DISCUSSION

4.1 Mean Performance of Parents

From the present findings the mean performance of parents with respect to plant height in F_1 hybrids Line (H-88-78-5), tester (Kashi Aman) and (H-88-78-1x Kashi Chaya). It may be noted that plant height was superior due to interaction components which was highly significant in terms of plant height. The present results are in line with Amin et al [7-9]. The number of fruit per cluster as in F_1 hybrids Line (ToLev-15), tester (Kashi Aman) and (H-88-78-1×Kashi Chaya). It may be well noted that number of fruit per cluster was superior due to interaction components which was highly significant in terms of number of fruit per cluster. The number of branches per plant as in F_1 hybrids Line (H-88-78-1), tester (Kashi Chaya) with (H-88-78-1× Kashi Chaya). The present study revealed that maximum branches were significant and superior as most significant contribution of line and tester observed for number of branches. The findings were similar to the studies with Gowthami et al [10-12] in tomato. The number of fruits per plant as in F1 hybrids Line (H-88-78-5), tester (VRT-30) with (H-88-78-1× Kashi Chaya). The present study revealed that maximum number of fruits per plant were significant and superior as most significant contribution of line and tester observed for number of fruits per plant. The data on days to 50% flowering was as in F1 hybrids Line (TOLev-32), tester (VRT-30) and (H-88-78-1×Kashi Chaya). The present study revealed that maximum number of days to 50% flowering were non-significant and superior in comparison to minimum number of days to 50% flowering as most significant contribution of line and tester observed for days to 50% flowering. The present findings were similar to the studies [13-15] in tomato. For number of cluster per plant was as in F1 hybrids Line (TOLev-32), tester (VRT-30) with (H-88-78-1×Kashi Chaya). The present study revealed that maximum number of cluster per plant were significant and superior in comparison to minimum number of cluster per plant as most significant contribution of line and tester observed for days to 50% flowering. The number of flower per plant was as in F1 hybrids Line (H-88-78-1), tester (VRT-30) with (H-88-78-1×Kashi Chaya). It may be well referred from the present study that number of flower per plant were significantly better under the hybrid lines and

Table 1a. Mean performance of F1-hybrids of genotypes

S. No	Parents	Plant Height (cm)	Number of Branches Per Plant	Number of Fruits Per Plant	50% Flowering	Number of Cluster Per Plant	Number of Flower Per Cluster	Number of Fruit Per Cluster	Days to First Fruit Harvest	Fruiting Duration	Fruit Length	Fruit Width	Lycopene Content	Yield Per Plant (g)
	Line													
1	H-88-78-5	97.34	17.80	15.16	44.37	7.30	7.77	6.75	63.67	51.80	7.47	8.27	11.21	103.82
2	H-88-78-4	94.65	17.07	14.13	48.70	7.10	7.10	6.68	59.57	53.53	6.73	7.93	10.56	108.65
3	VRT-67	95.11	16.32	14.88	44.73	7.17	7.47	6.72	56.28	51.13	6.77	7.97	11.31	110.69
4	TOLeV-15	93.79	17.00	14.06	50.43	7.13	7.27	6.59	60.08	53.83	6.89	7.37	10.34	105.94
5	VRT-16-1	92.88	17.90	14.03	49.33	7.17	7.20	6.29	60.54	54.63	6.80	7.33	10.30	103.82
6	VRT-06	93.40	16.97	13.14	50.50	7.20	7.40	6.29	58.40	55.37	6.66	7.47	10.38	102.23
7	VRT-19	92.80	17.94	13.34	52.58	7.23	7.30	6.59	60.11	54.30	6.66	7.37	10.18	100.24
8	H-88-78-1	95.09	18.89	12.97	47.03	7.37	7.40	6.74	55.95	52.17	7.69	7.87	11.27	113.57
9	VRT-51	90.29	17.99	13.37	50.33	7.03	7.27	6.60	59.74	54.30	6.37	7.23	10.10	101.63
10	TOLeV-28	91.23	17.97	13.99	53.33	7.07	7.27	6.52	58.88	53.33	6.27	7.33	10.17	99.29
11	VRT-50	91.98	17.87	12.89	53.33	6.87	7.20	6.60	58.44	53.40	6.26	7.47	9.48	99.43
12	TOLeV-32	90.36	18.38	13.07	54.23	6.83	7.30	6.70	59.44	55.47	6.57	6.87	9.88	98.40
	Tester													
1	KASHI CHAYA	89.48	18.93	13.91	45.47	7.07	7.20	6.37	54.95	52.63	7.37	7.27	10.51	106.10
2	VAIBHAV	90.24	18.44	13.82	47.63	7.17	7.23	6.40	58.73	54.30	6.83	7.17	10.21	100.55
3	KASHI AMAN	90.26	18.30	13.93	47.73	6.93	7.23	6.34	59.67	54.00	6.77	7.33	9.93	98.05
4	VRT-50	89.30	17.81	13.67	48.60	6.90	7.33	6.32	54.92	53.77	6.37	6.77	9.94	97.10
5	VRT-30	88.71	18.67	14.06	49.10	6.93	7.40	6.34	64.57	54.77	6.43	6.20	9.36	94.85
	Mean	**92.17**	**17.90**	**13.79**	**49.26**	**7.09**	**7.31**	**6.52**	**59.06**	**53.69**	**6.76**	**7.36**	**10.30**	**102.61**
	Min	88.71	16.32	12.89	44.37	6.83	7.10	6.29	54.92	51.13	6.26	6.20	9.36	94.85
	Max	97.34	18.93	15.16	54.23	7.37	7.77	6.75	64.57	55.47	7.69	8.27	11.31	113.57

Table 1b. Mean performance of F_1-hybrids and their crosses

Sr. No	Parents	Plant Height (cm)	Number of Fruit Per Cluster	Number of Branches Per Plant	Number of Fruits Per Plant	50% Flowering	Number of Cluster Per Plant	Number of Flower Per Cluster	Number of Fruit Per Cluster	Days to First Fruit Harvest	Fruiting Duration	Fruitlength	Fruit Width	Lycopene Content	Yield Per Plant (g)
1	H-88-78-5 × KASHI CHAYA	93.34	12.41	14.51	14.02	45.53	7.20	7.17	6.67	64.26	56.57	6.70	6.93	11.24	117.02
2	H-88-78-5 × VAIBHAV	90.48	11.39	19.83	15.13	54.00	6.73	7.37	6.67	65.12	87.67	6.50	7.30	11.19	117.55

Sr. No	Parents	Plant Height (cm)	Number of Fruit Per Cluster	Number of Branches Per Plant	Number of Fruits Per Plant	50% Flowering	Number of Cluster Per Plant	Number of Flower Per Cluster	Number of Fruit Per Cluster	Days to First Fruit Harvest	Fruiting Duration	Fruitlength	Fruit Width	Lycopene Content	Yield Per Plant (g)
3	H-88-78-5 ×KASHI AMAN	92.66	12.09	18.41	15.23	50.63	6.63	7.53	6.63	56.40	88.29	6.70	7.27	11.20	118.86
4	H-88-78-5 × VRT-50	92.65	12.09	17.68	14.67	50.93	6.50	6.33	6.50	69.23	85.60	6.53	7.30	11.19	113.17
5	H-88-78-5 × VRT-30	92.59	12.49	19.10	14.63	56.27	6.20	6.63	6.50	64.69	88.00	6.57	6.77	11.19	109.36
6	H-88-78-4 × KASHI CHAYA	92.52	12.22	15.38	13.87	45.27	7.27	7.40	6.80	63.26	56.17	6.87	6.83	10.49	118.34
7	H-88-78-4 × VAIBHAV	90.04	12.08	19.99	15.22	52.07	6.77	7.53	6.73	64.75	84.83	6.67	7.37	10.53	111.61
8	H-88-78-4 ×KASHI AMAN	92.37	12.15	18.42	15.23	47.32	6.47	7.40	6.77	56.28	90.20	6.77	7.37	10.54	112.37
9	H-88-78-4 × VRT-50	92.77	12.71	17.51	14.80	51.93	6.57	6.50	6.50	68.55	85.30	6.67	7.33	10.54	109.12
10	H-88-78-4 × VRT-30	93.11	13.25	19.02	14.23	55.07	6.17	7.60	6.63	61.89	87.57	6.73	7.27	10.53	109.06
11	VRT-67 ×KASHI CHAYA	97.88	12.21	16.84	14.07	44.20	7.37	7.70	7.10	54.42	54.10	7.10	8.00	11.33	124.86
12	VRT-67 ×VAIBHAV	89.66	12.12	20.28	14.86	51.93	7.03	6.80	6.77	63.66	85.97	6.77	6.70	11.28	116.09
13	VRT-6× KASHI AMAN	92.92	12.18	18.45	14.97	51.30	6.50	7.47	6.70	62.70	88.73	6.73	6.70	11.28	115.59
14	VRT-67 × VRT-50	93.50	12.39	17.93	15.47	52.93	6.53	6.73	6.47	64.75	86.63	6.63	6.60	11.34	111.21
15	VRT-67 × VRT-30	93.37	12.21	18.73	14.30	55.20	6.20	6.73	6.40	63.63	85.67	6.53	7.30	11.26	110.70
16	TOLeV-16 × KASHI CHAYA	93.81	13.15	15.84	14.33	46.17	7.17	7.50	6.67	56.81	57.60	6.80	7.27	10.30	115.09
17	TOLeV-16 X×VAIBHAV	92.00	12.38	21.31	14.39	52.93	7.07	6.77	6.83	60.59	85.50	6.80	7.20	10.30	114.03
18	TOLeV-16 × KASHI AMAN	91.63	12.38	18.60	15.57	51.93	6.43	7.53	6.70	63.77	87.67	6.83	7.20	10.28	110.41

Sr. No	Parents	Plant Height (cm)	Number of Fruit Per Cluster	Number of Branches Per Plant	Number of Fruits Per Plant	50% Flowering	Number of Cluster Per Plant	Number of Flower Per Cluster	Number of Fruit Per Cluster	Days to First Fruit Harvest	Fruiting Duration	Fruitlength	Fruit Width	Lycopene Content	Yield Per Plant (g)
19	TOLeV-16 × VRT-50	89.78	10.22	18.59	12.97	55.87	5.70	7.27	5.73	70.50	91.17	8.13	7.97	12.22	98.51
20	TOLeV-16 × VRT-30	93.95	12.10	17.81	14.30	55.19	6.53	6.63	6.37	62.93	86.60	6.43	7.37	10.27	108.63
21	VRT-16-1 × KASHI CHAYA	92.60	13.02	16.93	14.20	48.23	7.17	7.60	6.87	55.86	87.00	6.97	7.43	10.28	113.85
22	VRT-16-1 × VAIBHAV	89.74	11.49	19.73	14.56	53.00	6.83	6.63	6.83	59.89	84.60	6.80	7.33	10.21	113.17
23	VRT-16-1 × KASHI AMAN	91.80	12.09	19.38	15.37	51.10	6.50	7.43	7.03	64.64	86.43	7.13	7.27	10.23	112.23
24	VRT-16-1 × VRT-50	90.00	10.38	18.67	13.37	56.87	5.67	7.50	5.67	71.21	91.07	8.30	7.80	12.41	94.93
25	VRT-16-1 × VRT-30	92.63	12.34	17.95	14.63	56.09	6.47	6.50	6.40	65.69	85.03	6.50	6.73	10.23	109.25
26	VRT-06 ×KASHI CHAYA	94.18	12.27	17.81	14.18	46.17	7.00	7.43	7.07	58.35	88.59	6.73	7.60	10.36	109.92
27	VRT-06 × VAIBHAV	90.66	11.39	19.95	15.03	54.03	6.83	6.67	6.77	68.16	87.27	6.80	7.43	10.33	108.49
28	VRT-06 × KASHI AMAN	92.74	12.06	18.34	15.07	51.97	6.50	6.67	6.30	65.59	87.00	6.33	7.37	10.31	107.99
29	VRT-06 × VRT-50	89.59	10.50	18.59	12.93	57.23	5.63	7.53	5.67	70.54	91.23	8.30	7.87	12.30	91.60
30	VRT-06 ×VRT-30	93.80	12.29	18.09	14.57	57.41	6.67	6.41	6.40	64.61	84.20	6.50	7.27	10.31	108.40
31	VRT-19 × KASHI CHAYA	93.98	12.09	18.46	14.06	44.98	7.03	7.50	6.83	57.87	87.83	6.77	6.70	10.22	107.84
32	VRT-19 × VAIBHAV	92.19	11.27	18.55	14.83	54.43	6.77	7.07	6.50	68.25	87.03	6.47	6.77	10.18	106.94
33	VRT-19 × KASHI AMAN	92.64	12.77	18.77	14.73	53.00	6.53	6.77	6.30	66.75	85.40	6.33	6.73	10.19	106.64
34	VRT-19 × VRT-50	90.03	10.33	18.75	13.00	59.30	5.73	7.60	5.67	72.59	92.47	8.37	7.47	12.41	94.38

Sr. No	Parents	Plant Height (cm)	Number of Fruit Per Cluster	Number of Branches Per Plant	Number of Fruits Per Plant	50% Flowering	Number of Cluster Per Plant	Number of Flower Per Cluster	Number of Fruit Per Cluster	Days to First Fruit Harvest	Fruiting Duration	Fruitlength	Fruit Width	Lycopene Content	Yield Per Plant (g)
35	VRT-19 ×VRT-30	94.12	11.88	18.11	14.57	56.17	6.67	6.38	6.57	62.17	87.20	6.63	7.27	10.17	106.17
36	H-88-78-1 × KASHI CHAYA	98.11	11.92	22.64	15.50	44.47	7.27	7.83	6.93	56.12	88.60	6.87	7.23	11.28	123.16
37	H-88-78-1 X×VAIBHAV	92.63	11.26	18.81	14.53	53.07	6.77	7.23	6.47	69.70	86.57	6.50	7.27	11.23	114.73
38	H-88-78-1 × KASHI AMAN	92.81	12.59	19.31	14.23	52.93	6.47	6.50	6.20	66.70	84.53	6.37	7.20	11.26	114.95
39	H-88-78-1 × VRT-50	89.81	11.16	18.48	12.93	58.33	5.67	7.80	5.63	72.55	93.83	8.40	7.50	12.53	98.04
40	H-88-78-1 × VRT-30	94.39	11.78	19.32	14.56	55.23	6.57	6.30	6.27	61.29	86.33	6.37	7.37	11.24	110.63
41	VRT-51 × KASHI CHAYA	92.91	11.75	18.66	15.10	55.20	7.13	7.40	6.77	58.44	88.60	6.70	7.30	10.13	112.27
42	VRT-51 × VAIBHAV	93.70	11.26	18.95	14.63	53.03	6.70	7.30	6.57	68.74	88.06	6.50	7.33	10.13	113.12
43	VRT-51 × KASHI AMAN	93.32	12.37	19.09	14.07	51.40	6.50	6.53	6.27	65.70	87.96	6.27	7.27	10.14	111.72
44	VRT-51 × VRT-50	89.22	10.24	17.88	12.97	57.77	5.67	7.63	5.50	72.82	90.50	8.37	7.50	12.56	96.82
45	VRT-51 × VRT-30	94.52	11.78	19.65	14.22	57.52	6.60	6.37	6.27	59.86	85.77	6.33	6.77	10.07	108.22
46	TOLeV-28 × KASHI CHAYA	91.66	11.67	18.62	15.16	53.00	7.03	7.30	6.57	59.41	86.60	6.43	7.40	10.18	110.08
47	TOLeV-28 × VAIBHAV	92.04	12.28	19.22	14.90	54.00	6.70	7.23	6.57	70.00	85.60	6.50	7.43	10.18	110.64
48	TOLeV-28 × KASHI AMAN	93.18	12.46	18.42	14.87	49.37	6.50	6.37	6.27	69.28	87.70	6.43	7.40	10.14	108.97
49	TOLeV-28 × VRT-50	92.99	11.14	18.54	14.17	50.73	6.00	6.83	6.30	69.89	88.60	6.40	7.33	10.14	112.97
50	TOLeV-28 × VRT-30	94.54	12.04	19.31	14.47	55.23	6.53	6.47	6.30	60.47	88.89	6.40	7.27	10.14	111.27

Sr. No	Parents	Plant Height (cm)	Number of Fruit Per Cluster	Number of Branches Per Plant	Number of Fruits Per Plant	50% Flowering	Number of Cluster Per Plant	Number of Flower Per Cluster	Number of Fruit Per Cluster	Days to First Fruit Harvest	Fruiting Duration	Fruitlength	Fruit Width	Lycopene Content	Yield Per Plant (g)
51	VRT-50 ×KASHI CHAYA	92.11	11.48	19.51	15.00	54.07	7.00	7.23	6.83	60.11	86.80	6.73	6.77	9.50	109.68
52	VRT-01 ×VAIBHAV	94.11	12.40	18.63	14.67	53.10	6.70	7.23	6.43	68.85	86.35	6.47	6.73	9.50	109.63
53	VRT-01 ×KASHI AMAN	93.04	11.89	18.80	14.57	50.33	6.37	6.37	6.73	69.53	87.23	6.83	6.70	9.50	107.61
54	VRT-01 × VRT-50	92.56	12.18	18.49	14.50	53.47	6.37	7.20	6.23	62.95	86.60	6.43	7.50	9.47	108.73
55	VART-01 × VRT-30	92.59	12.10	19.46	14.37	57.23	6.53	6.53	6.47	64.57	85.57	6.57	7.33	9.47	107.51
56	TOLeV-32 × KASHI CHAYA	92.28	11.50	20.95	15.17	53.03	6.87	7.37	6.60	61.18	87.30	6.53	7.23	9.70	110.90
57	TOLeV-32 × VAIBHAV	93.92	12.17	18.56	15.50	50.27	6.70	7.47	6.37	64.32	87.02	6.47	7.23	9.73	110.57
58	TOLeV-32× KASHI AMAN	92.78	12.11	18.49	14.60	50.03	6.43	6.33	6.53	69.29	88.78	6.60	7.27	9.74	109.54
59	TOLeV-32 × VRT-50	93.88	12.38	18.92	14.80	54.80	6.23	7.30	6.27	63.61	86.80	6.30	7.37	9.77	108.53
60	TOLeV-32× VRT-30	94.29	12.13	19.93	14.43	56.19	6.17	6.70	6.17	64.30	85.67	6.30	7.40	9.66	105.64
	Mean F_1	**92.65**	**11.94**	**18.68**	**14.52**	**52.67**	**6.58**	**7.05**	**6.48**	**64.33**	**85.31**	**6.77**	**7.24**	**10.60**	**109.99**
	Min	89.22	10.22	14.51	12.93	44.20	5.63	6.30	5.50	54.42	54.10	6.27	6.60	9.47	91.60
	Max	98.11	13.25	22.64	15.57	59.30	7.37	7.83	7.10	72.82	93.83	8.40	8.00	12.56	124.86
	Mean All	**92.55**	**11.93**	**18.51**	**14.36**	**51.92**	**6.69**	**7.11**	**6.48**	**63.17**	**78.33**	**6.77**	**7.26**	**10.53**	**108.36**
	Min	88.71	10.22	14.51	12.89	44.20	5.63	6.30	5.50	54.42	51.13	6.26	6.20	9.36	91.60
	Max	98.11	13.25	22.64	15.57	59.30	7.37	7.83	7.10	72.82	93.83	8.40	8.27	12.56	124.86
	SE(d) ±	0.52	0.09	0.19	0.36	0.59	0.11	0.13	0.15	0.82	0.68	0.13	0.08	0.10	1.11
	C.D. at 5%	1.03	0.18	0.37	0.70	1.17	0.22	0.25	0.29	1.62	1.35	0.26	0.16	0.19	2.20
	C.V. (%)	0.69	0.92	1.25	3.04	1.40	2.04	2.19	2.79	1.59	1.07	2.35	1.35	1.14	1.26

tester. The test of significance of variance due to line x tester exhibited a significant variation in terms of number of flower per plant. The number of fruit per cluster was as in F1 hybrids Line (H-88-78-5), tester (Vaibhav) with (H-88-78-1× Kashi Chaya). The mean performance of line, tester and their crosses clearly indicated that there is no single genotype involved or revealed the superiority in all the traits. As a general trend it may be well established from the present result that better performance of the lines, tester and their hybrids clearly indicated significant variation in terms of number of fruit per cluster. The present result is in agreement with that of Singh et al [16-18] in tomato.For days to first fruit harvest was as in F1 hybrids Line (H-88-78-1), tester (VRT-50) with (H-88-78-1× Kashi Chaya). It may be well noted that days to first fruit harvest was superior due to interaction components which was highly significant in terms of days to first fruit harvest. The present results are in line with El-Mansy et al [19,17,18] in tomato. Fruiting duration was as in F1 hybrids Line days (H-88-78-5), tester (Kashi Chaya) with (H-88-78-1×Kashi Chaya). It may be inferred from the current study that fruiting duration was superior due to interaction components which was highly significant in terms of fruiting duration. The present results are in line with Reddy [20-22] in tomato.For fruit length was as in F1 hybrids Line (H-88-78-5), tester (Kashi Chaya) with (H-88-78-1× Kashi Chaya). The mean performance of line, tester and their crosses clearly indicated that there is no single genotype involved or revealed the superiority in all the traits for fruit length and its architecture. As a general trend it may be well established from the present result that better performance of the lines, tester and their hybrids clearly indicated significant variation in terms of fruit length. The present result is in agreement with that of Narasimhamurthy and Gowda [23-27] in tomato. Fruit width was as in F1 hybrids Line (H-88-78-5), tester (Kashi Aman) with (H-88-78-1x Kashi Chaya). As a general trend it may be well established from the current result that better performance of the lines, tester and their hybrids clearly indicated significant variation in terms of fruit width. The present result are in accordance with that of Tekkam et al [28-30] in tomato. The Lycopene content was as in F1 hybrids Line (H-88-78-1), tester (Kashi Chaya) with (H-88-78-1x Kashi Chaya). It may be noted from the present results that lycopene content was higher due to interaction components and the general combiner for most of the traits which was highly significant in terms of lycopene content. The present study is in agreements with that of Panthee [31]. Yield per plant (g) was as in F1 hybrids Line (H-88-78-1), tester (Kashi Chaya) with (H-88-78-1x Kashi Chaya). It may be noted that yield per plant was superior due to interaction components of the best hybrids and their combination. The best hybrid combination reflected the high significant values in terms of plant yield.

5. CONCLUSION

Among all the different line employed in the present research. The (H-88-78-5), tester (Kashi Aman) with (H-88-78-1x Kashi Chaya) was found to be a good general combiner for maximum characters. Thus, obtained results can help in deciding the suitable parents as well as crosses for particular trait that can be better and further utilized in breeding programmes in tomato.

6. FUTURE SCOPE

Thus, the most suitable inbred lines to be employed in future breeding programmes can be identified thanks to this study, which uses a variety of tomato genotypes. The consequences of crossing showed that some parent were a good general match for many character, indicating that some parents will need to be chosen for genetic enhancement depending on specific qualities taken into account. Because tomatoes are a highly consumed produce, experts are focusing on developing superior hybrids with desired parent combinations through crop improvement programmes. Additionally, hybrids that produce larger yields assist farmers in meeting the ongoing need of the market.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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