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Assessment of Heterosis in Tomato (*Lycopersicon esculentum* L.)

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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 present study, Estimate of Heterosis in Tomato (*Lycopersicon esculentum* L.) under the Bundelkhand Region, was conducted in Rabi 2021–22 and 2022–23 at the Experimental, Organic Research farm Kargunwa ji, Department of Horticultural Sciences, Institute of Agricultural Sciences, Bundelkhand University Jhansi (Uttar Pradesh). The study involved raising all 17 parents (12 lines and 5 testers) in separate plots, along with a check grown in RBD *i.e.* to determine the best F1 hybrid, in order to calculate the proportion or amount of heterosis in the crossings, and relationship between different traits. The three most effective line and testers with their combinations *viz.,.* H-88-78-5, Kashi Aman, and H-88-78-5. Their F1 hybrids, H-88-78-1×Kashi Chaya, VRT-67 Kashi Chaya, and H-88-78-5VRT-50, outperformed the other treatments by a large margin in terms of maximum plant height was recorded (98.11,) VRT-67 × Kashi Chaya, number of fruit per cluster in

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F1 hybrids Line was recorded (9.67) under Tolev-16 × Kashi Aman which was *at par* with (9.63) under VRT-51×VRT-30 and VRT-01 ×Kashi Aman. However, mean performance for lycopene content was recorded for 12 lines and 5 testers. Lycopene content was (11.31) under the line VRT-67 and mean performance for their F1 hybrids after the crosses (12.56) were under treatment VRT-51×VRT-50.

Keywords: Estimate; heterosis; line; tomato; Lycopersicon esculentum L.; tester.

1. INTRODUCTION

Tomato (*Lycopersicon esculentum* L.) is the second most popular vegetable in the world after potato. It belongs to the large family Solanaceae with chromosome number of 2n=24 (x=12) and originated from South America. Tomato is a self- pollinated warm season crop equitably resistant to heat, drought and grows well in broad range of soil and climatic conditions [1].

Lycorpersicon is a genus that contains nine closely related species, including *L. esculentum*, *L. pimpinefolium, L.cheesmaniae, L.perviflorum, L.chnielewskii, and L.* species, according to Esquin *et al.*, (1982). The English word "tomato" comes from the word "tomate," which is taken from the Mexican word "tomatal."Globally, the production of tomatoes is surpassed only by that of potatoes Peixoto et al. [2]. India is the world second largest producer of the tomatoes, right after China, Warnock et al. [3].

Heterosis breeding is utilised because conventional methods are insufficient to increase the amount and quality of tomato (*Lycopersicon esculentum L.*) output.Given the increasing demand tomatoes, genotypes with higher yield and quality must be developed, therefore even a small improvement in production per unit area is crucial.

Breeders must look into natural variety as a source of novel alleles in order to boost crop output, quality, and nutritional value, Ayenan et al. [4]. The first to notice heterosis and hybrid vigour in tomatoes as a means of boosting yield and fruit production were Hedrick and Booth (1907). Choudhary (1965) emphasised the widespread use of heterosis to increase tomato yield. Sundaram [5] emphasised the commercial potential of tomato F1 hybrid production. Hayes [6] attributes the term "heterosis" to Shull. Heterozygous plants possess characteristics that enable their hybrids to be more resilient and alive than their parents Angadi and Dharmatti [1] and Tamta and Singh [7].

Every effective breeding programme must include both the breeding technique and the selection of suitable parents. Heterosis in tomatoes is the occurrence in which F1 hybrids (first-generation offspring) exceed their parental lines in specific attributes.As a result, selecting parents is essential for heterosis exploitation, Warnock et al. [3]. Information from the general mean performance of parents and the specialized combining ability of crosses aid in the identification of suitable parents and related cross-combinations. This study aimed to identify the finest tomato F1 hybrids and assess heterosis in the hybrids relative to their parents.

2. MATERIALS AND METHODS

The “Estimate of Heterosis in Tomato (*Lycopersicon esculentum* L.)” experiment was conducted in Rabi 2022–22 and 2022–23 at the Department of Horticultural Sciences, Institute of Agricultural Sciences, Bundelkhand University Jhansi (Uttar Pradesh), at the Experimental, Organic Research farm Kargunwa ji, Jhansi. The performance of 17 parents (12 lines and 5 testers) who were chosen based on how well they performed for different qualities was tested in the current experiment using a Randomized block design (RBD) with three replications.

2.1 Hybridization Program

Each of the 12 lines was crossed with 5 testers to produce 60 hybrids, and F1S was allowed to self to produce F2S. The healthy flower buds from the new flush, which were due to open the next day, were selected for emasculation and pollination. The selected buds were emasculated by hand using forceps in the evening hours between 4:00pm and 5:30pm. The emasculated flowers were covered with cotton to avoid contamination by foreign pollen.

Statistical methods: Analysis of variance (ANOVA) was calculated for each character by following the standard statistical procedure. Heterosis was estimated in terms of Standard heterosis (expressed over the standard check).

Heterosis was measured as the proportion of deviation of the value from the standard check [8]. The estimation was expressed in percentage.

3. RESULTS AND DISCUSSION

Mean performance of parents and their crosses: The mean performance of 60 genotypes of tomato for 2 morphological characters are presented in (Table 1 & 1a). Mean values of various characters based on line × tester and their hybrids observations of both the individual environments (2021-22 and 2022-23) and combined over environments. It is cleared from the data that, all germplasm were showed a wide range of variations for most of the traits, which are described as under. The results reflected in the Table 1 are given.

Plant height (cm): Significant variation exists between genotypes when it comes to plant height at 15, 30, 45, 60, 75, and 90 days following transplantation. At 15 days following transplantation, the plant height for 12 lines was recorded as maximum under (14.40 cm) under H-88-78-5 and minimum under (10.53 cm) under VRT-19; for tester, it was maximum exhibited under (12.92 cm) under VRT-50 and minimum under (11.07 cm) under Kashi Chaya. At 30 days following transplantation, the plant height for 12 lines was recorded as maximum under (36.66 cm) under H-88 78-5 and minimum under (32.72 cm) under VRT-19. For tester, it was maximum exhibited under (33.94 cm) under Kashi Chaya and minimum under (30.50 cm) under VRT-30 as referred by Amin et al. [9] and Atugwu et al. [10]. At 45 days after transplantation the plant height for 12 lines was recorded maximum under (47.80 cm) under H-88 78-5 and minimum under (41.84 cm) under VRT-51. However, for tester was maximum exhibited under (46.62 cm) under Kashi Chaya and minimum (44.74 cm) under VRT-30 as quoted by Avdikos et al. [11]. At 60 days after transplantation the plant height for 12 lines was recorded maximum under (64.81 cm) under H-88-78-5 and minimum under (57.81 cm) under VRT-50. However, for tester was maximum exhibited under (58.88 cm) under Kashi Aman and minimum (57.46 cm) under VRT-30 as noted by Ayenan et al. [4]. At 75 days after transplantation the plant height for 12 lines was recorded maximum under (79.48 cm) under H-88-78-5 and minimum under (74.66 cm) under H-88-78-4. However, for tester was maximum exhibited under (77.85 cm) under VRT-50 and minimum (76.34cm) under Kashi Chaya, Bhalala et al. [12].

At 90 days after transplantation the plant height for 12 lines was recorded maximum under (97.34cm) under H-88-78-5 and minimum under (90.29cm) under VRT-51. However, for tester was maximum exhibited under (90.26 cm) under Kashi Aman and minimum under (88.71 cm) VRT-30. It may be noted that plant height was superior due to interaction components which was highly significant in terms of plant height as per the findings of Baraskar et al. [13] and Choudhury et al. [14].

Similarly, the mean performance for their F1 hybrids after the crosses were transplanted the data revealed significant variability among different genotypes in terms of the plant height at 15, 30, 45, 60, 75, and 90 days. At 15 days the plant height was recorded (16.42) VRT-67 × Kashi Chaya followed by (15.70) and (15.19) under the genotypes VRT-01 ×Kashi Aman and H-88-78-1 × Kashi Chaya and minimum plant height recorded (11.03) under the genotype Tolev-16 × VRT-50. At 30 days the plant height was recorded (35.70) VRT-67 × Kashi Chayafollowed by (34.33) and (33.17) under the genotypes H-88-78-1 × Kashi Chaya and Tolev-16 ×Kashi Chaya and minimum plant height recorded (24.32) under the genotype VRT-51×VRT-50. At 45 days the plant height was recorded (50.0) VRT-67 × Kashi Chaya followed by (49.68) and (48.32) under the genotypes H-88-78-1 × Kashi Chaya and Tolev-16 × Kashi Chaya and minimum plant height recorded (38.62) under the genotype VRT-51×VRT-50.

At 60 days the plant height was recorded (65.63) VRT-01 × Vaibhav followed by (65.4) and (63.6) under the genotypes VRT-67 × Kashi Chaya and H-88-78-1× Kashi Chayaand minimum plant height recorded (49.55) under the genotype Tolev-16 × VRT-50.

At 75 days the plant height was recorded (88.73) VRT-16-1 ×VRT-30 followed by (88.53) and (87.77) under the genotypes H-88-78-1× Kashi Chaya and VRT-67 × Kashi Chaya and minimum plant height recorded (75.14) under the genotype VRT-19 × VRT-50.

At 90 days the plant height was recorded (98.11,) VRT-67 × Kashi Chaya followed by (97.88) and (94.54) under the genotypes VRT-67 × Kashi Chaya and Tolev-28 ×VRT-30 and minimum plant height recorded (89.22) under the genotype VRT-51 × VRT-50.

Table 1. Mean performance for parents

S.No	Parents	Plant height (cm)						Number of fruit per cluster				
		15 DAT	30 DAT	45 DAT	60 DAT	75 DAT	90 DAT	30 DAT	45 DAT	60 DAT	75 DAT	90 DAT
	Line											
1	H-88-78-5	14.40	36.66	47.80	64.81	79.48	97.34	1.00	3.10	5.90	9.60	12.48
2	H-88-78-4	12.37	33.32	46.18	62.38	74.66	94.65	0.67	2.10	4.23	8.57	12.20
3	VRT-67	13.34	35.85	47.15	62.86	78.12	95.11	1.00	3.03	3.57	8.23	12.30
4	TOLeV -15	13.22	34.42	45.35	62.17	74.99	93.79	0.33	2.90	4.23	7.57	13.18
5	VRT-16-1	12.21	33.49	44.98	61.41	75.33	92.88	0.33	2.90	4.20	7.40	12.87
6	VRT-06	12.33	32.97	43.87	60.28	76.55	93.40	0.67	1.97	4.30	8.27	12.29
7	VRT-19	10.53	32.72	42.86	59.89	76.68	92.80	0.67	1.93	4.40	8.20	12.14
8	H-88-78-1	13.17	34.98	46.42	62.28	78.32	95.09	1.00	2.27	5.73	8.20	11.82
9	VRT-51	11.12	34.44	41.84	59.29	76.21	90.29	0.33	2.00	4.77	8.73	11.53
10	TOLeV-28	13.21	33.12	42.18	58.69	77.13	91.23	0.67	2.10	5.23	8.27	11.34
11	VRT-50	13.21	33.54	42.87	57.81	77.92	91.98	0.33	1.97	5.33	8.17	11.65
12	TOLeV -32	13.09	33.01	42.97	58.52	78.15	90.36	0.33	2.10	5.37	7.50	11.62
	Tester											
1	Kashi Chaya	11.07	33.94	46.62	58.70	76.34	89.48	1.00	2.37	5.63	8.27	11.28
2	Vaibhav	12.13	33.32	46.25	57.79	76.73	90.24	0.33	2.03	4.80	8.63	11.47
3	Kashi Aman	12.30	33.93	46.15	58.88	77.20	90.26	0.67	2.10	5.27	8.40	11.31
4	VRT-50	12.92	33.43	45.48	58.87	77.85	89.30	0.33	2.03	5.37	8.23	11.54
5	VRT-30	12.06	30.50	44.74	57.46	77.82	88.71	0.67	2.07	5.43	7.67	11.42
	Mean	**12.51**	**33.74**	**44.92**	**60.12**	**77.03**	**92.17**	**0.61**	**2.29**	**4.93**	**8.23**	**11.91**
	Min	10.53	30.50	41.84	57.46	74.66	88.71	0.33	1.93	3.57	7.40	11.28
	Max	14.40	36.66	47.80	64.81	79.48	97.34	1.00	3.10	5.90	9.60	13.18

Table 1a. Mean performance of F1-hybrids

S.No	Crosses (Line × tester)	Plant height (cm)						Number of fruit per cluster				
		15 DAT	30 DAT	45 DAT	60 DAT	75 DAT	90 DAT	30 DAT	45 DAT	60 DAT	75 DAT	90 DAT
1	H-88-78-5 ×Kashi Chaya	13.81	31.00	42.63	59.07	82.50	93.34	1.03	3.13	6.07	9.43	12.41
2	H-88-78-5 × Vaibhav	13.64	32.65	47.46	62.28	78.62	90.48	1.00	3.20	5.83	7.53	11.39
3	H-88-78-5 ×Kashi Aman	13.91	32.28	46.35	62.88	84.47	92.66	1.00	2.97	4.63	9.53	12.09
4	H-88-78-5 ×VRT-50	14.12	30.11	45.86	59.29	82.39	92.65	1.00	2.53	5.83	9.37	12.09
5	H-88-78-5 × VRT-30	13.99	32.48	46.14	59.07	82.63	92.59	1.07	3.00	5.77	9.20	12.49
6	H-88-78-4 × Kashi Chaya	13.90	32.74	43.00	58.52	82.21	92.52	1.03	2.33	4.33	8.53	12.22
7	H-88-78-4 × Vaibhav	13.42	30.22	42.95	60.21	77.44	90.04	1.00	3.27	4.83	7.60	12.08
8	H-88-78-4 × Kashi Aman	13.96	30.06	42.95	62.58	85.05	92.37	0.67	3.63	5.87	9.57	12.15
9	H-88-78-4 × VRT-50	13.79	31.84	42.17	59.34	82.61	92.77	0.67	2.90	4.83	9.27	12.71
10	H-88-78-4 ×VRT-30	13.85	31.15	42.57	56.44	82.32	93.11	1.03	2.67	4.83	9.27	13.25
11	VRT-67 × Kashi Chaya	16.42	35.70	50.00	65.40	87.77	97.88	1.03	2.17	3.97	8.23	12.21
12	VRT-67 × Vaibhav	13.68	31.85	43.15	58.77	77.96	89.66	1.00	3.13	5.23	7.60	12.12
13	VRT-67 × Kashi Aman	13.93	31.33	43.12	61.70	84.64	92.92	1.00	2.80	5.23	9.60	12.18
14	VRT-67 × VRT-50	13.99	29.92	42.71	58.40	82.57	93.50	1.00	3.00	5.23	9.37	12.39
15	VRT-67 ×VRT-30	14.01	32.57	42.64	58.06	86.07	93.37	1.03	2.90	5.17	9.33	12.21
16	Tolev-16 ×Kashi Chaya	13.82	33.17	43.22	58.08	80.37	93.81	1.03	3.10	4.37	7.40	13.15
17	Tolev-16 ×Vaibhav	14.43	30.06	43.14	58.41	76.78	92.00	1.00	2.80	5.33	7.60	12.38
18	Tolev-16 ×Kashi Aman	14.51	29.88	42.69	60.65	84.49	91.63	1.00	2.87	5.33	9.67	12.38
19	Tolev-16 × VRT-50	11.03	28.55	39.92	49.55	78.85	89.78	0.43	2.33	3.23	6.73	10.22
20	Tolev-16 × VRT-30	14.63	30.66	42.90	59.14	86.25	93.95	1.03	2.80	5.27	8.73	12.10
21	VRT-16-1 ×Kashi Chaya	13.74	31.00	40.89	57.59	79.77	92.60	0.67	3.17	4.07	7.37	13.02
22	VRT-16-1 × Vaibhav	13.43	32.61	43.18	59.02	78.49	89.74	1.00	2.50	5.37	7.43	11.49
23	VRT-16-1 × Kashi Aman	13.89	30.07	43.06	61.23	83.81	91.80	1.00	2.93	5.33	9.47	12.09
24	VRT-16-1 ×VRT-50	11.73	27.44	39.29	50.37	77.11	90.00	0.93	2.30	3.43	6.57	10.38

S.No	Crosses (Line × tester)	Plant height (cm)						Number of fruit per cluster				
		15 DAT	30 DAT	45 DAT	60 DAT	75 DAT	90 DAT	30 DAT	45 DAT	60 DAT	75 DAT	90 DAT
25	VRT-16-1 ×VRT-30	14.30	32.15	43.06	58.60	88.73	92.63	1.07	2.30	5.27	8.87	12.34
26	VRT-06 × Kashi Chaya	13.47	31.22	48.29	58.51	79.36	94.18	0.67	3.20	5.83	7.43	12.27
27	VRT-06 ×Vaibhav	14.56	30.21	48.32	59.70	77.12	90.66	1.00	2.80	5.83	7.47	11.39
28	VRT-06 ×Kashi Aman	14.68	32.13	47.59	62.32	83.61	92.74	1.00	3.00	5.83	9.47	12.06
29	VRT-06 ×VRT-50	12.07	26.85	39.24	51.26	75.44	89.59	0.90	2.17	3.47	7.07	10.50
30	VRT-06 ×VRT-30	14.29	30.26	46.48	58.54	83.93	93.80	1.03	2.57	5.77	9.57	12.29
31	VRT-19 ×Kashi Chaya	11.48	30.17	46.14	62.94	80.28	93.98	1.03	3.30	4.27	7.30	12.09
32	VRT-19 ×Vaibhav	11.59	31.81	46.22	59.18	78.51	92.19	1.00	2.53	4.27	7.60	11.27
33	VRT-19× Kashi Aman	12.00	29.95	46.18	60.55	82.92	92.64	1.00	3.03	4.23	9.53	12.77
34	VRT-19 × VRT-50	11.48	25.71	39.31	51.52	75.14	90.03	0.97	2.13	3.37	7.20	10.33
35	VRT-19× VRT-30	11.66	32.69	42.57	58.94	83.49	94.12	1.03	2.77	4.23	9.53	11.88
36	H-88-78-1 × Kashi Chaya	15.19	34.33	49.68	63.60	88.53	98.11	1.00	3.60	3.90	7.23	11.92
37	H-88-78-1 × Vaibhav	12.11	29.66	47.00	59.55	81.12	92.63	1.00	2.27	4.03	7.87	11.26
38	H-88-78-1 × Kashi Aman	12.44	32.95	46.59	59.30	83.81	92.81	1.00	2.87	3.97	9.57	12.59
39	H-88-78-1 ×VRT-50	11.38	25.18	39.18	51.89	78.75	89.81	0.90	2.20	3.20	6.83	11.16
40	H-88-78-1 × VRT-30	12.87	31.02	42.83	57.29	82.46	94.39	1.00	2.73	3.87	9.50	11.78
41	VRT-51 ×Kashi Chaya	11.21	32.91	46.16	61.69	82.62	92.91	0.33	3.37	4.33	7.37	11.75
42	VRT-51 × Vaibhav	11.64	32.62	46.09	59.34	81.56	93.70	0.00	2.97	4.33	9.43	11.26
43	VRT-51 ×Kashi Aman	11.94	30.18	45.46	58.41	84.92	93.32	0.33	3.00	4.33	9.53	12.37
44	VRT-51 ×VRT-50	11.99	24.32	38.62	52.05	79.01	89.22	0.50	2.17	3.30	6.97	10.24
45	VRT-51 ×VRT-30	12.20	32.24	42.87	60.30	77.80	94.52	0.33	2.87	4.33	9.63	11.78
46	Tolev-28 × Kashi Chaya	14.31	30.11	46.09	61.40	76.11	91.66	0.33	3.43	4.27	7.40	11.67
47	Tolev-28 × Vaibhav	14.38	29.81	46.02	57.96	82.58	92.04	0.00	2.97	4.23	9.40	12.28
48	Tolev-28 ×kashi Aman	14.73	31.84	45.46	59.32	83.82	93.18	0.33	2.70	4.23	9.60	12.46
49	Tolev-28 × VRT-50	14.44	31.48	45.71	60.52	81.29	92.99	0.33	2.87	4.23	8.80	11.14
50	Tolev-28 ×VRT-30	13.85	30.20	42.98	62.68	76.56	94.54	0.67	2.83	4.23	9.37	12.04
51	VRT-50× Kashi Chaya	14.39	31.59	44.04	59.95	75.22	92.11	1.00	3.30	4.33	7.40	11.48
52	VRT-01 ×Vaibhav	14.45	31.92	43.97	65.63	82.88	94.11	1.00	2.87	4.33	9.40	12.40
53	VRT-01 ×Kashi Aman	15.70	29.92	44.01	59.96	82.54	93.04	0.67	2.60	4.33	9.63	11.89

S.No	Crosses (Line × tester)	Plant height (cm)						Number of fruit per cluster				
		15 DAT	**30 DAT**	**45 DAT**	**60 DAT**	**75 DAT**	**90 DAT**	**30 DAT**	**45 DAT**	**60 DAT**	**75 DAT**	**90 DAT**
54	VRT-01 ×VRT-50	14.61	29.85	43.63	61.95	80.70	92.56	1.00	2.93	4.33	8.83	12.18
55	VRT-01 × VRT-30	14.66	29.81	42.59	62.17	77.20	92.59	1.00	2.67	4.27	8.40	12.10
56	Tolev-32 × Kashi Chaya	14.23	30.11	42.98	60.23	75.61	92.28	0.00	3.23	4.43	7.50	11.50
57	Tolev-32 × Vaibhav	14.67	29.66	42.76	62.98	84.42	93.92	0.00	3.20	4.43	9.43	12.17
58	Tolev-32 ×Kashi Aman	14.89	32.98	42.95	59.69	82.73	92.78	0.00	2.53	4.43	9.57	12.11
59	Tolev-32 ×VRT-50	14.57	31.11	42.67	60.85	81.81	93.88	0.33	3.03	4.43	9.17	12.38
60	Tolev-32 ×VRT-30	15.02	29.53	42.49	62.21	78.76	94.29	0.33	2.47	4.33	8.37	12.13
	Mean F1	**13.58**	**30.80**	**43.97**	**59.32**	**81.28**	**92.65**	**0.78**	**2.83**	**4.60**	**8.53**	**11.94**
	Min	11.03	24.32	38.62	49.55	75.14	89.22	0.00	2.13	3.20	6.57	10.22
	Max	16.42	35.70	50.00	65.63	88.73	98.11	1.07	3.63	6.07	9.67	13.25
	SE(d) ±	0.15	0.50	0.48	0.50	0.61	0.52	0.29	0.16	0.09	0.18	0.09
	C.D. at 5%	0.29	1.00	0.95	0.99	1.20	1.03	0.57	0.32	0.18	0.36	0.18
	C.V. (%)	1.35	1.96	1.33	1.03	0.92	0.69	47.26	7.32	2.34	2.62	0.92

Table 2. Mean performance of F1-hybrids

S.No	Parents	Lycopene content
	Line	
1	H-88-78-5	11.21
2	H-88-78-4	10.56
3	VRT-67	11.31
4	TOLcV-15	10.34
5	VRT-16-1	10.30
6	VRT-06	10.38
7	VRT-19	10.18
8	H-88-78-1	11.27
9	VRT-51	10.10
10	TOLcV-28	10.17
11	VRT-50	9.48
12	TOLcV-32	9.88
	Tester	
1	KASHI CHAYA	10.51
2	VAIBHAV	10.21
3	KASHI AMAN	9.93
4	VRT-50	9.94
5	VRT-30	9.36
	Mean	10.30
	Min	9.36
	Max	11.31

Table 2a. Mean performance of parents

S.No	Parents	Lycopene content
1	H-88-78-5 X KASHI CHAYA	11.24
2	H-88-78-5 X VAIBHAV	11.19
3	H-88-78-5 X KASHI AMAN	11.20
4	H-88-78-5 X VRT-50	11.19
5	H-88-78-5 X VRT-30	11.19
6	H-88-78-4 X KASHI CHAYA	10.49
7	H-88-78-4 X VAIBHAV	10.53
8	H-88-78-4 X KASHI AMAN	10.54
9	H-88-78-4 X VRT-50	10.54
10	H-88-78-4 X VRT-30	10.53
11	VRT-67 X KASHI CHAYA	11.33
12	VRT-67 X VAIBHAV	11.28
13	VRT-67 KASHI AMAN	11.28
14	VRT-67 X VRT-50	11.34
15	VRT-67 X VRT-30	11.26
16	TOLeV-16 X KASHI CHAYA	10.30
17	TOLeV-16 X VAIBHAV	10.30
18	TOLeV-16 X KASHI AMAN	10.28
19	TOLeV-16 X VRT-50	12.22
20	TOLeV-16 X VRT-30	10.27
21	VRT-16-1 X KASHI CHAYA	10.28
22	VRT-16-1 X VAIBHAV	10.21
23	VRT-16-1 X KASHI AMAN	10.23
24	VRT-16-1 X VRT-50	12.41
25	VRT-16-1 X VRT-30	10.23

S.No	Parents	Lycopene content
26	VRT-06 X KASHI CHAYA	10.36
27	VRT-06 X VAIBHAV	10.33
28	VRT-06 X KASHI AMAN	10.31
29	VRT-06 X VRT-50	12.30
30	VRT-06 VRT-30	10.31
31	VRT-19 X KASHI CHAYA	10.22
32	VRT-19 X VAIBHAV	10.18
33	VRT-19 X KASHI AMAN	10.19
34	VRT-19 X VRT-50	12.41
35	VRT-19 VRT-30	10.17
36	H-88-78-1 X KASHI CHAYA	11.28
37	H-88-78-1 X VAIBHAV	11.23
38	H-88-78-1 X KASHI AMAN	11.26
39	H-88-78-1 X VRT-50	12.53
40	H-88-78-1 X VRT-30	11.24
41	VRT-51 X KASHI CHAYA	10.13
42	VRT-51 X VAIBHAV	10.13
43	VRT-51 X KASHI AMAN	10.14
44	VRT-51 X VRT-50	12.56
45	VRT-51 X VRT-30	10.07
46	TOLeV-28 X KASHI CHAYA	10.18
47	TOLeV-28 X VAIBHAV	10.18
48	TOLeV-28 X KASHI AMAN	10.14
49	TOLeV-28 X VRT-50	10.14
50	TOLeV-28 X VRT-30	10.14
51	VRT-50 X KASHI CHAYA	9.50
52	VRT-01 X VAIBHAV	9.50
53	VRT-01 X KASHI AMAN	9.50
54	VRT-01 X VRT-50	9.47
55	VART-01 X VRT-30	9.47
56	TOLeV-32 X KASHI CHAYA	9.70
57	TOLeV-32 X VAIBHAV	9.73
58	TOLeV-32 X KASHI AMAN	9.74
59	TOLeV-32 X VRT-50	9.77
60	TOLeV-32 X VRT-30	9.66
	Mean F1	92.65
	Min	89.22
	Max	98.11
	Mean All	92.55
	Min	88.71
	Max	98.11
	SE(d) ±	0.52
	C.D. at 5%	1.03
	C.V. (%)	0.69

Number of fruit per cluster: The analysis of the Table 1 demonstrates significant variability among different genotypes in terms of the number of fruit per cluster at 30,45,60,75 and 90 days. At 30 days after transplantation the number of fruit per cluster for 12 lines was recorded maximum under (1.00) under H-88-78-5 and minimum under (0.33) under VRT-51. However, for tester maximum exhibited under (1.00) under Kashi Chaya and minimum number of fruit per cluster recorded (0.33) under the genotype Vaibhav. At 45 days after transplantation the number of fruit per cluster for 12 lines was recorded maximum under

(3.10) under H-88-78-5 and minimum under (1.93) under VRT-50. However, for tester maximum exhibited under (2.37) under Kashi Chaya and minimum number of fruit per cluster recorded (2.03) under Vaibhav as mentioned by Peixoto et al. [2] and Sundaram et al. [5].

Similarly, the mean performance for their F1 hybrids after the crosses were transplanted the data revealed significant variability among different genotypes in terms of the number of fruit per cluster at 30,45,60,75 and 90 days. At 30 days the number of fruit per cluster recorded (1.07) under the genotype H-88-78-5 × VRT-30 which was *at par* under (1.07) the genotype VRT- 16-1 ×VRT-30 and minimum number of fruit per cluster recorded (0.33) under the genotype VRT-51 ×Kashi Chaya.At 45 days the number of fruit per cluster recorded (3.63) under the genotype H-88-78-4 × Kashi Aman followed by (3.60) which was *at par* under the genotype H-88-78-4× Kashi Chaya and TOLeV-28 × Kashi Chaya and minimum number of fruit per cluster recorded (2.13) under the genotype VRT-19 × VRT-50. At 60 days the number of fruit per cluster was recorded maximum under (6.07) H-88-78-5 × Kashi Chaya followed by (5.87 and 5.83) H-88- 78-4 × Kashi Amanand H-88-78-5 × Vaibhav. However, minimum was observed under (3.2) under H-88-78-1 ×VRT-50. as stated by Farwah et al. [15] and Gascuel et al. [16].

At 75 days after transplantation the number of fruit per cluster in F1 hybrids Line was recorded (9.67) under Tolev-16 × Kashi Amanwhich was *at par* with (9.63) under VRT-51 × VRT-30 and VRT-01 ×Kashi Aman. 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 asper the findings of Atugwu et al. [10] and Avdikos et al. [11]. Finally at 90 days after transplantation the number of fruit per cluster in F1 hybrids Line was recorded (13.25) under Tolev-16 × Kashi Amanwhich was *at par* with (13.15) and (13.02) under Tolev-16 ×Kashi Chaya and VRT-16-1×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 as per the findings of Atugwu et al. [10] and Avdikos et al. [11].

Lycopene content: The mean performance for lycopene content was recorded for 12 lines and 5 testers. Lycopene content was recorded maximum (11.31, 11.27, 11.21,) under the line VRT-67, followed by H-88-78-1 and H-88-78-5. However the lycopene content was observed minimum (9.48) under VRT-50 [17-19]. However, for tester maximum lycopene content exhibited (10.51) under Kashi Chaya and minimum lycopene content recorded (9.36) under the genotype VRT-30. Similarly, the mean performance for their F1 hybrids after the crosses were transplanted the data revealed significant variability among different genotypes in terms of the lycopene content was maximum under (12.56) VRT-51×VRT-50 followed by (12.53) H-88-78-1 ×VRT-50 and (12.41) under VRT-16-1×VRT-50. However, minimum lycopene content was observed (9.47) under VRT-01 ×VRT-50. It may be well noted that for lycopene content these treatments were superior due to interaction components which was highly significant in terms of lycopene content as per the findings of Narasimhamurthy et al. [20] and Singh et al. [21].

4. CONCLUSION

Between all the various lines used in the current study. It was discovered that an excellent general combiner for maximal characters was the (H-88- 78-5), tester (Kashi Aman) with (H-88-78-1x Kashi Chaya). The results gained can be used to determine the best parents and crossings for a certain feature that can be improved upon and used even more in tomato breeding programmes.

5. FUTURE SCOPE

Consequently, this study's use of a range of tomato genotypes allows for the identification of the most suitable inbred lines to be used in future breeding programmes. The results of crossing demonstrated that some parents were a good general match for many character, indicating that depending on specific qualities taken into account, some parents will need to be chosen for genetic enhancement. Since tomatoes are a highly consumed produce, experts are concentrating on developing superior hybrids with desired parent combinations through crop improvement programmes. Furthermore, hybrids that produce larger yields help farmers meet the market's ongoing demands.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Authors declare 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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