EVALUATION OF F_1 HYBRIDS IN TOMATO
(*Solanum lycopersicum* L.)

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EVALUATION OF F_1 HYBRIDS IN TOMATO (*Solanum lycopersicum* L.)

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By

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CERTIFICATE

This is to certify that the thesis entitled "**EVALUATION OF F_1 HYBRIDS IN TOMATO (*Solanum lycopersicum* L.)**" submitted by **SANTOSHKUMAR HEGADE** for the degree of **MASTER OF SCIENCE (HORTICULTURE)** in **VEGETABLE SCIENCE** to the University of Horticultural Sciences, Bagalkot is a record of research work carried out by him during the period of his study in this University, under my guidance and supervision, and the thesis has not previously formed the basis of the award of any degree, diploma, associateship, fellowship or other similar titles.

Place : ARABHAVI
Date : SEPTEMBER, 2017

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AFFECTIONATELY

DEDICATED TO

MY BELOVED PARENTS,
BROTHERS, SISTERS,

TEACHERS AND HOD

CONTENTS

LIST OF ABBREVIATIONS

σ^2	:	Variance
$\sigma^2 g$	:	Variance due to general combinig ability
$\sigma^2 s$	:	Variance due to specific combinig ability
ANOVA	:	Analysis of variance
BP	:	Heterobeltiosis /Better parent heterosis
BTP	:	Best parent heterosis
CC	:	Heterosis over commercial check
CD at 0.01	:	Critical Difference at 1 per cent level of significance
CD at 0.05	:	Critical Difference at 5 per cent level of significance
cm	:	Centimeter
DAT	:	Days after transplanting
df	:	Degrees of freedom
et al.	:	Co-workers
g	:	Grams
kg	:	Kilograms
m	:	Million
M	:	Metric
t	:	Tonnes
gca	:	General Combining Ability (effect)
GCA	:	General Combining Ability (variance)
mg	:	Milligram
MS	:	Mean Squares
q	:	Quintol
RBD	:	Randomized Block Design
sca	:	Specific Combining Ability (effect)
SCA	:	Specific Combining Ability (variance)
SE (d)	:	Standard error of difference
UHSB	:	University of Horticultural Sciences
viz.,	:	Namely

LIST OF TABLES

Contd……

LIST OF PLATES

LIST OF APPENDICES

1. INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is a popular vegetable crop grown throughout the world due to its wider adaptability. It belongs to family solanaceae having chromosome number 2n = 24. Though the centre of origin is Peru ecuador region, it was introduced to India in early 16th century by eastern countries. In the middle of ninetyôs on introduction of high yielding exotic cultivars like Roma, Sioux and Marglobe, the tomato cultivation was boosted up. The three main breeding institutes responsible for development of such high yielding tomato cultivars are namely Indian Agricultural Research Institute, New Delhi (Pusa cultivars), Punjab Agricultural University, Ludhiana (Punjab cultivars) in north India and Indian Institute of Horticultural Research, Bangalore (Arka cultivars) in south India.

It is considered as óprotective foodô due to its nutritive value, antioxidant molecules like carotenoids (ascorbic acid, lycopene, vitamin E and phenol compounds, particularly flavonoids) (Septa *et al.*, 2013). It is also considered as ópoor manôs orangeô because of its nutritive value and attractive appearance (Singh *et al.*, 2004). Lycopene is having beneficial effects on human health. Lycopene reduces the risk of heart attacks and many types of cancer (Dorgan *et al.*, 1998) ; (Clinton, 2005).

Tomato is an annual and short lived perennial, herbaceous, typical day neutral and self pollinated plant but certain percentage of cross pollination also occurs (0.5 to 4 %). Crop is a warm season one, resistant to heat and drought and it grows under wide range of soil and climate. Since mid-nineteenth century cultivation of tomato has become popular. So far many breeders of vegetable from both private and public sector have contributed for considerable improvement in quality and yield characters.

Tomatoes are being used in salads, sandwiches and processed products such as paste, soup, puree, juice, sauce, ketchup, drinks and canned fruit (Bose *et al.*, 2002). The fruits mainly consumed as raw or used for preparation of chatni, sambar and pickles *etc.*

In India tomato ranks second among vegetables in production (18.39 m.M.t) after potato (43.77 m.M.t) with 11.20% share and third in area of 0.76 m ha. It accounts for an average productivity of 16.10 M.t/Ha (NHB 2016). Karnataka is the second leading tomato producing state after Andhra Pradesh, and second highest in area in the country (NHB, 2016).

Heterosis and combining ability estimation in tomato crop started after the discovery of heterosis (Shull, 1908). Combining ability studies are more reliable as they provide useful information for the selection of parents in terms of performance of the hybrids and elucidate the nature and magnitude of various types of gene actions involved in the expression of quantitative traits (Khoja and Ahmad, 2008).

Though, tomato is a self-pollinated crop, it has tremendous potential for heterosis breeding. The commercial exploitation of hybrid vigour in tomato received greater importance on account of several advantages of hybrids over pure line varieties with response to marketable fruit yield and its component traits as well as resistance to biotic and abiotic stresses. F_1 hybrids in tomato having several advantages like earliness, uniformity and provide a convenient and quick way of combining desirable characters. Here has been increasing interest for the production of hybrids with as high as 100 per cent increase in tomato yield has been achieved because of manifestation of hybrid vigour. Keeping this background in view, the investigation was aimed with following objectives.

1. To evaluate the F_1 hybrids for yield and quality characters along with to assess the magnitude and direction of heterosis for growth, earliness and quality parameters.

2. To identify good general combiners among the lines for growth, earliness, yield and quality parameters.

3. To identify good specific combiners among lines for growth, earliness, yield and quality parameters.

2. REVIEW OF LITERATURE

Tomato (*Solanum lycopersicum* L.) is one of the most important solanaceous vegetable grown worldwide under open and protected conditions. The genetic improvement of both quantitative and qualitative characters is the main interest of plant breeders. The information on genetics of various quantitative traits particularly of those that contribute to yield and quality would be most useful in planning the breeding programmes, so as to make effective selections. The purpose of this selection is to give comprehensive up-to-date information to the various aspects of genetic improvement by hybridization and at the same time elucidate the nature and magnitude of different type of gene action involved.

The information available in the literature pertaining to tomato germplasm for yield and quality traits have been reviewed here under the following sub heads:

2.1 Heterosis

2.2 Combining ability

2.1 Heterosis

Heterosis is defined as general biological phenomenon deserved in F_1 generation which manifests itself by greater variability, rapid growth and development, higher productivity, resistance, adoption and uniform maturity, which are combined by a number of other valuable economic characters in the quickest possible time. Shull (1908) referred to this phenomenon as the stimulus of heterozygosis. The expression of heterosis may be due to factors such as heterozygosity, allelic interaction such as dominance or over dominance, non-allelic interaction or epistasis and maternal interactions. The degree of heterosis depends on the number of heterozygous alleles. The higher the number of heterozygous alleles, more is the heterosis expected (East and Hayes, 1912). The term heterobeltiosis has been coined by Fonseka and Patterson (1968), which refers to increase or decreased vigour of F_1 over its better parent. A comprehensive characterwise review of literature on heterosis is mentioned in Table 1.

Table 1. Review of literature on extent of heterosis over better parent, the best parent and commercial check for different traits in tomato

Sl. No.	Characters	Hybrids studied	Range of per cent heterosis over			References
			Heterosis over better parent (%)	Heterosis over best parent (%)	Standard Heterosis (%)	
1	Plant height	15	-	53.73 to 36.33	-	Bhutani *et al*. (1973)
		28	-	1.90 to 41.10	-	Singh *et al*. (1976)
		20	2.86 to 83.19	0.42 to 45.37	-	Mishra and Khanna (1977)
		30	-	12.10 to 26.40	-	Singh *et al*. (1978)
		16	-	-	-23.29 to 2.23	Peter and Rai (1978)
		21	Up to 50.16	Up to 26.34	-	Sidhu *et al*. (1981)
		44	Up to 82.00	-	-	Govindarasu *et al*. (1982)
		5	6.5 to 16.56	4.5 to 12.80	-	Ramamohan (1988)
		45	-2.775 to 8.87	5.27 to 5.63	-	Kanthaswamy and Balakrishnan (1989)
		28	-	-	-22.27 to 23.92	Dundi (1991)
		36	-	7.40 to 40.10	-	Dod and Kale (1992)
		16	37.5 to 5.1	-	-	Singh and Singh (1993)
		50	-65.52 to 81.27	-50.98 to 60.45	-58.82 to 148.64	Dharmatti (1995)
		36	-	4.65 to 13.06	-	Dod *et al*. (1995)
		6	-8.37 to 24.05	-25.53 to 14.28	-	Nagaraja (1995)
		45	-63.41 to -5.26	-	-	Raijadhav *et al*. (1996)
		28	-	-10.00 to 59.00	Negative	Patil (1996)
		36	39.70 to 42.99	12.74 to 13.94	-	Ghosh *et al*. (1997)

Contd.....

Table 1 contd….

Sl. No.	Characters	Hybrids studied	Range of per cent heterosis over			References
			Heterosis over better parent (%)	Heterosis over best parent (%)	Standard Heterosis (%)	
1	Plant height	28	-6.22 to 6.51	-	3.10 to 15.30	Patil (1998)
		16	-53.33 to 29.41	-	-23.61 to 75.00	Lakshmi (1997)
		45	159.1 to 190.7	-53.73 to 36.33	-	Srivastava *et al*. (1998)
		15	-23.80 to 6.81	-	-14.44 to 29.46	Kulkarni (1999)
		91	0.53 to 123.40	-	-	Bhatt *et al*. (1999)
		36	-10.98 to 37.18	-	-	Baishya *et al*. (2001)
		24	-40.94 to -2.36	-	-36.31 to 4.64	Sharma *et al*. (2001)
		41	-	14.29 to 27.73	52.81 to 70.79	Fageria *et al*. (2001)
		36	-23.80 to 6.81	-	-14.44 to 26.46	Sajjan (2002)
		15	-19.36 to 49.21	-	23.04 to 58.00	*Padma et al. (2002)*
		36	-	15.71 to 129.67	-	Joshi and Thakur (2003)
		50	-18.94 to 20.45	-20.98 to 17.57	48.89 to 0.07	Kulkarni (2003)
		45	-21.54 to 55.05	-27.93 to 34.62	-10.94 to 72.95	Prashanth (2004)
		9	-32.7 to 47.6	-45.9 to 37.5	-45.6 to 38.7	Tiwari and Lal (2004)
		45	-	-24.22 to-25.76	6.22 to 55.70	Mahendrakar (2004)
		40	31.46 to 69.13	-45.30 to 62.38	-	Ashwini (2005)
		30	-33822 to 20.16	-43.98 to 14.43	-	Premalakshmi *et al.* (2006)
		45	-	37.28	-	Asati *et al*. (2007)
		45	-	2.28 to 74.91	-	Singh *et al.* (2007)
		24	-	-34.44 to 43.67	-55.32 to 26.19	Sharma and Thakur (2008)
		49	-	117.29	-	Singh *et al.* (2008)

Contd…..

Table 1 contd….

Sl. No.	Characters	Hybrids studied	Range of per cent heterosis over			References
			Heterosis over better parent (%)	Heterosis over best parent (%)	Standard Heterosis (%)	
1	Plant height	36	-22.52 to 44.19	-35.99 to 26.02	-40.99 to 4.73	Yashavantakumar (2008)
		45	-43.48 to 30.76	-	-	Sekhar *et al.* (2010)
		45	-17.83 to 31.08	-	-17.83 to 16.36	Kumari and Sharma (2011)
		15	-8.57	Negetive	-	Premalakshmi (2010)
		39	Up to 70.06	-	-	Singh and Asati (2011)
		14	-0.70 to 70.16	-	-	Ahmad *et al.* (2011)
		19	ï 7.51 to 75.54	-	-	Islam *et al.* (2012)
		49	-12.79 to 68.58	-0.29 to 17.29	-	Singh *et al.* (2012)
		30	-47.6 to 45.94	-	-42.77 to 55.50	Sunil *et al.* (2013)
		72	-4.88 to 8.83	-	-	Akram *et al.* (2012)
		30	-47.60 to 45.94	-	-	Yadav and Venkat (2013)
		21	-2.82 to 24.72	-	-	Marbhal *et al.* (2016)
2	Number of branches per plant	16	-	-	55.84 to 93.89	Peter and Rai (1978)
		21	Negative	Positive	55.84 to 93.49	Sidhu *et al.* (1981)
		15	Positive	Positive	-	Patil (1984)
		45	-	-8.77 to 31.58	-	Kumar *et al.* (1988)
		5	24.80 to 72.50	-6.70 to 15.67	-	Ramamohan (1988)
		19	17.824 to 60.367	16.06 to 57.237	-	Kanthaswamy and Balakrishnan (1989)
		28	-	-	-32.77 to 71.11	Dundi (1991)
		16	-12.66 to 12.26	-	-	Singh and Singh (1993)

Contd…..

Table 1 contd….

Sl. No.	Characters	Hybrids studied	Range of per cent heterosis over			References
			Heterosis over better parent (%)	**Heterosis over best parent (%)**	**Standard Heterosis (%)**	
2	Number of branches per plant	36	-	-3.22 to 6.47	-	Dod *et al*. (1995)
		50	-78.84 to 83.23	-79.88 to 62.16	-76.07 to 231.29	Dharmatti (1995)
		36	43.26 to 45.67	22.54 to 28.74	-	Ghosh *et al*. (1997)
		28	-	-33.33 to 54.5	15.00 to 60.00	Patil (1996)
		28	-2.99 to 46.02	-	-32.26 to 90.65	Patil (1998)
		45	66.57 to 122.16	-	-	Srivastava *et al.* (1998)
		15	28.95 to 20.12	-	-17.81 to 38.36	Kulkarni (1999)
		36	-18.88 to 21.82	-25.35 to 1.01	-21.30 to 8.26	Sajjan (2002)
		50	-53.85 to 34.02	-57.4 to 30.49	-52.61 to 33.18	Kulkarni (2003)
		9	25.6 to 50.8	-18.90 to 38.90	36.2 to 59.6	Tiwari and Lal (2004)
		45	-	-14.35 to 18.66	-9.92 to 23.35	Mahendrakar (2004)
		30	-	-19.27 to 35.21	-18.86 to 23.13	Duhan *et al*. (2005)
		45	-	48.93	-	Asati *et al*. (2007)
		49	-	155.8	-	Singh *et al*.(2008)
		36	-38.07 to 55.52	-42.15 to 39.46	-65.10 to 15.86	Yashavantakumar (2008)
		45	-34.69 to 22.47	-	-	Sekar *et al*. (2010)
		45	13.90	1.34	-	Premalakshmi (2010)
		45	-17.83 to 31.08	-	-17.83 to 16.36	Kumari and Sharma (2011)
		39	Up to 43.84	-	-	Singh and Asati (2011)
		49	-3.97 to 29.47	-64.23 to 59.78	-	Singh *et al.* (2012)
		30	-59.33 to 25.22	-	-55.56 to 36.81	Sunil *et al.* (2013)

Contd…..

Table 1 contd….

Sl. No.	Characters	Hybrids studied	Range of per cent heterosis over			References
			Heterosis over better parent (%)	Heterosis over best parent (%)	Standard Heterosis (%)	
3	Days to flower initiation	45	-42.85 to 9.22	-33.33 to 16.66	16.66 to 103.29	Tendulkar (1994)
		48	-14.76 to 15.66	-	-	Rajadhav *et al.* (1996)
		16	-33.60 to -3.89	-	-29.50 to -3.82	Lakshmi (1997)
		21	-16.44 to 26.67	-	-	Rai *et al.* (1998)
		45	Up to -17.58	-	-	Srivastava *et al.* (1998)
		36	-17.79 to 2.82	-	-	Baishaya *et al.*(2001)
		36	-16.36 to 11.76	-	-	Joshi and Thakur (2003)
		45	Up to 47.69	Up to -35.98	Up to -54.71	Mahendrakar (2004)
		30	Up to -8.57	-	-	Premalakshami *et al.* (2006)
		15	-8.87	Negetive	-	Premalakshmi (2010)
		45	-8.41 to 10.87	-	-1.00 to 15.15	Kumari and Sharma (2011)
		45	-6.50 to 16.31	-	-3.03 to 15.50	Santosh and Manish (2011)
		49	Up to 63.44	-	-	Singh *et al.* (2012)
		72	-26.7 to 15.50	-	-	Akram *et al.* (2013)
		21	-	-15.45 to -1.67	-	Marbhal *et al.* (2016)
4	Days to 50 per cent flowering	28	-44.53 to 8.74	-34.89 to 17.36	-	Pujari and Kale (1994)
		45	-33.56 to 18.29	-28.46 to 21.26	0.00-67.25	Tendulkar (1994)
		28	-	2.43 to 22.2	-	Patil (1996)
		28	-10.25 to 8.98	-	-22.93 to 12.10	Patil (1998)
		15	-5.08 to 12.62	-	-11.22 to 5.10	Padma *et al.* (2002)
		50	-13.38 to 9.89	-13.10 to 20.64	-14.28 to 3.41	Kulkarni (2003)

Contd…..

Table 1 contd….

Sl. No.	Characters	Hybrids studied	Range of per cent heterosis over			References
			Heterosis over better parent (%)	Heterosis over best parent (%)	Standard Heterosis (%)	
4	Days to 50 per cent flowering	45	-	-24.36 to 25.76	-30.56 to 3.52	Mahendrakar (2004)
		30	-	-7.63 to 12.71	-3.27 to 10.60	Duhan *et al*. (2005)
		49	-	-4.13	-	Singh *et al*.(2008)
		45	-17.43 to 17.56	-	-	Kumari and Sharma (2011)
		15	Up to -34.55	-	Up to 34.55	Kumar *et al*. (2013)
		21	-15.45 to -1.67	-10.67 to 18.61		Marbhal *et al.* (2016)
5	Days to first fruit harvest for earliness	18	-11.42 to 12.50	-	-	Viredelwala *et al*. (1987)
		45	-20.27 to 15.50	-9.96 to 20.93	8.16 to 45.28	Tendulkar (1994)
		90	High	-	-	Uppal *et al*. (1997)
		45	Up to -9.61	-	-	Srivastava *et al*. (1998)
		91	-14.73 to -0.39	-	-	Bhatt *et al*. (1999)
		36	-9.15 to 27.67	-	-	Baishya *et al*. (2001)
		24	-11.20 to -2.90	-	-11.39 to -0.40	Sharma *et al*. (2001)
		45	18.97	-	14.52	Mahendrakar (2004)
		15	5.59 to 21.37	-	-	Alice *et al*. (2011)
		15	-8.88 to 8.92	-6.99 to 9.33	-8.87 to 6.07	Hannan *et al*. (2007)
		19	-	ï 13.95 to 4.90	-	Islam *et al.* (2012)
		49	-11.52 to 14.59	-0.29 to 17.29	-	Singh *et al.* (2012)
		66	-35.22 to 115.3	-41.27 to 112.2	-	Saeed *et al*.(2014)

Contd…..

Table 1 contd….

Sl. No.	Characters	Hybrids studied	Range of per cent heterosis over			References
			Heterosis over better parent (%)	Heterosis over best parent (%)	Standard Heterosis (%)	
6	Average fruit weight	45	-	0.67 to 36.59	-	Dixit *et al.* (1980)
		21	-	67.28 to 88.39	-	Anbu *et al*. (1981)
		28	-35.40 to 65.30	-	-	Rajput (1987)
		50	-	Positive	-	Ahmed *et al*. (1988)
		45	-	-	11.20 to 28.30	Kumar *et al.* (1988)
		5	31.50	31.50	-	Ramamohan (1988)
		36	-	-29.11 to 25.70	-	Yadav *et al*. (1989)
		21	-37.63 to 55.40	-49.62 to 38.53	-72.40 to 114.95	Dundi (1991)
		28	-	-30.47 to 76.45	-	Pujari and Kale (1994)
		78	-8.07 to 38.98	-7.18 to 29.28	-	Reddy and Reddy (1994)
		45	-36.21 to 22.95	-51.13 to 8.71	-52.58 to 62.23	Tendulkar (1994)
		50	-100 to 106.14	-100 to 106.16	-100 to 258.29	Dharmatti (1995)
		40	-	13.13 to 24.91	-	Dod *et al*. (1995)
		36	-46.38 to 93.89	-96.88 to 72.45	-	Nagaraja (1995)
		45	-70.93 to 37.74	-	-	Raijadhav *et al*. (1996)
		16	-46.88 to 27.39	-	-33.33 to 133.33	Lakshmi (1997)
		36	43.07 to 57.99	10.28 to 21.05	-	Ghosh *et al*. (1997)
		28	-34.09 to 10.00	-	-4.49-78.83	Patil (1998)
		15	-15.95 to 28.22	-	18.08 to 60.71	Kulkarni (1999)
		40	-64.90 to 66.50	-	-	Mageswari and Natarajan (1999)

Contd…..

Table 1 contd….

Sl. No.	Characters	Hybrids studied	Range of per cent heterosis over			References
			Heterosis over better parent (%)	Heterosis over best parent (%)	Standard Heterosis (%)	
6	Average fruit weight	24	-103.83 to 205.17	-80.59 to 80.63	-	Sharma *et al.* (2001)
		45	-	-26.79 to 7.33	9.43 to 35.85	Fageria *et al.* (2001)
		45	-70.83 to 53.65	-76.29 to 42.40	-73.55 to 19.21	Sajjan (2002)
		36	-11.93 to 120.00	-36.36 to 96.88	-	Baishya *et al.* (2001)
		15	-36.84 to 21.68	-	-58.14 to 23.73	Padma *et al*. (2002)
		36	-31.16 to 41.13	-	-	Joshi and Thakur (2003)
		50	-45.73 to 57.59	-59.49 to 44.07	-59.52 to 71.23	Kulkarni (2003)
		28	Up to 3.82	-	-	Patagaonkar *et al*. (2003)
		45	-	-71.78 to 24.14	-64.55 to 70.95	Mahendrakar (2004)
		45	-42.54 to 52.92	-45.97 to 29.66	-51.80 to 55.37	Prashanth (2004)
		40	-38.95 to 90.69	-	-	Ashwini (2005)
		30	-	-44.05 to 73.64	-2.37 to 98.81	Duhan *et al.* (2005)
		30	-61.49 to 45.01	-62.50 to 40.31	-	Premalakshmi *et al.* (2006)
		45	-	42.87	-	Asati *et al.* (2007)
		24	-	-21.60 to 23.52	-33.57 to 10.22	Sharma and Thakur (2008)
		49	-	2.04 to 40.00	-	Singh *et al.* (2008)
		36	-30.50 to 30.50	-37.76 to 30.05	-28.71 to 32.84	Yashavantakumar (2008)
		45	45	-54.89 to 12.23	-	Sekar *et al.* (2010)
		45	-29.85 to 14.82	-	-41.66 to 0.91	Kumari and Sharma (2011)
		15	40.31	-	-	Premalakshmi (2010)
		39	63.14	-	-	Singh and Asati (2011)

Contd…..

Table 1 contd….

Sl. No.	Characters	Hybrids studied	Range of per cent heterosis over			References
			Heterosis over better parent (%)	Heterosis over best parent (%)	Standard Heterosis (%)	
6	Average fruit weight	15	-60.06 to 15.98	-	-	Alice *et al.* (2011)
		14	-4.76 to 16.67.	-	-	Ahmad *et al.* (2011)
		81	-10.67 to 14.92	-	-	Akram *et al.* (2012)
		19	-	ï 42.84 to 21.21	-	Islam *et al.* (2012)
		49	-52.07 to 98.70	-25.67 to 69.81	-	Singh *et al.* (2012)
		30	-61.37 to 26.58	-	60.21 to 29.51	Sunil *et al.* (2013)
		30	-	-61.35 to 26.58	-	Yadav and Venkat (2013)
		21	-	-6.04 to 69.01	-	Marbhal *et al.* (2016)
		15	-	-15.07 to 10.35	-	Aisyah *et al.* (2016)
		10	-	--9.03 to 67.33		Kumar and Ramanjinigowda (2016)
7	Number of fruits per plant	45	-	0.79 to 38.75	-	Dixit *et al.* (1980)
		21	Up to 61.14	Up to 28.85	-	Sidhu *et al*. (1981)
		18	-35.93 to 82.64	-	-	Viredelwala *et al*. (1987)
		44	Up to 81.80	Up to 54.00	-	Govindarasu *et al*. (1982)
		84	-	-45.92 to 81.28	-	Jamwal *et al.* (1984)
		30	-	Positive	-	Ahmed *et al.* (1988)
		36	-	-23.31 to 48.68	-	Yadav *et al.* (1989)
		45	20.65 to 98.93	-25.69 to 13.25	-	Kanthaswamy and Balakrishnan (1989)
		28	-	-	23.93 to 207.9	Dundi (1991)

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Table 1 contd….

Sl. No.	Characters	Hybrids studied	Range of per cent heterosis over			References
			Heterosis over better parent (%)	**Heterosis over best parent (%)**	**Standard Heterosis (%)**	
7	Number of fruits per plant	16	-7.58 to 24.44	-	-	Singh and Singh (1993)
		28	-	-47.61 to 58.00	-	Pujari and Kale (1994)
		45	-17.38 to 114.2	34.10 to 96.89	-47.87 to 114	Tendulkar (1994)
		50	-100 to 142.62	-100 to 94.74	-100 to 1133.50	Dharmatti (1995)
		36	-	10.78 to 46.51	-	Dod *et al.* (1995)
		21	Up to 193.55	Up to 35.66	Up to 36.62	Kumar *et al*. (1995)
		6	-40.51 to -0.83	-	-	Nagaraja (1995)
		21	-	3.8 to 132.1	-50.7 to 35.9	Sureshkmar *et al.* (1995)
		36	47.15 to 55.96	30.94 to 53.51	-	Ghosh *et al*. (1997)
		16	-85.00 to 19.15	-	-70.00 to 180.00	Lakshmi (1997)
		28	-	-	-40.59 to 33.75	Patil (1998)
		21	25.00 to 79.66	-	-	Rai *et al*. (1998)
		45	Up to 74.15	-	-	Srivastava *et al*. (1998)
		91	1.74 to 132.98	-	-	Bhatt *et al*. (1999)
		15	-50.41 to 1.29	-	-46.11 to 10.07	Kulkarni (1999)
		36	-60.00 to 122.00	-	-	Baishya *et al*. (2001)
		28	-4.27 to 137.82	-16.93 to 87.32	24.65 to 50.26	Sajjan (2002)
		15	-53.79 to 14.86	-	-21.17 to 94.11	Padma *et al*. (2002)
		36	-	-27.69 to 49.37	-	Joshi and Thakur (2003)
		50	-27.78 to 181.52	-40.50 to 123.39	-40.41 to 181.51	Kulkarni (2003)
		45	-	-24.17 to 52.28	-17.07 to 60.06	Mahendrakar (2004)

Contd…..

Table 1 contd….

Sl. No.	Characters	Hybrids studied	Range of per cent heterosis over			References
			Heterosis over better parent (%)	Heterosis over best parent (%)	Standard Heterosis (%)	
7	Number of fruits per plant	45	42.52 to 52.92	-45.97 to 29.66	-59.64	Prashanth (2004)
		9	5.90 to 248.9	25.90 to 153.8	15.90 to 137.5	Tiwari and Lal (2004)
		40	-65.64 to 353.91	-79.27 to 29.21	300.00	Ashwini (2005)
			-	-56.81 to 77.90	-42.64 to 69.50	Duhan *et al.* (2005)
		20	-	-	-	Sharma *et al*. (2006)
		30	15.52 to 213.52	6.96 to 210.70	-	Premalakshmi *et al.* (2006)
		45	-	38.96	-	Asati *et al.* (2007)
		49	-	165.43	-	Singh *et al.* (2008)
		36	-18.45 to 232.37	-30.37 to 215.77	-63.11 to 24.41	Yashavantakumar (2008)
		15	210.70	121.48	-	Premalakshmi (2010)
		45	-50.82 to 28.57	-	-	Sekar *et al.* (2010)
		45	-19.22 to 22.64	-28 to 15.31		Kumari and Sharma (2011)
		45	-16.48 to 34.13	-	28.08 to 16.33	Santosh and Manish (2011)
		14	3.76 to 83.88	-	-	Ahmad *et al.* (2011)
		81	-9.2125.03	-	-	Akram *et al*.(2012)
		19	-	ï 43.30 to 67.44	-	Islam *et al.* (2012)
		49	-20.30 to 102.08	-58.37 to 59.69	-	Singh *et al.* (2012)
		30	-67.58 to 40.20	-	-52.50 to 58.50	Sunil *et al.* (2013)
		30	-	-65.78 to 40.20	-	Yadav *et al*. (2013)
		8	-	-14.65 to 24.24	-	Saleem *et al* .(2015)
		15	-	-36.39 to 48.37	-	Aisyah *et al*. (2016)
		10	-	-	-30.3 to 38.62	Kumar and Ramanjinigowda (2016)

Contd…..

Table 1 contd….

Sl. No.	Characters	Hybrids studied	Range of per cent heterosis over			References
			Heterosis over better parent (%)	Heterosis over best parent (%)	Standard Heterosis (%)	
8	Yield per plant	45	0.40 to 60.36	-	-	Dixit *et al.* (1980)
		21	45.50 to 74.15	-	-	Anbu *et al.* (1981)
		30	-54.40 to 31.44	-	-	Jamwal *et al.* (1984)
		28	-12.60 to 84.10	-28.90 to 69.20	-	Rajput (1987)
		5	87.60	14.60	-	Ramamohan (1988)
		45	-24.96 to 29.51	-41.67 to 7.68	-	Kanthaswamy and Balakrishnan (1989)
		36	-	-166.83 to 62.36	-	Yadav *et al*. (1989)
		28	-25.39 to 88.85	27.87 to 72.89	-37.55 to 44.98	Dundi (1991)
		56	39.60 to 14.40	-	-	Singh and Singh (1993)
		28	-	-30.47 to 76.45	-	Pujari and Kale (1994)
		45	-	-	-45.61 to 22.07	Tendulkar (1994)
		36	-	13.97 to 94.66	-	Dod *et al*. (1995)
		50	-100 to 142.62	-	-	Dharmatti (1995)
		6	-85.92 to 38.11	-92.09 to 22.89	-	Nagaraja (1995)
		28	-	-10.14 to 26.65	-30.47 to -17.20	Patil (1996)
		36	47.15 to 55.96	30.94 to 53.51	-	Ghosh *et al*. (1997)
		28	-21.97 to 40.27	-	-30.11 to 47.16	Patil (1998)
		45	45.01 to 138.94	-	-	Srivastava *et al*. (1998)
		45	-	17.28 to 48.21	-23.89 to -4.71	Fageria *et al.* (2001)
		24	-	15.44 to 58.59	-18.49 to 31.21	Sharma *et al.* (2001)

Contd…..

Table 1 contd….

Sl. No.	Characters	Hybrids studied	Range of per cent heterosis over			References
			Heterosis over better parent (%)	**Heterosis over best parent (%)**	**Standard Heterosis (%)**	
8	Yield per plant	45	-57.22 to 172.52	-70.48 to 108.60	-22.04 to 376.27	Sajjan (2002)
		36	-41.85 to 129.67	-80.92 to 113.03	-	Baishya *et al.* (2001)
		15	-40.74 to 93.13	-41.30 to 87.41	-47.06 to 65.36	Kulkarni (2003)
		36	-	-10.22 to 42.49	-	Joshi and Thakur (2003)
		91	0.47 to 120.41	2.92 to 54.17	4.80 to 48.00	Bhatt *et al.* (2004)
		45	-	-46.01 to 91.63	-53.72 to 55.38	Mahendrakar (2004)
		9	65.8 to 402.7	16.6 to 222.6	13.3 to 109.1	Tiwari and Lal (2004)
		40	-78.09 to 682.11	-	55.38	Ashwini (2005)
		30	-	-52.33 to 116.03	-47.90 to 60.13	Duhan *et al.* (2005)
		20	0.06-179.45	-38.99 to 177.84	-	Premalakshmi *et al.* (2006)
		30	-	75.68	-	Asati *et al.* (2007)
		45	-	-29.04 to 40.74	-48.87 to 12.28	Sharma and Thakur (2008)
		45	-	210.45	-	Singh *et al.* (2008)
		36	0.40 to 60.36	-43.67 to 310.91	-69.58 to 42.40	Yashavantakumar (2008)
		30	45.50 to 74.15	-	-	Gul *et al.* (2010)
		45	-54.40 to 31.44	-	-15.90 to 30.97	Santosh and Manish (2011)
		39	Up to 212.12	-	-8.54 to 31.14	Singh and Asati (2011)
		14	0.56 to 62.31	-	-	Ahmad *et al.* (2011)
		49	Up to 45.89	-	-	Singh *et al.*(2012)
		66	Up to 193.30	-	291.11	Gaikwad and Cheema (2012)
		81	-10.00 to 36.82	-	-	Akram *et al.* (2012)

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Table 1 contd….

Sl. No.	Characters	Hybrids studied	Range of per cent heterosis over			References
			Heterosis over better parent (%)	Heterosis over best parent (%)	Standard Heterosis (%)	
8	Yield per plant	19	-	ï 21.74 to 54.82	-	Islam *et al.* (2012)
		49	Up to 45.89	-	-	Brajendra *et al.*(2013)
		30	-68.45 to 34.85	-	-55.52 to 29.57	Sunil *et al.* (2013)
		30	-	-65.45 to 34.82	-	Yadav and Venkat (2013)
		66	-	-15.6 to 33.02	-	Saeed *et al.*(2014)
		8	-	0.03 to 66.26	-	Saleem *et al.*(2015)
		21	-	-10.70 to 46.52	-	Marbhal *et al.* (2016)
		15	-	-495.26 to 482.39	-	Aisyah *et al.* (2016)
		10	-	-	-17.26 to 38.86	Kumar and Ramanjinigowda (2016)
9	Yield per ha	30	-68.45 to 34.82		-55.52 to 29.57	Sunil *et al.* (2013)
10	Number of locules per fruit	16	-	-	Up to 55.10	Peter and Rai (1978)
		21	Up to -21.09	Up to -5.67	-	Sidhu *et al.* (1981)
		28	-27.97 to 133.33	-	-45.50 to 99.82	Dundi (1991)
		156	Up to 34.50	-	-	Reddy and Reddy (1994)
		45	-32.02 to 111.65	1.50 to 163.50	-36.10 to 68.37	Tendulkar (1994)
		50	-100.00 to 87.36	-	-100.00 to 103.50	Dharmatti (1995)
		36	37.88 to 46.59	-	-	Ghosh *et al.* (1997)
		28	-	-	-18.98 to 8.48	Patil (1998)
		45	Up to 141.71	-	-	Srivastava *et al.* (1998)
		15	-44.75 to -17.35	-	-	Kulkarni (1999)

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Table 1 contd….

Sl. No.	Characters	Hybrids studied	Range of per cent heterosis over			References
			Heterosis over better parent (%)	Heterosis over best parent (%)	Standard Heterosis (%)	
10	Number of locules per fruit	74	-	-3.33 to 136.67	-	Chadha *et al*. (2002)
		28	Up to -24.28	-	-	Patagaonkar *et al*. (2003)
		30	-35.62 to 65.00	13.21 to 75.47	-	Premalakshmi *et al*. (2003)
		45	Up to -24.07	-	-15.69	Mahendrakar (2004)
		14	5.41 to 27.5	-	-	Ahmad *et al*. (2011)
		49	-61.43 to 165.03	-46.23 to 109.05	-	Singh *et al.* (2012)
		81	-8.71 to 8.18	-	-	Akram *et al.* (2012)
		19	Positive	-	-	Islam *et al.* (2012)
		66	-35.45 to 82.29	-28.6 to 20.00		Saeed *et al*. (2014)
		15	-21.7 to 53.47	-6.09 to 4.25		Aisyah *et al. (*2016)
11	Total soluble solids	16	-	-	1.44 to 24.22	Peter and Rai (1978)
		21	Up to 1.85	-	-	Sidhu *et al*. (1981)
		20	-	-32.72 to 35.45	-	Patil and Bojappa (1988)
		28	-32.82 to 65.28	-	-7.14 to 126.19	Dundi (1991)
		156	Up to 12.80	-	-	Reddy and Reddy (1994)
		45	-33.94 to 48.04	42.26 to 13.85	-40.17 to 17.38	Tendulkar (1994)
		50	-100.00 to 282.59	-	-100.00 to 68.11	Dharmatti (1995)
		6	-23.68 to -8.85	-	-	Nagaraja (1995)
		16	-18.18 to 10.71	-	-13.33 to 20.00	Lakshmi (1997)
		28	-	-	-17.61 to 40.88	Patil (1998)

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Table 1 contd….

Sl. No.	Characters	Hybrids studied	Range of per cent heterosis over			References
			Heterosis over better parent (%)	**Heterosis over best parent (%)**	**Standard Heterosis (%)**	
11	Total soluble solids	15	-25.41 to 18.78	-	-20.12 to 27.22	Kulkarni (1999)
		40	-43.40 to 43.10	-	-	Mageswari and Natarajan (1999)
		90	Up to 25.97	Up to 11.93	Up to 19.02	Bhatt *et al*. (2001)
		24	-25.31 to 24.61	-	-21.44 to 24.04	Sharma *et al*. (2001)
		15	-1.14 to 26.25	-	3.77 to 25.78	Padma *et al*. (2002)
		36	-21.32 to 26.40	-	-	Joshi and Thakur (2003)
		28	Up to 23.19	Up to 15.93	-	Patagaonkar *et al*. (2003)
		9	Up to 19.20	-	Up to 35.50	Tiwari and Lal (2004)
		45	-45.16 to 37.55	-22.03 to 26.83	-	Prashanth (2004)
		45	102.80	2.87	120.70	Mahendrakar (2004)
		40	-27.66 to 35.69	-36.49 to 33.80	-	Ashwini (2005)
		30	-	-58.77 to 45.98	131.00	Duhan *et al.* (2005)
		49	-	0.71 to 49.53	-	Singh *et al.* (2007)
		24	-	-27.14 to 6.93	-27.83 to 9.31	Sharma and Thakur (2008)
		49	-	66.36	-	Singh *et al.* (2008)
		36	-24.22 to 25.52	-26.51 to 10.98	5.17 to 89.66	Yashavantakumar (2008)
		45	-8.04 to 5.36	-	-	Kumari and Sharma (2011)
		14	3.93 to 31.89	-	-	Ahmad *et al.* (2011)
		19	-	-29.12 to 13.11	-	Islam *et al.* (2012)
		30	-29.95 to 27.91	-	-27.50 to 37.50	Sunil *et al.* (2013)

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Table 1 contd….

Sl. No.	Characters	Hybrids studied	Range of per cent heterosis over			References
			Heterosis over better parent (%)	Heterosis over best parent (%)	Standard Heterosis (%)	
11	Total soluble solids	49	Up to 11.17	-	-	Brajendra *et al*. (2013)
		28	Positive	-	-	Gul *et al*. (2013)
		30	-48.72 to 36.96	-	-31.90 to 32.52	Vinod *et al*.(2013)
		66	-25.8 to 53.47	-27.3 to 40.03	-	Saeed *et al*.(2014)
12	Pericarp thickness	28	-7.57 to 73.29	-17.22 to 63.16	-44.40 to 55.5	Dundi (1991)
		40	-	9.91	-	Dod and Kale (1992)
		45	-11.50 to 50.27	-13.67 to 40.98	-39.60 to 0.77	Tendulkar (1994)
		40	-	-7.41 to 5.69	-	Dod *et al*. (1995)
		36	-48.21 to 57.72	-38.63 to 47.61	-	Ghosh *et al*. (1997)
		28	-4.41 to 14.22	-	-18.98 to 8.48	Patil (1998)
		50	-43.71 to 94.10	-45.73 to 73.22	-67.17 to 26.16	Kulkarni (2003)
		45	-23.92 to 58.02	-29.50 to 5.93	-26.18 to 40.14	Prashanth (2004)
		9	-12.6 to 41.70	-29.40 to -23.40	-30.20 to 31.40	Tiwari and Lal (2004)
		24	-38.34 to 48.31	-47.26 to 45.83	-30.00 to 84.33	Prabhushankar (1990)
		24	-	-13.33 to 4.27	-3.74 to 14.02	Sharma *et al.* (2001)
		45	-12.00 to 40.74	-13.95 to 37.83	8.82 to 50.00	Sajjan (2002)
		45	-	-19.56 to 22.37	-30.22 to 0.70	Mahendrakar (2004)
		9	-12.6 to 41.7	-29.4 to 23.4	-30.2 to 31.4	Tiwari and Lal (2004)
		45	-	-43.40 to 29.19	-43.40 to 32.35	Joshi *et al.* (2005)
		45	-25.00 to 57.89	-30.77 to 66.67	-	Kumar *et al.* (2006)

Contd…..

Table 1 contd….

Sl. No.	Characters	Hybrids studied	Range of per cent heterosis over			References
			Heterosis over better parent (%)	Heterosis over best parent (%)	Standard Heterosis (%)	
12	Pericarp thickness	45	-	38.24	-	Asati *et al.* (2007)
		45	-8.04 to 5.36	-	-	Kumari and Sharma (2011)
		45	0.08	0.06	-	Dechin *et al.* (2012)
		49	Up to 21.05	-	-	Brajendra *et al.* (2013)
		30	-48.72 to 36.96	-	-31.90 to 32.52	Vinod *et al.*(2013)
		15	-	-0.75 to 0.27	-	Aisyah *et al.* (2016)
13	Fruit length	24	-	-19.65 to 10.17	-17.67 to 3.24	Sharma *et al.* (2001)
		28	Up to 4.16	-	-	Patagaonkar *et al.* (2003)
		45	-	-43.46 to 29.16	-43.46 to 29.16	Mahendrakar (2004)
		14	0.56 to 24.1l	-	-	Ahmad *et al.* (2011)
		49	Up to 4.83		-	Singh *et al.* (2012)
		19	-	ï 17.87 to 3.09	-	Islam *et al.* (2012)
		30	-44.97 to 27.28	-	-42.97 to 27.27	Sunil *et al.* (2013)
		66	-	-7.08 to 10.9	-	Saeed *et al.*(2014)
		8	-	0.01 to 32.59	-	Saleem *et al.*(2015)
		15	-	-10.53 to 5.85	-	Aisyah *et al.* (2016)
14	Fruit girth	24	-	-37.88 to 3.15	-18.55 to 26.61	Sharma *et al.* (2001)
		15	-27.12 to 14.48	-	-33.42 to -9.31	Padma *et al.* (2002)
		28	Up to 4.16	-	-	Patagaonkar *et al.* (2003)
		45	-	-37.14 to 23.36	-27.30 to 23.68	Mahendrakar (2004)

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Table 1 contd….

Sl. No.	Characters	Hybrids studied	Range of per cent heterosis over			References
			Heterosis over better parent (%)	**Heterosis over best parent (%)**	**Standard Heterosis (%)**	
14	Fruit girth	30	Up to 8.70	-	-	Gul *et al.* (2010)
		14	0.53 to 15.49	-	-	Ahmad *et al.* (2011)
		19	-	ï 16.37 to 14.11	-	Islam *et al.* (2012)
		49	Up to 16.50	-	-	Singh *et al.* (2012)
		30	-49.33 to 29.70	-	-42.50 to 42.97	Sunil *et al.* (2013)
		66	-	-7.08 to 10.9	-	Saeed *et al.*(2014)
		8	-	0.01 to 32.59	-	Saleem *et al.*(2015)
		15	-	-10.53 to 5.85	-	Aisyah *et al.* (2016)

2.2 Combining ability

The success of hybridization depends upon the selection of suitable parental genotypes and performance of their cross combinations. Selection made on phenotypic performance alone does not lead to expected degree of heterosis. Therefore, study on combining ability of parents is essential in selection of parents for development of F_1 hybrids because selection of parents on the basis of phenotypic performance alone is not a sound procedure, since phenotypically superior lines may not lead to expected degree of heterosis. Further, it is useful in providing information on gene action which is of great value to the vegetable breeder in adopting the appropriate breeding procedures.

The combining ability concept was first proposed by Spargue and Tatum (1942) in corn. General combining ability (gca) is the comparative ability of line to combine the other line. It is the deviation of the mean performance of all crosses involving a parent from overall mean. Specific combining ability (sca) is deviation in the performance of specific crosses from the performance expected on the basis of general combing ability effect of parents involved in the crosses. A positive general combing ability (gca) indicate that a parent that produces above average progeny, whereas parent with negative gca produces progeny which performs below average of the population. Specific combing ability (sca) can be either negative or positive and sca always refers to specific cross and never to a particular parent by itself. For combining ability studies, the most commonly used designs are line × tester (L × T) and diallel analysis. Combining ability analysis by the use of line x tester technique was given by Kempthorne (1957) and Arunachalan (1974), is frequently used for testing the performance of lines in hybrid combination. Review of literature on combining ability and gene action for various traits in tomato are given in Table 2.

Table 2. Review of literature on combining ability and gene action for various traits in tomato

Sl. No.	Characters	Material and method used	Combining ability		Gene action		References
			GCA	SCA	Additive	Non-additive	
1	Plant height	8 × 8 HD	Significant	Significant	-	+	Kalloo *et al*. (1973)
		7 × 2 L × T	-	Significant	-	+	Mittal *et al*. (1974)
		12 × 3 L × T	Significant	Significant	+	+	Dudi *et al*. (1979)
		12 × 2 L × T	Significant	Significant	-	+	Anbu *et al*. (1980)
		11 × 4 L × T	-	Significant	-	+	Govindarasu *et al*. (1981)
		7 × 7 HD	Significant	Significant	+	+	Sidhu *et al*. (1981)
		10 × 4 L × T	Significant	Significant	+	+	Raijadhav and Kale (1987)
		12 × 2 L × T	-	Significant	-	+	Sharma (1996)
		8 × 6 L × T	Significant	Significant	+	-	Kumar *et al*. (1995)
		4 × 4 L × T	Significant	Significant	+	-	Lakshmi (1997)
		15 × 3 L × T	Significant	Significant	-	+	Srivastava *et al*. (1998)
		5 × 10 L × T	Significant	Significant	-	+	Dharmatti *et al*. (1995)
		6 × 6 HD	Significant	Significant	+	+	Kulkarni (1999)
		14 × 14 HD	Significant	Significant	+	+	Bhatt *et al*. (1999)
		5 × 10 L × T	Significant	Significant	-	+	Dharmatti *et al*. (2001)
		7 × 3 L × T	Significant	Significant	+	-	Gaikwad *et al*. (2002)
		6 × 6 HD	Significant	Significant	+	+	Padma *et al*. (2002)
		10 × 2 L × T	Significant	Significant	-	+	Joshi and Thakur (2003)
		5 × 10 L × T	Significant	Significant	+	-	Kulkarni (2003)
		9 × 3 L × T	Significant	Significant	+	-	Prashanth (2004)
		5 × 8 L × T	Significant	Significant	+	-	Ashwini (2005)
		10 × 3 L × T	Significant	Significant	-	+	Pandey *et al*. (2006)
		4 × 2 L × T	Significant	Significant	-	+	Kamalveer *et al*. (2006)

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Table 2 contd…..

Sl. No.	Characters	Material and method used	Combining ability		Gene action		References
			GCA	SCA	Additive	Non-additive	
		6 × 6 HD	Significant	Significant	-	+	Premalakshmi *et al*. (2006)
		13 × 3 L × T	Significant	-	+	-	Singh and Asati (2011)
		4 × 3 L × T	Significant	Significant	-	+	Izge and Garba (2012)
		3 × 6 H D	Significant	-	+	+	Saleem *et al*. (2013)
		9 × 9 F D	Significant	Significant	-	+	Akram *et al*. (2012)
		8 × 3 L × T	Significant	-	+	-	Adhi *et al*. (2013)
		30 L × T	Significant	Significant	-	-	Kumar *et al.* (2013)
		5 × 2 H D	Significant	-	+	+	Gabry *et al.* (2014)
		7 × 3 L × T	Significant	Significant			Marbhal *et al.* (2016)
		3 × 3 L × T	Significant	Significant			Narasimhamurty and Gowda (2016)
2	Number of branches per Plant	8 × 8 HD	Significant	Significant	-	+	Kalloo *et al*. (1973)
		7 × 2 L × T	High	-	+	-	Mittal *et al*. (1974)
		12 × 3 L × T	Significant	Significant	+	+	Dudi *et al*. (1979)
		11 × 4 L × T	Significant	Significant	-	+	Govindarasu *et al*. (1981)
		7 × 7 HD	Significant	Significant	+	+	Sidhu *et al*. (1981)
		-	Significant	Significant	+	+	Dundi (1991)
		5 × 10 L × T	High	-	+	-	Dharmatti (1995)
		4 × 4 L × T	-	Significant	+		Lakshmi (1997)
		8 × 8 HD	High	-	+	-	Patil (1998)
		15 × 3 L × T	Significant	Significant	-	+	Srivastava *et al*. (1998)
		5 × 10 L × T	Significant	Significant	-	+	Dharmatti *et al*. (1999)
		6 × 6 HD	Significant	Significant	+	+	Kulkarni (1999)
		14 × 14 HD	Significant	Significant	+	+	Bhatt *et al*. (1999)
		7 × 3 L × T	Significant	Significant	+	-	Gaikwad *et al*. (2002)

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Table 2 contd.....

Sl. No.	Characters	Material and method used	Combining ability		Gene action		References
			GCA	SCA	Additive	Non-additive	
		6 × 6 HD	Significant	Significant	+	+	Padma *et al*. (2002)
		5 × 10 L × T	Significant	Significant	+	-	Kulkarni (2003)
		5 × 9 L × T	Significant	Significant	+	-	Prashanth (2004)
		5 × 8 L × T	Significant	Significant	+	-	Ashwini (2005)
		4 × 2 L × T	Significant	Significant	+	-	Kamalveer *et al*. (2006)
		6 × 6 HD	Significant	Significant	+	-	Premalakshmi *et al*. (2006)
		13 × 3 L × T	Significant	Significant	+	-	Singh and Asati (2011)
		4 × 3 L × T	Significant	Significant	-	+	Izge and Garba (2012)
		30 L × T	Significant	Significant	+	-	Kumar *et al.* (2013)
		8 × 3 L × T	Significant	-	+	-	Adhi *et al*. (2013)
		5 × 2 H D	Significant	Significant	+	+	Gabry *et al.* (2014)
		3 × 3 L × T	Significant	Significant			Narasimhamurty and Gowda (2016)
3	Days to flower initiation	7 × 2 L × T	High	-	+	-	Mittal *et al.* (1974)
		10 × 2 L × T	Significant	Significant	-	+	Anbu *et al*. (1980)
		10 × 3 L × T	Significant	Significant	+	+	Jamwal *et al*. (1984)
		4 × 4 L × T	-	Significant	-	+	Laksmi (1997)
		15 × 3 L × T	Significant	Significant	-	+	Srivathsva *et al*. (1998)
		3 × 19 L × T	Significant	Significant	-	+	Dhaliwal *et al*. (2000)
		18 × 2 L × T	Significant	Significant	-	+	Thakur and Joshi (2000)
		7 × 3 L × T	Significant	Significant	-	+	Gaikwad *et al*. (2002)
		9 × 9 F D	Significant	Significant	-	+	Akram *et al*. (2012)
		30 L × T	Significant	Significant	-	+	Kumar *et al.* (2013)
		7 × 3 L × T	Significant	Significant			Marbhal *et al.* (2016)

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Table 2 contd…..

Sl. No.	Characters	Material and method used	Combining ability		Gene action		References
			GCA	SCA	Additive	Non-additive	
4	Days to 50 per cent flowering	7 × 7 HD	Significant	Significant	-	+	Anbu *et al.* (1981)
		10 × 10 HD	-	High	-	+	Patil (1984)
		10 × 2 L × T	Significant	Significant	-	+	Prabhushankar (1990)
		6 × 6 HD	-	Significant	-	+	Dundi (1991)
		15 × 3 L × T	Significant	Significant	+	-	Tendulkar (1994)
		10 × 10 HD	Significant	Significant	+	-	Patil (1998)
		5 × 6 L × T	High	-	+	-	Roopa *et al*. (2001)
		5 × 3 L × T	Significant	Significant	+	-	Kulkarni (2003)
		15 × 3 L × T	Significant	Significant	-	+	Mahendrakar (2004)
		15 × 3 L × T	Significant	Significant	+	-	Singh *et al.* (2008)
		4 × 3 L × T	Significant	Significant	-	+	Izge and Garba(2012)
		8 × 3 L × T	Significant	Significant	+	-	Adhi *et al*. (2013)
		7 × 3 L × T	Significant	Significant			Marbhal *et al.* (2016)
5	Days to first harvest for earliness	7 × 2 L × T	High	-	+	-	Mittal *et al*. (1974)
		9 × 2 L × T	High	-	+	-	Viredelwala *et al*. (1987)
		3 × 15 L × T	Significant	Significant	+	+	Tendulkar (1994)
		12 × 2 L × T	Significant	-	+	-	Sharma (1996)
		15 × 3 L × t	Significant	Significant	-	+	Srivastava *et al*. (1998)
		5 × 6 L × T	-	High	-	+	Roopa *et al*. (2001)
		14 × 14 H D	Significant	Significant	+	+	Bhatt *et al*. (2004)
		4 × 3 L × T	-	High	-	+	Izge and Garba(2012)
		3 × 6 H D	Significant	Significant	+	+	Saleem *et al*. (2013)
		12 HD	High	Low	-	+	Saeed *et al*.(2014)

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Table 2 contd…..

Sl. No.	Characters	Material and method used	Combining ability		Gene action		References
			GCA	SCA	Additive	Non-additive	
6	Average fruit weight	7 × 2 L × T	Significant	Significant	+	+	Mittal *et al*. (1974)
		10 × 2 L × T	Significant	Significant	-	+	Anbu *et al*. (1980)
		15 × 3 L × T	Significant	Significant	+	-	Dixit *et al*. (1980)
		7 × 7 HD	Significant	-	+	+	Sidhu *et al*. (1981)
		9 × 2 L × T	-	High	-	+	Viredelwala *et al*. (1987)
		6 × 5 L × T	-	High	-	+	Sathyanarayana and Anand (1992)
		3 × 15 L × T	Significant	Significant	-	+	Tendulkar (1994)
		5 × 10 L × T	-	High	-	+	Dharmatti (1995)
		3 × 5 L × T	Significant	Significant	-	+	Kurian and Peter (1995)
		4 × 4 L × T	Significant	Significant	+	-	Lakshmi (1997)
		8 × 8 HD	High	-	+	-	Patil (1998)
		7 × 7 HD	Significant	Significant	+	-	Rai *et al*. (1998)
		6 × 6 HD	Significant	Significant	+	+	Kulkarni (1999)
		3 × 19 L × T	Significant	Significant	+	-	Dhaliwal *et al*. (2000)
		5 × 10 L × T	Significant	Significant	-	+	Dharmatti *et al*.(2001)
		5 × 6 L × T	-	High	-	+	Roopa *et al*.(2001)
		11 × 3 L × T	Significant	Significant	+	-	Gaikwad *et al*.(2002)
		6 × 6 HD	Significant	Significant	+	+	Padma *et al*.(2002)
		5 × 9 L × T	Significant	Significant	-	+	Prashanth (2004)
		5 × 8 L × T	Significant	Significant	-	+	Ashwini (2005)
		6 × 6 HD	Significant	Significant	-	+	Premalakshmi *et al.* (2006)
		10 × 3 L × T	Significant	Significant	-	+	Pandey *et al*. (2006)
		15 × 3 L × T	Significant	Significant	+	-	Asati *et al.* (2007)
		10 × 5 L × T	Significant	Significant	-	+	Kavitha *et al*. (2007)
		15 × 3 L × T	Significant	Significant	+	+	Singh *et al* .(2008)

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Table 2 contd…..

Sl. No.	Characters	Material and method used	Combining ability		Gene action		References
			GCA	SCA	Additive	Non-additive	
		6 × 6 L × T	-	Significant	-	+	Yashavantakumar (2008)
		13 × 3 L × T	Significant	Significant	+	-	Singh and Asati (2011)
		4 × 3 L × T	Significant	Significant	+	+	Izge and Garba(2012)
		3 × 6 H D	-	Significant	-	+	Saleem *et al*. (2013)
		8 × 3 L × T	Significant	Significant	-	-	Adhi *et al*. (2013)
		30 L × T	Significant	Significant	-	+	Kumar *et al.* (2013)
		5 × 2 H D	Significant	Significant	+	+	Gabry *et al.* (2014)
		12 HD	-	Significant	-	+	Saeed *et al*. (2014)
		7 × 3 L × T	Significant	-			Marbhal *et al.* (2016)
		6 × 6 FD	-	Significant	+	-	Aisyah *et al.* (2016)
7	Number of fruits per plant	8 × 8 HD	Significant	Significant	+	-	Kalloo *et al*. (1973)
		7 × 2 L × T	-	High	-	+	Mittal *et al.* (1974)
		12 × 3 L × T	Significant	Significant	+	+	Dudi *et al*. (1979)
		10 × 2 L × T	Significant	Significant	-	+	Anbu *et al*. (1980)
		15 × 3 L × T	Significant	Significant	+	-	Dixit *et al.* (1980)
		11 × 4 L × T	-	Significant	-	+	Govindarasu *et al*. (1981)
		7 × 7 HD	Significant	-	+	-	Sidhu *et al*. (1981)
		9 × 2 L × T	-	High	-	+	Viredelwala *et al*. (1987)
		10 × 3 L × T	Significant	Significant	+	+	Jamwal *et al*. (1984)
		3 × 15 L × T	Significant	Significant	+	-	Tendulkar (1994)
		5 × 10 L × T	-	High	-	+	Dharmatti (1995)
		8 × 6 L × T	-	Significant	-	+	Kumar *et al*. (1995)
		4 × 4 L × T	-	Significant	-	+	Lakshmi (1997)
		5 × 10 L × T	Significant	Significant	+	-	Kulkarni (2003)

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Sl. No.	Characters	Material and method used	Combining ability		Gene action		References
			GCA	SCA	Additive	Non-additive	
		5 × 9 L × T	Significant	Significant	+	-	Prashanth (2004)
		5 × 8 L × T	Significant	Significant	+	-	Ashwini (2005)
		6 × 6 HD	Significant	Significant	+	-	Premalakshmi *et al*. (2006)
		10 × 3 L × T	Significant	Significant	+	-	Pandey *et al*. (2006)
		15 × 3 L × T	Significant	-	+	-	Asati *et al.* (2007)
		10 × 5 L × T	-	High	-	+	Kavitha *et al*. (2007)
		15 × 3 L × T	Significant	Significant	+	+	Singh *et al.* (2008)
		4 × 3 L × T	Significant	Significant	-	+	Izge and Garba(2012)
		30 L × T	Significant	-	+	-	Kumar *et al.* (2013)
		3 × 6 H D	Significant	High	-	+	Saleem *et al*. (2013)
		5 × 2 H D	Significant	Significant	+	+	Gabry *et al.* (2014)
		12 HD	Significant	High	-	+	Saeed *et al*.(2014)
		7 × 3 L × T	Significant	High			Marbhal *et al.* (2016)
8	Yield per plant	8 × 8 HD	Significant	Significant	+	-	Kalloo *et al.* (1973)
		7 × 2 L × T	Significant	Significant	-	+	Mittal *et al.* (1974)
		12 × 3 L × T	Significant	Significant	+	-	Dudi *et al.* (1979)
		10 × 2 L × T	Significant	Significant	-	+	Anbu *et al.* (1980)
		15 × 3 L × T	Significant	Significant	+	-	Dixit *et al.* (1980)
		11 × 4 L × T	Significant	Significant	-	+	Govindarasu *et al.* (1981)
		7 × 7 HD	Significant	Significant	+	-	Sidhu *et al.* (1981)
		10 × 3 L × T	Significant	Significant	+	-	Jamwal *et al.* (1984)
		10 × 4 L × T	Significant	Significant	+	-	Raijadhav and Kale (1987)
		3 × 15 L × T	Significant	Significant	-	+	Tendulkar (1994)
		5 × 10 L × T	Significant	Significant	-	+	Dharmatti (1995)

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Sl. No.	Characters	Material and method used	Combining ability		Gene action		References
			GCA	SCA	Additive	Non-additive	
		6 × 6 HD	Significant	Significant	-	+	Kulkarni (1999)
		12 × 2 L × T	Significant	Significant	+	-	Sharma *et al.* (1999)
		3 × 19 L × T	Significant	Significant	-	+	Dhaliwal *et al.* (2000)
		14 × 14 HD	Significant	Significant	-	+	Bhatt *et al.* (2001)
		5 × 10 L × T	Significant	Significant	-	+	Dharmatti *et al.* (2001)
		5 × 6 L × T	Significant	Significant	+	-	Roopa *et al.* (2001)
		7 × 3 L × T	Significant	Significant	-	+	Gaikwad *et al.* (2002)
		6 × 6 HD	Significant	Significant	-	+	Padma *et al*. (2002)
		5 × 10 L × T	Significant	Significant	+	-	Kulkarni (2003)
		5 × 9 L × T	Significant	Significant	+	-	Prashanth (2004)
		5 × 8 L × T	Significant	Significant	+	-	Ashwini (2005)
		6 × 6 HD	Significant	Significant	-	+	Premalakshmi *et al*. (2006)
		10 × 5 L × T	Significant	Significant	+	-	Kavitha *et al*. (2007)
		8 × 6 L × T	Significant	Significant	+	-	Kumar *et al*. (1995)
		10 × 5 L × T	Significant	Significant	-	+	Singh *et al.* (2008)
		6 × 6 L × T	Significant	Significant	-	+	Yashavantakumar (2008)
		13 × 3 L × T	Significant	Significant	+	-	Singh and Asati (2011)
		4 × 3 L × T	Significant	Significant	-	+	Izge and Garba(2012)
		30 L × T	Significant	-	+	-	Kumar *et al.* (2013)
		3 × 6 H D	Significant	Significant	+	+	Saleem *et al*. (2013)
		5 × 2 H D	Significant	Significant	+	+	Gabry *et al.* (2014)
		7 × 3 L × T	Significant	Significant			Marbhal *et al.* (2016)
		6 × 6 FD	Significant	Significant	+	-	Aisyah *et al.* (2016)
		3 × 3 L × T	Significant	-			Narasimhamurty and Gowda (2016)

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Table 2 contd…..

Sl. No.	Characters	Material and method used	Combining ability		Gene action		References
			GCA	SCA	Additive	Non-additive	
9	Number of locules per fruit	8 × 8 HD	Significant	Significant	+	-	Kalloo *et al*. (1973)
		7 × 2 L × T	-	High	-	+	Mittal *et al*. (1974)
		10 × 2 L × T	Significant	Significant	-	+	Govindarasu *et al*. (1981)
		7 × 7 HD	Significant	Significant	+	+	Patil (1985)
		3 x15 L × T	Significant	Significant	-	+	Rai *et al*. (1998)
		3 × 5 L × T	Significant	Significant	+	+	Kumar *et al*. (1995)
		7 × 7 HD	-	Significant	-	+	Patil (1998)
		8 × 6 L × T	Significant	Significant	+	+	Srivastava *et al*. (1998)
		15 × 3 L × T	Significant	Significant	+	+	Kulkarni (1999)
		12 × 12 HD	Significant	Significant	+	+	Dhaliwal *et al*. (2000)
		6 × 6 HD	Significant	Significant	+	+	Roopa *et al*. (2001)
		3 × 19 L × T	Significant	Significant	-	-	Chadha *et al*. (2002)
		5 × 6 L × T	-	High	+	+	Gaikwad *et al*. (2002)
		5 × 10 L × T	Significant	Significant	+	-	Kulkarni (2003)
		15 × 3 L × T	Significant	Significant	+	+	Mahendrakar (2004)
		7 × 7 HD	-	Significant	-	+	Joshi and Thakur (2003)
		6 × 6 L × T	Significant	Significant	-	+	Yashavantakumar (2008)
		3 × 6 H D	Significant	-	+	+	Saleem *et al*. (2013)
		30 × 3 L × T	Significant	Significant	+	+	Kumar *et al.* (2013)
		5 × 2 H D	Significant	Significant	+	+	Gabry *et al.* (2014)
		12 HD	High	-	-	+	Saeed *et al*.(2014)
10	TSS	8 × 8 HD	Significant	Significant	-	+	Kalloo *et al.* (1973)
		11 × 4 L × T	Significant	Significant	-	+	Govindarasu *et al.* (1981)
		7 × 7 HD	-	High	-	+	Sidhu *et al*. (1981)

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Table 2 contd…..

Sl. No.	Characters	Material and method used	Combining ability		Gene action		References
			GCA	SCA	Additive	Non-additive	
		10 × 10 HD	Significant	Significant	+	+	Patil and Bojappa (1988)
		10 × 4 L × T	-	Significant	-	+	Raijadhav and Kale (1987)
		6 × 5 L × T	-	High	-	+	Sathyanarayana and Anand (1992)
		3 × 15 L × T	-	Significant	-	+	Tendulkar (1994)
		5 × 10 L × T	-	High	-	+	Dharmatti (1995)
		3 × 5 L × T	Significant	Significant	-	+	Kurian and Peter (1995)
		8 × 6 L × T	-	Significant	-	+	Kumar *et al*. (1997)
		4 × 4 L × T	-	Significant	-	+	Lakshmi (1997)
		8 × 8 HD	High	-	+	-	Patil (1997)
		12 × 2 L × T	Significant	Significant	+	-	Sharma *et al*. (1999)
		3 × 19 L × T	Significant	Significant	-	+	Dhaliwal *et al.* (2000)
		5 × 6 L × T	-	High	-	+	Roopa *et al.*(2001)
		5 × 10 L × T	Significant	Significant	+	-	Kulkarni (2003)
		5 × 9 L × T	Significant	Significant	-	+	Prashanth (2004)
		5 × 8 L × T	Significant	Significant	+	-	Ashwini (2005)
		30 L × T	Significant	-	-	+	Kumar *et al.* (2013)
		12 HD	-	High	-	+	Saeed *et al*. (2014)
		3 × 3 L × T	-	Significant			Narasimhamurty and Gowda (2016)
11	Rind thickness	10 × 10 HD	Significant	Significant	+	+	Patil (1985)
		15 × 3 L × T	-	High	-	+	Tendulkar (1994)
		7 × 7 HD	Significant	Significant	+	-	Patil (1998)
		5 × 6 L × T	Significant	Significant	-	+	Roopa *et al.* (2001)
		15 × 3 L × T	Significant	Significant	+	-	Sajjan (2002)
		8 × 3 L × T	-	Significant	-	+	Chadha *et al.* (2002)

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Table 2 contd…..

Sl. No.	Characters	Material and method used	Combining ability		Gene action		References
			GCA	SCA	Additive	Non-additive	
		5 × 9 L × T	Significant	Significant	+	+	Prashanth (2004)
		15 × 3 L × T	Significant	Significant	-	+	Mahendrakar (2004)
		5 × 8 L × T	Significant	Significant	+	+	Joshi and Thakur (2003)
		18 × 2 L × T	Significant	Significant	+	+	Thakur and Kohli (2005)
		15 × 3 L × T	Significant	Significant	+	+	Singh *et al.* (2008)
		5 × 2 H D	Significant	Significant	+	+	Gabry *et al.* (2014)
		30 L × T	Significant	Significant	+	+	Kumar *et al.* (2013)
		6 × 6 FD	-	High	+	-	Aisyah *et al.* (2016)
12	Fruit length	12 × 4 L × T	Significant	Significant	+	-	Raijadhav and Kale (1987)
		7 × 7 HD	Significant	Significant	+	-	Rai *et al.* (1998)
		15 × 3 L × T	Significant	Significan	-	+	Srivastava *et al.* (1998)
		12 × 2 L × T	Significant	Significant	-	+	Sharma *et al.* (1999)
		5 × 6 L × T	Significant	Significant	+	+	Roopa *et al.* (2001)
		3 × 12 L × T	-	Significant	-	+	Kaur *et al.* (2002)
		3 × 6 HD	Significant	-	+	+	Padma *et al.* (2002)
		7 × 7 HD	Significant	-	+	-	Rai *et al.* (2003)
		15 × 3 L × T	Significant	Significant	-	+	Mahendrakar (2004)
		5 × 5 HD	Significant	-	+	-	Singh *et al.* (2004)
		10 × 3 L × T	Significant	-	+	-	Pandey *et al.* (2006)
		8 × 3 L × T	Significant	Significant	-	-	Adhi *et al*. (2013)
		12 HD	High	-	-	+	Saeed *et al*.(2014)
		6 × 6 FD	Significant	Significant	+	-	Aisyah *et al.* (2016)
13	Fruit girth	7 × 2 L × T	Significant	Significant	+	+	Mittal *et al.* (1974)
		12 × 3 L × T	Significant	Significant	+	+	Dudi *et al*. (1979)

Contd……

Table 2 contd…..

Sl. No.	Characters	Material and method used	Combining ability		Gene action		References
			GCA	SCA	Additive	Non-additive	
		12 × 4 L × T	Significant	-	+	-	Raijadhav and Kale (1987)
		12 × 2 L × T	Significant	Significant	-	+	Sharma (1996)
		4 × 4 L × T	Significant	Significant	+	+	Laksmi (1997)
		7x7 HD	Significant	Significant	+	+	Rai *et al*. (1998)
		15 × 3 L × T	Significant	Significant	-	+	Srivastava *et al*. (1998)
		5 × 6 L × T	Significant	Significant	+	+	Roopa *et al*. (2001)
		3x12 L × T	-	Significant	-	+	Kaur *et al*. (2002)
		6 × 6 HD	Significant	Significant	+	+	Padma *et al*. (2002)
		3 × 6 L × T	High	-	+	-	Rai *et al.* (2003)
		15 × 3 L × T	Significant	Significant	+	+	Mahendrakar (2004)
		5 × 3 H D	Significant	Significant	+	+	Saleem *et al*. (2013)
		8 × 3 L × T	Significant	Significant	-	-	Adhi *et al*. (2013)
		12 HD	-	High	-	+	Saeed *et al*.(2014)

3. MATERIAL AND METHODS

The details of materials used and the techniques adopted during the course of investigation are presented in this chapter.

3.1 Experimental site

The field experiment was at Regional Horticultural Research and Extension Centre (RHREC), Dharwad, Karnataka under irrigated conditions during *kharif* and ruby seasons of the year 2016-17.

3.2 Location and climate of experimental site

Dharwad is situated in northern transition zone (zone-8) of Karnataka at 15^0 26ô north latitude and 75^0 07ô east longitude. Spread 750 m above mean sea level, the city enjoys a salubrious climate, thick vegetation. Dharwad sits at the cusp of two geographical divisions - Malenadu (hilly forest land with red soil) and Belavalanadu (deccan plains with black soil).

Dharwad has a plenty of green cover. The climate is mildly hot during the summer, pleasant during the rest of years, it have lot of greenery around. The average yearly rainfall is 838 mm.

3.3 Season-I: Hybridization programme

Totally 39 genotypes of tomato were collected from Regional Horticultural Research and Extension Centre, Dharwad with a main intension to evaluate the entries along with their progenies developed by hybridization. Among the entries 18 parents were selected based on their yield performances. From these 18 genotypes, 45 crosses were evolved in a line × tester design with 15 genotypes as lines (female) and three genotypes as testers (male). Testers were selected based on the larger fruit size, which will directly correlated to yield and the superior fruit quality characters among them. The genotypes along with their sources are presented in Table 3.

Plate 1. General view of experimental plot

Table 3: Salient features of the parents selected

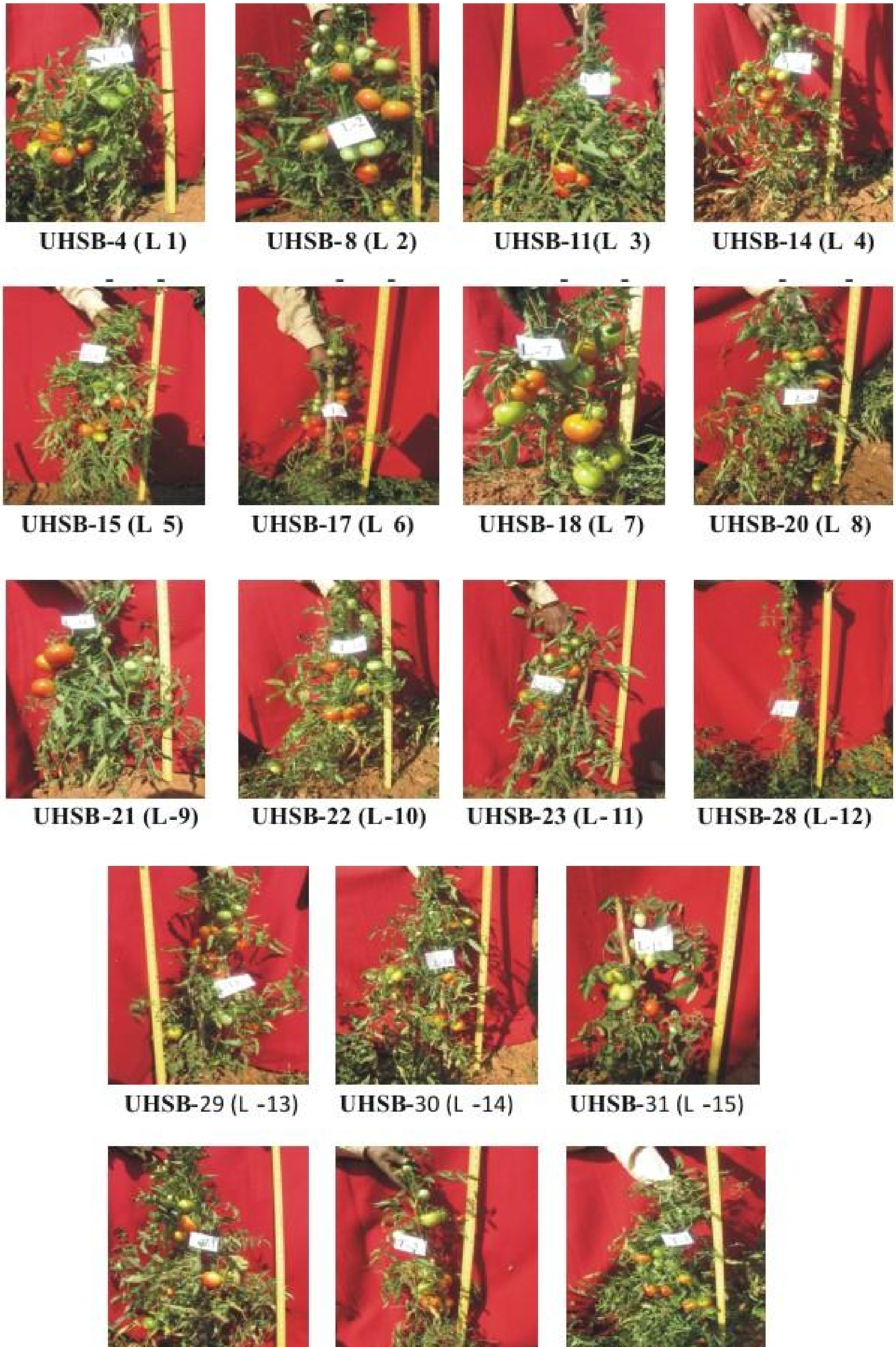
Sl. No.	Lines/Females	Source	Features
1.	UHSB-4(L-1)	RHREC, Dharwad (UHSB).	Medium sized, flatish round, ridges present on fruit, weighs average about 50g per fruit, medium red coloured and fruits having lesser number of locules.
2.	UHSB-8(L-2)	RHREC, Dharwad (UHSB).	Medium sized, flatish round, ridges present on fruit, weighs average about 50g per fruit, medium red coloured and fruits having more number of locules.
3.	UHSB-11(L-3)	RHREC, Dharwad (UHSB).	Medium sized, round, dark red coloured weighs average about 55g per fruit.
4.	UHSB-14(L-4)	RHREC, Dharwad (UHSB).	Small sized, round, dark red coloured fruits.
5.	UHSB-15(L-5)	RHREC, Dharwad (UHSB).	Medium sized, flatish round, ridges present on fruit, weighs average about 70g per fruit, medium red coloured and fruits having more number of locules.
6.	UHSB-17(L-6)	RHREC, Dharwad (UHSB).	Plant having indeterminate growth habit, fruits are small sized, round, dark red coloured and very few locules per fruit.
7.	UHSB-18(L-7)	RHREC, Dharwad (UHSB).	Fruits with medium sized, flatish round shaped, ridges present on fruit, medium red coloured ,weighs average about 90g and having more number of locules.
8.	UHSB-20(L-8)	RHREC, Dharwad (UHSB).	Heavy bearer with more number of fruits per plant. Small sized, round, weighs average about 84g, dark red coloured fruits.
9.	UHSB-21(L-9)	RHREC, Dharwad (UHSB).	Flattened, medium sized, round, weighs average about 76g, dark red coloured fruits.
10.	UHSB-22(L-10)	RHREC, Dharwad (UHSB).	Smaller, round fruits, dark red coloured, weighs average about 78g per fruit, very few locules present per fruit.
11.	UHSB-23(L-11)	RHREC, Dharwad (UHSB).	Medium to bigger sized, round, weighs average about 85g, with dark red coloured fruits.

Contd….

Table 3 contd….

Sl. No.	Lines/Females	Source	Features
12.	UHSB-28(L-12)	RHREC, Dharwad (UHSB).	Plant having indeterminate growth habit. Smaller, orange coloured fruits with very few locules per fruit.
13.	UHSB-29(L-13)	RHREC, Dharwad (UHSB).	Fruits are Small sized; flattened, round, dark red coloured weighs average about 67g.
14.	UHSB-30(L-14)	RHREC, Dharwad (UHSB).	Fruits are small sized, flattened, weighs average about 92 g with dark red coloured.
15.	UHSB-31(L-15)	RHREC, Dharwad (UHSB).	Fruits glossy in appearance, big oblong fruits, plant have indeterminate growth habit.
	Testers/Males		**Features**
1.	UHSB-32(T-1)	RHREC, Dharwad (UHSB).	Fruits with large sized, medium red coloured and have average 4 locules per fruit.
2.	UHSB-33(T-2)	RHREC, Dharwad (UHSB).	Fruits with large sized, medium red coloured and have average about 4 locules per fruit.
3.	UHSB-37(T-3)	RHREC, Dharwad (UHSB).	Small to medium sized with dark red coloured fruits, tendency of bearing high number of fruits per plant and having good qualitative characteristics.

	Commercial check		
1	Arka Rakshak(C.C)	IIHR, Bangaluru	Indeterminate F_1 hybrid with big oblong fruits and resistant to early blight, bacterial wilt and TLCV.



UHSB-4 (L 1) UHSB-8 (L 2) UHSB-11(L 3) UHSB-14 (L 4)

UHSB-15 (L 5) UHSB-17 (L 6) UHSB-18 (L 7) UHSB-20 (L 8)

UHSB-21 (L-9) UHSB-22 (L-10) UHSB-23 (L-11) UHSB-28 (L-12)

UHSB-29 (L -13) UHSB-30 (L -14) UHSB-31 (L -15)

UHSB-32 (T -1) UHSB-33 (T-2) UHSB-37 (T -3)

Plate 2. The parents used for the experiment

3.3.1 Crossing programme

The seed sowing of all the parental genotypes carried out on April 24th, 2016 (*kharif*) in the protrays. Four week old seedlings transplanted in crossing block at spacing of 90 × 45 cm on 18th May 2016.

Healthy flower buds in a cyme preferably of the first flush which were expected to open in the next day were selected for emasculation and pollination. The selected buds were emasculated by hand by using forceps in the evening hours between 4:00 pm and 6:00 pm. The emasculated flowers (one to two per cyme) were covered with butter paper bags to avoid contamination. The pollination of emasculated flowers was done next day morning during anthesis time (7:00 am to 10:30 am). Well opened flowers with dehisced anthers were collected from the male parents, the butter paper bag was removed carefully and stigma brought in contact with dehisced anthers of male flowers. The female flower covered with white colored butter paper bag immediately for easy identification and further avoiding the contamination from other pollen. The pedicel of each pollinated flowers tied with label bearing information of female and male parents and date of crossing for identification. The ripe fruits harvested and the seeds extracted by the fermentation method. Simultaneously, some flowers in each of these genotypes selfed by covering the flowers with butter paper bags. The selfed fruits were collected and seeds were extracted.

3.3.2 Evaluation of F_1's, parents and commercial hybrid

Design : RBD (Randomized Complete Block Design)

Replications : Two

Spacing : 90 × 45 cm

Season **:** *Rabi* (2016-17)

The seeds of 18 parental genotype, 45 F_1 hybrids which were obtained by crossing in last season crop were sown in portrays along with one commercial check (Arka Rakshak) during second week of October 2016. Recommended cultural practices were followed for raising the healthy nursery. The healthy seedlings were transplanted in a Randomized Complete Block Design with 63 entries in two replications along with a commercial check. Plot size was 7.00 × 1.30 m. Ten plants of each genotype were transplanted in each replication at spacing of 90 × 45 cm on seventh November 2016.

The standard cultural practices recommended in the package of practices of vegetable crops of UHSB were followed to produce a healthy crop stand. Besides the application of FYM @ the rate of 25 t/ha, chemical fertilizers were applied as per the recommendation of package of practices *i.e.* 115 kg N, 100 kg P_2O_5 and 60 kg K_2O/ha. One third dose of N and full doses of P_2O5 and K_2O applied at the time of field preparations. Remaining two-third dose of ôNô top dressed in equal amounts after 30 and 45 days of transplanting.

3.4 Observations recorded

The observations were recorded from five randomly selected plants in each replication for all characters except for fruit characters for which observations were recorded on ten randomly selected fruits per replication. The characters studied were:

3.4.1 Plant height

Plant height measured in centimeters from the ground level to the tip of the plant at 30th, 60th and 90th days after transplanting.

3.4.2 Number of branches per plant

Number of primary branches per plant counted on 30th, 60th and 90th day after transplanting, respectively.

3.4.3 Days to flower initiation

Number of days taken from transplanting to first flower appearance was observed in five randomly selected plants and the average was worked out.

3.4.4 Days to fifty per cent flowering

Number of days from transplanting to 50 per cent flowering appearance was observed in five randomly selected plants and the average was recorded.

3.4.5 Days to fruit harvest for earliness

Number of days taken from transplanting to first fruit harvest was observed in five randomly selected plants and the average was worked out.

3.4.6 Average fruit weight

The ten fruits from all the pickings were taken and average weight was calculated and expressed in gram.

3.4.7 Number of fruits per plant

The marketable fruits harvested from randomly taken plants were counted and summed up at each harvest and averaged to obtain numbers of fruit per plant.

3.4.8 Yield per plant

Fruit yield was determined by adding the total fruit weight over all the pickings from each reference plant and expressed in grams.

3.4.9 Yield per plot

The total weight of fruits harvested from all the pickings in each plot is recorded as yield per plot.

3.4.10 Yield per hectare

Fruits harvested in each plot from all pickings were weighted in kilograms. Yield per hectare was calculated by using following formula and expressed in quintols per hectare.

$$\text{Yield per hectare (q)} = \frac{\text{Yield per plot (kg)} \times 10000 \text{ m}^2}{\text{Plot area (m}^2) \times 100}$$

3.4.11 Number of locules per fruits

Numbers of locules were counted from five fruits taken at random and cut transversely in the middle.

3.4.12 Total soluble solids (°brix)

A drop of tomato juice from each reference entry was placed on the prism of Brix hand refractrometer and reading was recorded. Necessary temperature corrections were made to room temperature (25°C).

3.4.13 Pericarp thickness

From each plant two to three fruits were cut transversely. The thickness of pericarp was measured with the help of Vernier caliper and average expressed in millimeter.

3.4.14 Fruit length

From each plant five fruits taken at random. The length of fruit was measured from the base of calyx to tip of fruit using Vernier calipers and average is expressed.

3.4.15 Fruit girth

From each plant five fruits were taken at random. The diameter of fruit was measured using Vernier caliper (equatorial length).

3.4.16 Fruit colour

The fruits colour scoring was taken into consideration based on the reference from IBPGR, Rome (Italy).

3.5 Statistical and biometrical analysis

Replication means of various characters of parents and hybrids were subjected to Line × tester ($l \times t$) with randomized block design analysis (Kempthorne, 1957).

3.5.1 Heterosis

The mean of all the replications for each parents, hybrids and check for all characters was computed and used in estimation of heterosis. Heterosis was calculated as the percentage increase or decrease of mean F_1 performance (F_1) over the means of better parent (MP), best parent (BP) and the commercial check (CC).

1. Heterosis over best parent (%) $= \dfrac{\overline{F_1} - \overline{BTP}}{\overline{BTP}} \times 100$

Where, $\overline{BTP}$ is the average of both the parent involved in development of respective F_1 hybrid.

2. Heterosis over the better parent (%) $= \dfrac{\overline{F_1} - \overline{BP}}{\overline{BP}} \times 100$
(Heterobeltiosis)

Where, $\overline{BP}$ is the mean of the best parent among 15 parents involved in development of F_1's for each character.

3. Heterosis over the commercial check (%) $= \dfrac{\overline{F_1} - \overline{CC}}{\overline{CC}} \times 100$
(Standard heterosis)

Where, $\overline{CC}$ is the mean of commercial check.

3.5.2 Combining ability

Variance due to general combining ability (GCA) of parents and specific combining ability (SCA) of crosses (hybrids) were worked out using the procedure developed by Kempthorne (1957).

Table 4: Formulae used for ANOVA for combining ability

Sources	Degrees of freedom	Mean sum of squares	Expected mean sum of squares
Replication	(r - 1)		
Genotype	(l+ t + lt - 1)	Mg	
Parents	(l+ t - 1)	Mp	
Parents Vs crosses	1	Mpc	
Crosses	(lt - 1)	Mc	

Lines	(l- 1)	M_1	σ^2 + rCov (F.S) ï 2Cov (F.S.) + lrCov (H.S.)
Testers	(t - 1)	M_2	σ^2 + rCov (F.S) ï 2Cov (F.S.) + trCov (H.S.)
Line × tester	(l- 1) × (t - 1)	M_3	σ^2 + rCov (F.S) ï 2Cov (F.S.)
Error	(l+ t + lt - 1) (r - 1)	M_4	e^2
Total	($l$tr-1)		

Where

r = number of replications

l = number of lines

t = number of testers

$$\sigma^2_{gca} = Cov\ HS = \frac{1}{r(2lt-1-t)}\left[\frac{(l-1)M_1+(t-1)M_2}{l+t+2} - M_3\right]$$

$$\sigma^2_{gca} = \frac{M_3 - M_4}{r}$$

$$\sigma^2_{sca} = Cov\ HS - 2Cov\ FS$$

Estimation of combining ability effects

The model adopted to estimate gca and sca effects of ijk observations was as follows.

$$X_{ijk} = \mu + g_i + g_j + S_{ij} + e_{ijk}$$

Where,

μ = population mean

g_i = gca effects of i^{th} line

g_j = gca effects of j^{th} tester

S_{ij} = sca effects of i j cross

e_{ijk} = error associated with observation ijk

The gca effects of parents and sca effects of crosses (hybrids) were estimated as indicated below.

General combining ability effects

$$(a)\text{Line}: \; g_i = \frac{x_{i..}}{t \times r} - \frac{x\ldots}{l \times t \times r}$$

$$(b)Testers: \; g_j = \frac{x_{.j.}}{l \times r} - \frac{x_{..}}{l \times t \times r}$$

Specific combining ability effects

$$S_{ij} = \frac{x_{ij}}{r} - \frac{x_{i..}}{t \times r} - \frac{x_{.j..}}{l \times r} + \frac{x\ldots}{l \times t \times r}$$

Where, l = number of lines

t = number of testers

r = number of replications

g_i = gca of i^{th} line

x_i.. = total of i^{th} line over all the testers

x... = total of all the crosses

g_j = gca of j^{th} testers

x_j... = total of j^{th} testers over all lines and replications

S_{ij} = sca effects of i j crosss

x.$_j$. = total of cross i × j over all replications

Standard errors of gca and sca effects

SE (GCA) for lines = $\sqrt{\frac{\text{Error variance}}{\text{t x r}}}$

SE (GCA) for testers = $\sqrt{\frac{\text{Error variance}}{l\text{ x r}}}$

$$\text{SE (SCA)} = \sqrt{\frac{\textit{Error variance}}{r}}$$

$$\text{SE for (BP and Check)} = \sqrt{\frac{2\ \textit{Error variance}}{r}}$$

Critical differences (CD) were calculated by multiplying the SE with tableάtô value at 5 per cent and 1 per cent of probabilities for error degrees of freedom.

4. EXPERIMENTAL RESULTS

The results of the experiment carried out on ‘**Evaluation of F_1 hybrids in tomato (*Solanum lycopersicum* L.)’** are presented in this chapter.

4.1 Analysis of variance

4.2 *Per se* performance and magnitude of heterosis

4.3 Combining ability studies

4.1 Analysis of Variance

The analysis of variance indicated highly significant differences among the parents and crosses for 20 different traits studied, which is presented in table 5. The mean sum of squares due to various sources of variation for characters such as plant height at 30,60 and 90 DAT (days after transplanting), number of primary branches per plant at 30,60 and 90 DAT, days to flower initiation, days to 50 per cent flowering, days to first harvest for earliness, average fruit weight, number of fruits per plant, fruit yield per plant, fruit yield per plot, fruit yield per hectare, number of locules per fruit, TSS, pericarp thickness, fruit length, fruit girth and fruit colour (scoring).

4.1.1 Genotypes

The variance due to genotypes (crosses and parents) was significant (at p=0.01) for all the growth, earliness, yield and quality parameters, *viz.*, plant height at 30,60 and 90 DAT (days after transplanting), number of primary branches per plant at 30,60 and 90 DAT (days after transplanting), days to flower initiation, days to 50 per cent flowering, days to first harvest for earliness, average fruit weight, number of fruits per plant, fruit yield per plant, fruit yield per plot, fruit yield per hectare, number of locules per fruit, TSS, pericarp thickness, fruit length, fruit girth and fruit colour (scoring).

Table 5. Analysis of variance (mean sum of squares) of line × tester analysis for growth, flowering, earliness, fruit yield and quality parameters in tomato

Sl. No.	Character	Replications	Genotypes	Parents	Parents v/s Crosses	Crosses	Lines	Testers	Line × tester	Error
	Degrees of freedom	**1**	**62**	**17**	**1**	**44**	**14**	**2**	**28**	**62**
	Growth Parameters									
1	Plant height at 30DAT	34.530**	164.342**	130.422**	4761.789**	81.658**	80.637 NS	359.877**	62.297**	4.384 NS
2	Plant height at 60 DAT	6.147 NS	235.807**	135.547**	1674.018**	236.333**	173.412 NS	1390.775**	185.334**	15.936 NS
3	Plant height at 90 DAT	103.686**	228.321**	135.794**	1711.409**	226.494**	173.464 NS	1399.125**	169.249**	5.557 NS
4	Number of primary branches at 30 DAT	1.682 NS	3.487**	2.779*	42.021**	2.993**	2.948 NS	12.693**	2.323 NS	1.494 NS
5	Number of primary branches at 60 DAT	13.894**	3.259**	3.213**	37.766**	2.623**	2.381 NS	10.114*	2.210**	0.812 NS
6	Number of primary branches at 90 DAT	60.251**	5.754**	5.199**	57.118**	5.083**	5.886 NS	14.016*	4.043*	2.175 NS
	Flowering and Earliness Parameters									
7	Days to flower initiation	5.452**	19.921**	14.157**	85.787**	21.562**	12.534 NS	164.163**	15.890**	0.564 NS
8	Days to 50 per cent flowering	0.437 NS	10.712**	8.241**	29.562**	11.777**	5.480**	123.049**	6.978**	0.737 NS
9	Days to first harvest for earliness	3.455 NS	27.648**	21.226**	166.642**	27.405**	13.457 NS	287.518**	15.8000**	0.876 NS
	Yield parameters									
10	Average fruit weight	118.301**	1991.819**	2004.703**	233.628**	2084.384**	1148.930 NS	27252.640**	754.378**	6.740 NS
11	Number of fruits per plant	27.384**	224.364**	154.762**	1649.648**	218.862**	255.022*	1612.448**	101.24*	1.916 NS
12	Yield per plant (kg)	10.395**	1.896**	1.084NS	30.942**	1.549**	1.090 NS	9.539**	1.209*	0.610 NS
13	Yield per plot (kg)	56.107**	136.950**	78.318**	2236.854**	111.877**	78.773 NS	689.278**	87.186***	5.194 NS
14	Yield per ha. (q)	0.007 NS	16538.800**	9453.988**	270166.000**	13511.860**	9512.388 NS	83258.870**	10529.660**	6.965 NS
	Quality parameters									
15	Number of locules per fruit	0.275 NS	0.559**	0.153NS	6.403**	0.583**	0.532 NS	0.834 NS	0.591**	0.242 NS
16	TSS	0.187 NS	1.684**	1.529**	2.886**	1.716**	2.060 NS	1.353 NS	1.570**	0.087 NS
17	Pericarp thickness (mm)	0.159 NS	0.450**	0.554**	0.268 NS	0.414**	0.312 NS	2.294**	0.330**	0.082 NS
18	Fruit length(mm)	1.417 NS	29.809**	32.614**	16.073*	29.038**	34.918 NS	48.355 NS	24.718**	3.232 NS
19	Fruit girth (mm)	2.775 NS	42.381**	50.416**	61.672**	38.839**	34.572 NS	99.221 NS	36.659**	7.168 NS
20	Fruit colour (scoring)	0.002 NS	1.076**	0.891**	19.441**	0.730**	0.958 NS	1.059 NS	0.593**	0.087 NS

*and** indicate significance of values at p= 0.05 and p= 0.01, respectively. NS: Non significant, DAT: Days after transplanting.

4.1.2 Parents

Parents differed significantly (at p=0.01) among themselves for traits like growth, earliness, yield and quality parameters studied except yield per plant and number of locules per fruit, which did not vary significantly at p=0.05. Only number of primary branches per plant at 30 DAT varied significantly.

4.1.3 Parents *Vs* Crosses

The variance due to parents *vs.* crosses was found significant (at p=0.01) among themselves for growth, earliness, yield and quality parameters studied except pericarp thickness which did not vary significantly.

4.1.4 Crosses

There was significant (at p=0.01) difference among the crosses for the growth, earliness, yield and quality parameters studied.

4.1.5 Lines

Lines not differed significantly (at p=0.01) among themselves for traits like growth, earliness, yield and quality parameters studied except days to 50 per cent flowering and number of fruits per plant both did vary significantly at p=0.01 and p=0.05 respectively.

4.1.6 Testers

Testers differed significantly (at p=0.01) among themselves for the traits like growth, earliness, yield and quality parameters studied except number of locules per fruit, TSS, fruit length, fruit girth and fruit colour, which did not vary significantly. Number of primary branches per plant at 60 DAT, 90 DAT vary significantly at p=0.05.

4.1.7 Line × Tester

Variance due to line × tester interaction was significant (at p=0.01) for the traits like growth, earliness , yield and quality parameters except number of primary branches

Plate 3. List of the F_1 hybrid fruits along with the commercial check

per plant at 30 DAT and number of primary branches per plant at 90 DAT, number of fruits per plant, yield per plant at p=0.05 only.

4.2 *Per se* performance, magnitude and direction of heterosis

The *per se* performance of parents, crosses and the commercial check presented here under. Heterosis can be defined as superiority of F_1 hybrid over the parents. Heterosis worked out over better parent, the best parent and the commercial check (Arka Rakshak) are presented for growth, earliness, yield and quality parameters. The hybrid (Arka Rakshak) was selected as the commercial check.

4.2.1 Plant height (Table 6 and 8)

Genotypes varied significantly among themselves for plant height at 30,60 and 90 DAT. Plant height at 30 DAT ranged from 29.40 (UHSB-18) to 61.32 cm (UHSB-15) among lines, 47.32 (UHSB-33) to 49.49 cm (UHSB-32) among testers and 50.26 (UHSB-18 × UHSB-32) to 5.81 cm (UHSB-15 × UHSB-37) among crosses.

Magnitude of heterosis over better parent, best parent and the commercial check was significant in both the directions. Maximum positive significant heterosis over better parent (55.31 %) was observed in the cross UHSB-8 × UHSB-37. The cross UHSB-15 × UHSB-37 exhibited maximum positive significant heterosis over best parent (23.63 %) and the cross UHSB-15 × UHSB-37 recorded maximum positive significant heterosis over commercial check (81.71 %). Out of 45 crosses studied, 39 crosses over better parent and 19 crosses over best parent and all the 45 crosses over the commercial check exhibited positive and significant heterosis for plant height at 30 DAT.

Plant height at 60 DAT varied from 66.08 (UHSB-18) to 94.43 cm (UHSB-31) among lines, 65.59 (UHSB-33) to 87.64 cm (UHSB-37) among testers and 65.73 (UHSB-18 × UHSB-37) to 105.21cm (UHSB-30 × UHSB-37) among crosses.

Magnitude of heterosis over better parent and the best parent was significant in both the directions, whereas heterosis over commercial check over all the 45 crosses exhibited positive significant heterosis. Maximum heterosis over better parent (98.63 %) was observed in the cross UHSB-17 × UHSB-37**.** The cross UHSB-30 ×

Table 6. ***Per se*** **performance of crosses, parents and commercial check for growth and earliness parameters in tomato**

Sl.No	Genotype	Plant height (cm)			Number of primary branches per plant			Days to flower initiation	Days to fifty per cent flowering	Days to first harvest for earliness
		30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT			
1	UHSB-4 × UHSB-32	53.27	81.41	91.91	6.23	10.85	13.85	24.50	28.10	67.30
2	UHSB-4 × UHSB-33	60.34	67.13	77.56	6.93	11.55	16.52	21.88	25.16	66.32
3	UHSB-4 × UHSB-37	71.40	94.99	105.49	9.03	12.04	14.85	15.02	19.92	59.78
4	UHSB-8 × UHSB-32	56.92	90.58	103.04	7.42	12.32	11.36	20.26	24.50	65.34
5	UHSB-8 × UHSB-33	56.42	67.76	80.29	8.47	10.69	12.98	17.96	23.52	65.66
6	UHSB-8 × UHSB-37	73.71	87.64	97.51	8.96	11.69	13.25	11.10	19.92	58.48
7	UHSB-11 × UHSB-32	58.94	83.23	94.85	7.84	10.50	12.50	21.24	27.12	70.88
8	UHSB-11 × UHSB-33	55.37	76.79	89.53	5.60	10.57	11.61	15.02	22.86	62.06
9	UHSB-11 × UHSB-37	67.48	81.83	92.75	7.28	12.95	14.73	15.36	22.22	62.40
10	UHSB-14 × UHSB-32	64.26	83.09	92.82	6.79	10.36	11.38	19.92	26.46	66.64
11	UHSB-14 × UHSB-33	61.32	79.52	89.81	7.42	10.15	11.95	17.96	24.18	66.96
12	UHSB-14 × UHSB-37	70.28	102.27	113.96	8.75	13.93	15.63	19.28	24.18	61.42
13	UHSB-15 × UHSB-32	65.87	82.81	94.50	9.10	10.92	12.35	21.24	27.12	71.22
14	UHSB-15 × UHSB-33	59.92	75.46	88.90	5.88	10.22	11.73	21.88	26.46	65.34
15	UHSB-15 × UHSB-37	75.81	97.37	110.04	8.05	12.60	13.53	10.46	19.28	57.16
16	UHSB-17 × UHSB-32	59.22	70.77	83.72	7.56	10.43	13.37	21.24	26.78	70.56
17	UHSB-17 × UHSB-33	55.02	75.39	88.48	6.79	11.30	13.52	21.24	27.12	67.62
18	UHSB-17 × UHSB-37	74.51	101.78	113.96	7.77	14.35	16.45	10.12	21.24	61.08
19	UHSB-18 × UHSB-32	50.26	84.42	95.97	8.26	10.78	13.28	23.84	28.74	72.84
20	UHSB-18 × UHSB-33	53.62	84.77	98.07	5.39	11.76	8.68	24.18	28.42	70.56
21	UHSB-18 × UHSB-37	57.96	65.73	79.94	4.90	10.08	12.40	16.66	23.84	61.74
22	UHSB-20 × UHSB-32	57.33	91.42	104.37	6.37	9.52	12.73	20.58	28.10	66.64
23	UHSB-20 × UHSB-33	64.40	76.72	90.44	7.21	10.36	13.04	22.54	27.12	63.04

Contd…..

Table 6 contd….

Sl.No	Genotype	Plant height (cm)			Number of primary branches per plant			Days to flower initiation	Days to fifty per cent flowering	Days to first harvest for earliness
		30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT			
24	UHSB-20 × UHSB-37	70.21	91.91	104.93	8.12	10.57	13.82	17.96	23.20	64.68
25	UHSB-21 × UHSB-32	72.73	91.91	102.20	8.40	12.88	15.95	17.32	23.20	62.72
26	UHSB-21 × UHSB-33	64.89	77.77	89.39	7.63	10.85	12.85	21.24	27.44	68.92
27	UHSB-21 × UHSB-37	65.73	86.52	98.42	8.61	14.28	16.22	18.62	23.84	59.78
28	UHSB-22 × UHSB-32	62.65	102.13	112.07	8.40	12.39	12.30	20.26	24.82	64.68
29	UHSB-22 × UHSB-33	63.28	70.49	82.53	6.86	11.20	13.33	20.26	25.48	63.04
30	UHSB-22 × UHSB-37	64.68	93.17	105.42	8.54	11.55	12.75	20.58	25.16	61.74
31	UHSB-23 × UHSB-32	61.95	95.55	106.75	8.40	11.76	14.89	18.30	24.18	62.40
32	UHSB-23 × UHSB-33	64.54	96.04	106.75	8.54	12.39	12.35	20.90	25.80	64.68
33	UHSB-23 × UHSB-37	64.47	95.06	108.92	9.66	12.39	14.86	19.92	24.18	65.98
34	UHSB-28 × UHSB-32	64.75	68.81	80.64	8.12	11.55	11.02	20.26	25.48	69.58
35	UHSB-28 × UHSB-33	61.67	76.16	86.73	6.51	12.32	15.34	21.24	25.80	64.36
36	UHSB-28 × UHSB-37	56.21	72.87	84.91	7.63	10.29	12.30	20.58	23.84	62.40
37	UHSB-29 × UHSB-32	52.78	90.02	103.04	6.58	10.92	13.50	21.88	27.12	70.56
38	UHSB-29 × UHSB-33	66.99	79.24	90.79	8.47	10.22	13.17	19.92	25.16	65.98
39	UHSB-29 × UHSB-37	61.18	89.81	103.39	10.24	10.57	12.08	17.96	22.54	62.06
40	UHSB-30 × UHSB-32	56.91	73.08	86.03	6.09	11.34	14.22	20.58	26.78	64.68
41	UHSB-30 × UHSB-33	51.03	70.84	85.26	5.60	9.94	12.90	19.92	25.80	62.06
42	UHSB-30 × UHSB-37	60.90	105.21	117.18	9.10	11.62	14.53	16.66	20.90	60.76
43	UHSB-31 × UHSB-32	61.95	66.50	79.94	7.00	10.15	11.94	22.86	28.10	67.62
44	UHSB-31 × UHSB-33	70.70	78.61	91.14	9.03	11.41	14.25	15.68	21.24	61.08
45	UHSB-31 × UHSB-37	59.71	90.79	103.60	8.82	11.90	14.80	17.96	23.84	62.06

Contd…..

Table 6 contd….

Sl.No	Genotype	Plant height (cm)			Number of primary branches per plant			Days to flower initiation	Days to fifty per cent flowering	Days to first harvest for earliness
		30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT			
	Lines									
46	UHSB-4	44.59	70.14	81.97	7.98	10.43	11.35	21.56	24.82	65.00
47	UHSB-8	45.71	70.63	82.60	6.44	10.36	13.20	21.24	25.48	66.96
48	UHSB-11	39.62	74.18	84.21	5.25	10.64	10.56	21.56	26.78	70.56
49	UHSB-14	42.14	67.62	79.94	5.46	8.68	10.23	23.20	27.12	66.32
50	UHSB-15	61.32	86.80	98.00	6.93	10.01	12.05	19.28	25.48	61.74
51	UHSB-17	51.24	70.42	82.18	7.42	10.15	13.23	18.94	26.78	67.62
52	UHSB-18	29.40	66.08	76.86	4.27	8.33	8.94	25.48	28.42	67.62
53	UHSB-20	58.24	76.51	88.34	7.56	10.01	13.11	24.82	28.42	70.24
54	UHSB-21	54.74	76.93	89.32	8.47	12.60	11.56	20.90	26.14	68.28
55	UHSB-22	55.72	78.75	91.14	7.28	9.38	12.28	17.64	24.82	65.98
56	UHSB-23	48.02	88.83	101.22	6.37	10.15	10.78	19.92	27.76	72.20
57	UHSB-28	47.46	77.49	90.86	6.58	9.29	11.38	20.58	23.84	65.34
58	UHSB-29	52.15	71.75	83.65	6.65	10.83	13.44	16.34	21.56	62.72
59	UHSB-30	47.53	70.28	82.67	5.25	8.47	10.02	18.30	22.86	62.40
60	UHSB-31	54.32	94.43	105.49	5.32	12.60	15.10	24.18	27.76	71.54
	Testers									
61	UHSB-32	49.49	66.85	80.36	6.37	9.94	11.5	21.88	26.46	71.54
62	UHSB-33	47.32	65.59	77.98	5.95	9.8	11.83	21.24	25.48	68.60
63	UHSB-37	47.46	87.64	99.54	5.18	11.48	13.06	21.56	25.80	66.31
64	CC (Arka Rakshak)	41.72	62.09	75.25	5.52	11.13	14.07	22.86	22.41	66.64
	S.Em ±	1.47	2.80	1.73	0.86	0.63	1.04	0.5705	0.65	0.66
	C.D. at 5%	4.15	7.91	4.89	2.42	1.79	2.93	1.61	1.84	1.86
	C.D. at 1%	5.52	10.52	6.50	3.22	2.38	3.90	2.14	2.45	2.47

*and** indicate significance of values at p= 0.05 and p= 0.01, respectively. NS: Non significant, DAT: Days after transplanting

Table 7. ***Per se*** **performance of crosses, parents and commercial check for yield and quality parameters in tomato**

Sl. No.	Genotypes	Average fruit weight (g)	Number of fruits per plant	Yield per plant (kg)	Yield per plot (kg)	Yield per hectare (q/ha)	Number of locules per fruits	TSS 0 Brix	Pericarp thickness (mm)	Fruit length (mm)	Fruit girth (mm)	Fruit colour (Scoring)
1	UHSB-4 × UHSB-32	120.12	38.29	2.89	24.54	269.71	3.50	4.56	4.94	37.30	46.75	4.83
2	UHSB-4 × UHSB-33	111.23	38.43	2.75	23.38	256.96	4.85	3.09	5.39	35.65	44.15	4.83
3	UHSB-4 × UHSB-37	49.63	48.79	1.72	14.64	160.85	3.98	4.84	4.31	38.73	45.22	5.20
4	UHSB-8 × UHSB-32	131.46	37.66	3.15	26.78	294.23	5.07	3.54	5.41	41.78	46.42	5.90
5	UHSB-8 × UHSB-33	106.12	40.04	2.90	24.63	270.69	3.73	4.16	4.81	39.78	47.57	5.53
6	UHSB-8 × UHSB-37	47.25	54.32	1.74	14.82	162.81	4.62	4.22	4.32	30.70	45.15	6.43
7	UHSB-11 × UHSB-32	108.92	44.10	3.60	30.61	336.40	5.12	2.30	5.33	39.70	45.85	5.53
8	UHSB-11 × UHSB-33	95.62	43.96	3.08	26.15	287.37	4.00	4.27	4.31	37.17	49.22	6.80
9	UHSB-11 × UHSB-37	77.56	65.45	4.18	35.52	390.35	3.85	2.49	4.42	39.22	49.05	6.80
10	UHSB-14 × UHSB-32	125.86	41.30	3.75	31.86	350.13	4.03	3.83	4.94	38.72	45.35	5.53
11	UHSB-14 × UHSB-33	103.88	39.97	3.00	25.53	280.50	3.95	3.80	5.22	37.53	47.62	5.73
12	UHSB-14 × UHSB-37	78.19	61.25	3.76	31.95	351.12	4.80	2.40	5.55	28.92	46.45	6.63
13	UHSB-15 × UHSB-32	105.21	47.88	3.80	32.31	355.04	3.92	4.02	5.30	41.08	47.37	6.27
14	UHSB-15 × UHSB-33	117.81	48.58	4.16	35.34	388.38	3.20	3.03	5.11	41.05	45.12	6.63
15	UHSB-15 × UHSB-37	55.86	65.94	3.15	26.78	294.23	4.52	2.27	4.99	46.30	31.05	6.27
16	UHSB-17 × UHSB-32	118.23	41.37	3.65	31.06	341.31	4.92	3.35	5.44	39.67	47.27	5.73
17	UHSB-17 × UHSB-33	132.44	45.85	4.66	39.63	435.46	3.98	2.12	4.80	36.77	46.32	6.43
18	UHSB-17 × UHSB-37	79.59	68.39	4.02	34.18	375.63	3.72	3.52	5.30	38.02	48.30	5.90
19	UHSB-18 × UHSB-32	98.84	39.69	2.84	24.10	264.81	4.03	3.12	5.38	37.12	47.37	5.93
20	UHSB-18 × UHSB-33	123.62	38.71	3.24	27.58	303.06	3.82	3.19	6.02	39.83	48.18	6.80
21	UHSB-18 × UHSB-37	94.43	57.68	3.96	33.65	369.75	4.18	4.84	4.82	32.77	48.17	5.37
22	UHSB-20 × UHSB-32	187.53	40.60	4.73	40.16	441.35	3.70	4.49	5.20	37.93	45.90	5.53

Contd……

Table 7 contd…

Sl. No.	Genotypes	Average fruit weight (g)	Number of fruits per plant	Yield per plant (kg)	Yield per plot (kg)	Yield per hectare (q/ha)	Number of locules per fruits	TSS 0 Brix	Pericarp thickness (mm)	Fruit length (mm)	Fruit girth (mm)	Fruit colour (Scoring)
23	UHSB-20 × UHSB-33	117.95	45.71	3.80	32.31	355.04	3.10	3.11	5.87	38.03	44.77	5.37
24	UHSB-20 × UHSB-37	42.63	54.60	1.84	15.62	171.63	3.07	4.18	5.05	39.38	48.13	5.90
25	UHSB-21 × UHSB-32	72.03	69.58	3.87	32.93	361.90	4.47	4.19	4.73	39.92	46.88	5.20
26	UHSB-21 × UHSB-33	96.39	59.99	4.41	37.49	411.92	3.65	5.07	5.01	39.67	50.22	6.63
27	UHSB-21 × UHSB-37	39.41	52.99	1.51	12.85	141.23	3.80	5.26	4.62	31.90	47.90	5.00
28	UHSB-22 × UHSB-32	104.79	48.23	3.61	30.70	337.38	4.62	4.40	5.58	40.20	50.03	6.80
29	UHSB-22 × UHSB-33	90.44	49.63	3.34	28.38	311.88	3.83	2.09	4.92	41.48	44.60	6.83
30	UHSB-22 × UHSB-37	46.55	46.76	1.41	11.96	131.42	3.30	4.86	4.91	43.80	29.55	5.57
31	UHSB-23 × UHSB-32	80.92	67.90	4.35	36.95	406.04	4.25	3.10	5.05	39.08	44.92	5.73
32	UHSB-23 × UHSB-33	82.17	50.12	3.18	27.04	297.17	3.42	3.54	5.55	38.12	47.53	6.80
33	UHSB-23 × UHSB-37	38.85	77.00	1.98	16.87	185.37	4.60	4.23	4.73	38.70	46.70	6.27
34	UHSB-28 × UHSB-32	103.32	36.05	2.39	20.35	223.62	3.30	1.97	5.86	42.32	47.03	6.80
35	UHSB-28 × UHSB-33	142.45	44.45	4.65	39.54	434.48	4.27	3.23	4.71	41.65	48.38	6.47
36	UHSB-28 × UHSB-37	62.79	56.21	2.50	21.24	233.42	3.75	2.34	4.63	30.12	45.03	5.40
37	UHSB-29 × UHSB-32	95.76	45.36	3.19	27.13	298.15	3.62	3.10	5.48	39.48	48.02	6.43
38	UHSB-29 × UHSB-33	104.58	49.49	3.92	33.29	365.83	4.33	4.37	4.88	40.95	45.33	5.90
39	UHSB-29 × UHSB-37	52.57	67.97	2.82	24.01	263.83	4.77	2.70	4.17	40.15	47.48	6.10
40	UHSB-30 × UHSB-32	125.72	44.38	4.05	34.45	378.58	4.30	2.11	4.90	37.12	49.22	6.83
41	UHSB-30 × UHSB-33	91.56	44.94	2.99	25.44	279.52	4.33	2.85	4.84	40.89	43.58	6.23
42	UHSB-30 × UHSB-37	52.85	49.28	2.03	17.23	189.29	3.43	3.69	4.94	32.05	46.25	5.60
43	UHSB-31 × UHSB-32	127.54	44.73	3.76	31.95	351.12	3.88	3.83	5.74	41.32	46.52	6.60
44	UHSB-31 × UHSB-33	77.00	65.17	3.69	31.33	344.25	3.25	2.31	5.78	41.60	47.37	6.80
45	UHSB-31 × UHSB-37	54.67	59.29	2.43	20.62	226.56	3.70	4.55	4.53	47.78	30.92	5.97

Contd……

Table 7 contd…

Sl. No.	Genotypes	Average fruit weight (g)	Number of fruits per plant	Yield per plant (kg)	Yield per plot (kg)	Yield per hectare (q/ha)	Number of locules per fruits	TSS 0 Brix	Pericarp thickness (mm)	Fruit length (mm)	Fruit girth (mm)	Fruit colour (Scoring)
	Lines											
46	UHSB-4	65.59	29.19	0.79	6.69	73.56	3.34	3.43	4.92	38.13	43.85	4.07
47	UHSB-8	144.41	36.40	3.22	27.40	301.10	3.45	2.19	5.37	39.58	47.70	4.43
48	UHSB-11	108.99	45.22	2.71	23.03	253.04	3.42	4.15	5.03	37.02	50.28	4.43
49	UHSB-14	109.69	33.04	1.73	14.73	161.83	2.94	2.53	5.87	40.27	45.93	4.83
50	UHSB-15	105.35	36.33	2.09	17.76	195.17	3.62	2.94	5.47	38.53	42.87	4.67
51	UHSB-17	101.22	48.09	2.58	21.96	241.27	3.85	3.69	4.67	29.25	42.55	5.73
52	UHSB-18	91.56	34.72	1.43	12.14	133.38	3.64	3.12	5.50	37.85	44.85	4.47
53	UHSB-20	151.06	35.91	3.13	26.60	292.27	3.55	2.97	5.99	35.28	45.20	5.90
54	UHSB-21	52.78	58.87	1.51	12.85	141.23	3.52	2.50	4.57	38.82	45.38	5.90
55	UHSB-22	37.31	43.26	0.89	7.59	83.37	3.92	2.04	4.07	38.78	45.72	5.00
56	UHSB-23	81.55	44.59	1.95	16.60	182.42	3.25	5.11	4.11	40.28	47.03	4.63
57	UHSB-28	129.43	38.22	2.72	23.12	254.02	4.10	4.19	4.62	30.73	44.30	5.73
58	UHSB-29	107.31	45.15	2.58	21.96	241.27	3.35	3.59	5.04	40.55	48.20	5.37
59	UHSB-30	82.25	39.90	1.65	14.01	153.98	3.34	3.66	4.84	40.53	44.53	6.27
60	UHSB-31	78.96	47.04	2.22	18.83	206.94	3.37	2.55	4.83	46.45	26.37	5.90
	Testers											
61	UHSB-32	106.61	37.59	2.30	19.55	214.79	3.39	2.53	4.79	39.43	43.68	4.67
62	UHSB-33	110.67	50.68	3.26	27.67	304.04	3.39	1.98	5.03	39.00	47.33	5.37
63	UHSB-37	58.45	62.86	2.08	17.58	193.21	3.82	4.21	4.56	31.85	40.42	5.73
64	CC (Arka Rakshak)	109.68	43.47	4.31	36.62	402.12	2.85	2.38	5.97	49.53	41.42	5.00
	S.Em +	1.84	0.97	0.55	1.60	1.87	0.35	0.21	0.20	1.26	1.89	0.21
	C.D. at 5%	5.19	2.75	1.57	4.52	5.28	0.98	0.59	0.57	3.56	5.33	0.58
	C.D. at 1%	6.90	3.65	2.08	6.01	7.02	1.30	0.78	0.75	4.74	7.09	0.78

*and** indicate significance of values at p= 0.05 and p= 0.01, respectively. NS: Non significant, DAT: Days after transplanting

Table 8. Heterosis (%) over better parent, the best parent and commercial check for plant height in tomato

Sl No.	Crosses	Plant height at 30 DAT			Plant height at 60 DAT			Plant height at 90 DAT		
		BP	BTP	CC	BP	BTP	CC	BP	BTP	CC
1.	UHSB-4 × UHSB-32	7.64**	-13.13**	27.68**	16.07**	-8.04*	31.12**	12.13**	-12.87**	22.14**
2.	UHSB-4 × UHSB-33	27.51**	-1.60 NS	44.63**	-4.29 NS	-24.17**	8.12*	-5.38*	-26.48**	3.07**
3.	UHSB-4 × UHSB-37	50.44**	16.44**	71.14**	8.39*	7.30 NS	52.99**	5.98*	0.00 NS	40.19**
4.	UHSB-8 × UHSB-32	15.01**	-7.18**	36.43**	28.25**	2.32 NS	45.89**	24.75**	-2.32 NS	36.93**
5.	UHSB-8 × UHSB-33	19.23**	-7.99**	35.23**	-4.06 NS	-23.46**	9.13*	-2.80 NS	-23.89**	6.70**
6.	UHSB-8 × UHSB-37	55.31**	20.21**	76.68**	0.00 NS	-1.01 NS	41.15**	-2.04 NS	-7.56**	29.58**
7.	UHSB-11 × UHSB-32	19.09**	-3.88 NS	41.28**	12.20**	-5.99 NS	34.05**	12.64**	-10.09**	26.05**
8.	UHSB-11 × UHSB-33	17.01**	-9.70**	32.72**	3.52 NS	-13.26**	23.68**	6.32*	-15.13**	18.98**
9.	UHSB-11 × UHSB-37	42.18**	10.05**	61.74**	-6.63 NS	-7.57 NS	31.79**	-6.82**	-12.08**	23.26**
10.	UHSB-14 × UHSB-32	29.84**	4.79*	54.03**	22.88**	-6.14 NS	33.82**	15.51**	-12.01**	23.35**
11.	UHSB-14 × UHSB-33	29.59**	0.00 NS	46.98**	17.60**	-10.18NS	28.07**	12.35**	-14.86**	19.35**
12.	UHSB-14 × UHSB-37	48.08**	14.61**	68.46**	16.69**	15.52**	64.71**	14.49**	8.03**	51.44**
13.	UHSB-15 × UHSB-32	7.42**	7.42**	57.89**	-4.60 NS	-6.46 NS	33.37**	-3.57 NS	-10.42**	25.58**
14.	UHSB-15 × UHSB-33	-2.28 NS	-2.28 NS	43.62**	13.06**	-14.76**	21.53**	-9.29**	-15.73**	18.14**
15.	UHSB-15 × UHSB-37	23.63**	23.63**	81.71**	11.10**	9.99*	56.82**	10.55**	4.31 NS	46.23**
16.	UHSB-17 × UHSB-32	15.57**	-3.42 NS	41.95**	0.50 NS	-20.06**	13.98**	1.87 NS	-20.64**	11.26**
17.	UHSB-17 × UHSB-33	7.38**	-10.27**	31.88**	7.06 NS	-14.84**	21.42**	7.67**	-16.12**	17.58**
18.	UHSB-17 × UHSB-37	45.41**	21.51**	78.60**	98.63**	14.97**	63.92**	14.49**	8.03**	51.44**
19.	UHSB-18 × UHSB-32	1.56 NS	-18.04**	20.47**	26.28**	-4.64 NS	35.96**	19.43**	-9.02**	27.53**
20.	UHSB-18 × UHSB-33	13.31**	-12.56**	28.52**	28.28**	-4.25 NS	36.53**	25.76**	-7.03**	30.33**
21.	UHSB-18 × UHSB-37	22.12**	-5.48*	38.93**	25.00**	-25.75**	5.86 NS	-19.69**	-24.22**	6.23*
22.	UHSB-20 × UHSB-32	-1.56 NS	-6.51**	37.42**	19.49**	3.26 NS	47.24**	18.15**	-1.06 NS	38.70**
23.	UHSB-20 × UHSB-33	10.58**	5.02*	54.36**	0.27 NS	-13.34**	23.56**	2.38 NS	-14.27**	20.19**
24.	UHSB-20 × UHSB-37	20.55**	14.50**	68.29**	4.87 NS	3.82 NS	48.03**	5.41*	-0.53 NS	39.44**
25.	UHSB-21 × UHSB-32	32.86**	18.61**	74.33**	19.47**	3.82 NS	48.03**	14.42**	-3.12 NS	35.81**

Contd….

Table 8 contd…

Sl No.	Crosses	Plant height at 30 DAT			Plant height at 60 DAT			Plant height at 90 DAT		
		BP	**BTP**	**CC**	**BP**	**BTP**	**CC**	**BP**	**BTP**	**CC**
26.	UHSB-21 × UHSB-33	18.54**	5.82**	55.54**	1.09 NS	-12.15**	25.25**	0.08 NS	-15.26**	18.79**
27.	UHSB-21 × UHSB-37	20.08**	7.19**	57.55**	-1.28 NS	-2.27 NS	39.35**	-1.13 NS	-6.70**	30.79**
28.	UHSB-22 × UHSB-32	12.44**	2.17 NS	50.17**	29.69**	15.36**	64.49**	22.96**	6.24*	48.93**
29.	UHSB-22 × UHSB-33	13.57**	3.20 NS	51.68**	-10.49*	-20.38**	13.53**	-9.45**	-21.77**	9.67**
30.	UHSB-22 × UHSB-37	16.08**	5.48*	55.03**	6.31 NS	5.24 NS	50.06**	5.91*	-0.07 NS	40.09**
31.	UHSB-23 × UHSB-32	25.18**	1.03 NS	48.49**	7.57 NS	7.93*	53.89**	5.46*	1.19 NS	41.86**
32.	UHSB-23 × UHSB-33	34.40**	5.25*	54.70**	8.12*	8.48*	54.68**	5.46*	1.19 NS	41.86**
33.	UHSB-23 × UHSB-37	34.26**	5.14*	54.53**	7.01 NS	7.38 NS	53.10**	7.61**	3.25 NS	44.74**
34.	UHSB-28 × UHSB-32	30.83**	5.59**	55.20**	-11.20**	-22.27**	10.82**	-11.25**	-23.56**	7.16**
35.	UHSB-28 × UHSB-33	29.94**	0.57 NS	47.82**	-1.72 NS	-13.97**	22.66**	-4.55 NS	-17.78**	15.26**
36.	UHSB-28 × UHSB-37	18.44**	-8.33**	34.73**	-16.85**	-17.69**	17.36**	-14.70**	-19.51**	12.84**
37.	UHSB-29 × UHSB-32	1.21 NS	-13.93**	26.51**	25.46**	1.68 NS	44.98**	23.18**	-2.32 NS	36.93**
38.	UHSB-29 × UHSB-33	28.46**	9.25**	60.57**	10.44**	-10.49**	27.62**	8.54**	-13.93**	20.65**
39.	UHSB-29 × UHSB-37	17.32**	-0.23 NS	46.64**	2.48 NS	1.45 NS	44.64**	3.87 NS	-1.99 NS	37.40**
40.	UHSB-30 × UHSB-32	14.99**	-7.19**	36.41**	3.98 NS	-17.45**	17.70**	4.06 NS	-18.45**	14.33**
41.	UHSB-30 × UHSB-33	7.36**	-16.78**	22.32**	0.80 NS	-19.98**	14.09**	3.13 NS	-19.18**	13.30**
42.	UHSB-30 × UHSB-37	28.13**	-0.68 NS	45.97**	20.05**	18.84**	69.45**	17.72**	11.08**	55.72**
43.	UHSB-31 × UHSB-32	14.05**	1.03 NS	48.49**	-29.58**	-24.88**	7.10 NS	-24.22**	-24.22**	6.23*
44.	UHSB-31 × UHSB-33	30.15**	15.30**	69.46**	-16.75**	-11.21**	26.61**	-13.60**	-13.60**	21.12**
45.	UHSB-31 × UHSB-37	9.92**	-2.63 NS	43.12**	-3.85 NS	2.55 NS	46.22**	-1.79 NS	-1.79 NS	37.67**
	S.Em ±	1.46	1.46	1.46	2.80	2.80	2.80	1.73	1.73	1.73
	C.D. at 5%	4.15	4.15	4.15	7.91	7.91	7.91	4.89	4.89	4.89
	C.D. at 1%	5.51	5.51	5.51	10.52	10.52	10.52	6.50	6.50	6.50

*and** indicate significance of values at p= 0.05 and p= 0.01, respectively. NS: Non significant, DAT: Days after transplanting

UHSB-37 recorded maximum positive significunt heterosis over the best parent (18.84%) and over commercial check (69.45 %). Among 45 crosses studied, 20 crosses over better parent, 7 crosses over best parent and 43 crosses over the commercial check exhibited positive and significant heterosis for plant height at 60 DAT.

Plant height at 90 DAT varied from 76.86 (UHSB-18) to 105.49 cm (UHSB-31) among lines, 77.98 (UHSB-33) to 99.54 cm (UHSB-37) among testers and 65.73 (UHSB-18 × UHSB-37) to 77.56 cm (UHSB-4 × UHSB-33) among crosses.

Magnitude of heterosis over better parent, best parent and the commercial check was significant in both the directions. Maximum heterosis over better parent (25.76 %) was observed in the cross UHSB-18 × UHSB-33**.** Maximum heterosis over best parent (11.08 %) was observed in the cross UHSB-30 × UHSB-37. All the crosses in the commercial check exhibited positive and significant heterosis and the cross UHSB-30 × UHSB-37 recorded maximum heterosis over commercial check (55.72 %). Among 45 crosses studied, 23 crosses over better parent and four crosses over the best parent and all the 45 crosses over the commercial check exhibited positive and significant heterosis for plant height at 90 DAT.

4.2.2 Number of primary branches per plant (Table 6 and 9)

Genotypes varied significantly among themselves for number of primary branches per plant at 30,60 and 90 DAT. Number of primary branches per plant at 30 DAT ranged from 4.27 (UHSB-18) to 8.47 (UHSB-21) among lines, 5.18 (UHSB-37) to 6.37 (UHSB-32) among testers and 4.9 (UHSB-18 × UHSB-37) to 10.24 (UHSB-29 × UHSB-37) among crosses.

Magnitude of heterosis over better parent, best parent and the commercial check was significant in both the directions. Maximum heterosis over better parent (73.33 %) was observed in the cross UHSB-30 × UHSB-37. Maximum heterosis over best parent (20.90 %) was observed in the cross UHSB-29 × UHSB-37. The cross UHSB-29 × UHSB-37 exhibited maximum heterosis over the commercial check (85.51 %). Among 45 crosses studied, 28 crosses over better parent, nine crosses over best parent and 41 crosses over the commercial check exhibited positive and significant heterosis for number of primary branches per plant at 30 DAT.

Table 9. Heterosis (%) over better parent, the best parent and commercial check for number of primary branches per plant in tomato

Sl. No.	Crosses	Number of primary branches per plant at 30 DAT			Number of primary branches per plant at 60 DAT			Number of primary branches per plant at 90 DAT		
		BP	BTP	CC	BP	BTP	CC	BP	BTP	CC
1.	UHSB-4 × UHSB-32	-21.93**	-26.45**	12.86**	4.03**	-13.89**	-2.25*	17.08**	-8.25**	-1.56 NS
2.	UHSB-4 × UHSB-33	-13.16**	-18.18**	25.54**	10.74**	-8.33**	4.04**	26.49**	9.44**	17.41**
3.	UHSB-4 × UHSB-37	13.16**	6.61**	63.59**	4.88**	-4.44**	8.45**	5.54**	-1.62 NS	5.54**
4.	UHSB-8 × UHSB-32	15.22**	-12.40**	34.42**	18.92**	-2.22*	10.96**	-13.94**	-24.74**	-19.26**
5.	UHSB-8 × UHSB-33	31.52**	0.00 NS	53.44**	3.19**	-15.16**	-3.68**	-1.67 NS	-14.01**	-7.75**
6.	UHSB-8 × UHSB-37	39.13**	5.79**	62.32**	1.83*	-7.22**	5.30**	0.34 NS	-12.26**	-5.86**
7.	UHSB-11 × UHSB-32	23.08**	-7.44**	42.03**	-1.32 NS	-16.67**	-5.39**	8.70**	-17.19**	-11.16**
8.	UHSB-11 × UHSB-33	-5.88**	-33.88**	1.45 NS	-0.66 NS	-16.11**	-4.76**	-1.86 NS	-23.09**	-17.48**
9.	UHSB-11 × UHSB-37	38.67**	-14.05**	31.88**	12.80**	2.78**	16.62**	12.75**	-2.45 NS	4.66**
10.	UHSB-14 × UHSB-32	6.59**	-19.83**	23.01**	4.23**	-17.78**	-6.65**	-1.04NS	-24.61**	-19.12**
11.	UHSB-14 × UHSB-33	24.71**	-12.40**	34.42**	3.57**	-19.44**	-8.54**	5.01**	-20.83**	-15.07**
12.	UHSB-14 × UHSB-37	60.26**	3.31**	58.51**	21.34**	10.56**	25.43**	19.68**	3.54*	11.09**
13.	UHSB-15 × UHSB-32	31.31**	7.44**	64.86**	9.09**	-13.33**	-1.62 NS	2.49NS	-18.18**	-12.22**
14.	UHSB-15 × UHSB-33	-15.15**	-30.58**	6.52**	2.10*	-18.89**	-7.91**	-10.18**	-22.29**	-16.63**
15.	UHSB-15 × UHSB-37	16.16**	-4.96**	45.83**	9.76**	0.00 NS	13.48**	3.56*	-10.40**	-3.87*
16.	UHSB-17 × UHSB-32	1.89 NS	-10.74**	36.96**	2.76**	-17.22**	-6.02**	1.06 NS	-11.43**	-4.98**
17.	UHSB-17 × UHSB-33	-8.49**	-19.83**	23.01**	11.33**	-10.32**	1.80*	2.19 NS	-10.43**	-3.91**
18.	UHSB-17 × UHSB-37	4.72**	-8.26**	40.76**	25.00**	13.89**	29.20**	24.34**	8.98**	16.92**
19.	UHSB-18 × UHSB-32	29.67**	-2.48*	49.64**	8.45**	-14.44**	-2.88**	15.48**	-12.02**	-5.61**
20.	UHSB-18 × UHSB-33	-9.41**	-36.36**	-2.36 NS	20.00**	-6.67**	5.93**	-26.63**	-42.50**	-38.31**
21.	UHSB-18 × UHSB-37	-5.41**	-42.15**	-11.23**	-12.20**	-20.00**	-9.16**	-5.05**	-17.85**	-11.87**
22.	UHSB-20 × UHSB-32	-15.74**	-24.79**	15.40**	-4.90**	-24.44**	-14.20**	-2.94*	-15.70**	-9.56**
23.	UHSB-20 × UHSB-33	-4.63**	-14.88**	30.62**	3.50**	-17.78**	-6.65**	-0.53 NS	-13.61**	-7.32**
24.	UHSB-20 × UHSB-37	7.41**	-4.13**	47.10**	-7.93**	-16.11**	-4.76**	5.42**	-8.45**	-1.78 NS

Contd….

Table 9 contd…..

Sl. No.	Crosses	Number of primary branches per plant at 30 DAT			Number of primary branches per plant at 60 DAT			Number of primary branches per plant at 90 DAT		
		BP	BTP	CC	BP	BTP	CC	BP	BTP	CC
25.	UHSB-21 × UHSB-32	-0.83 NS	-0.83 NS	52.17**	2.22*	2.22*	15.99**	37.98**	5.66**	13.36**
26.	UHSB-21 × UHSB-33	-9.92**	-9.92**	38.22**	-13.89**	-13.89**	-2.25*	8.62**	-14.87**	-8.67**
27.	UHSB-21 × UHSB-37	1.65 NS	1.65 NS	55.98**	13.33**	13.33**	28.57**	24.20**	7.45**	15.28**
28.	UHSB-22 × UHSB-32	15.38**	-0.83 NS	52.17**	24.65**	-1.67 NS	11.59**	0.16 NS	-18.52**	-12.58**
29.	UHSB-22 × UHSB-33	-5.77**	-19.01**	24.28**	14.29**	-11.11**	0.90 NS	8.55**	-11.69**	-5.26**
30.	UHSB-22 × UHSB-37	17.31**	0.83 NS	54.71**	0.61 NS	-8.33**	4.04**	-2.37 NS	-15.53**	-9.38**
31.	UHSB-23 × UHSB-32	31.87**	-0.83 NS	52.17**	15.86**	-6.67**	5.93**	29.43**	-1.39 NS	5.79**
32.	UHSB-23 × UHSB-33	34.07**	0.83 NS	54.71**	22.07**	-1.67 NS	11.59**	4.40**	-18.18**	-12.22**
33.	UHSB-23 × UHSB-37	51.65**	14.05**	75.00**	7.93**	-1.67 NS	11.59**	13.78**	-1.56 NS	5.61**
34.	UHSB-28 × UHSB-32	23.40**	-4.13**	47.10**	16.20**	-8.33**	4.04**	-4.17**	-27.00**	-21.68**
35.	UHSB-28 × UHSB-33	-1.06 NS	-23.14**	17.93**	25.71**	-2.22*	10.96**	29.67**	1.62 NS	9.03**
36.	UHSB-28 × UHSB-37	15.96**	-9.92**	38.22**	-10.37**	-18.33**	-7.28**	-5.86**	-18.55**	-12.62**
37.	UHSB-29 × UHSB-32	-1.05 NS	-22.31**	19.20**	0.83 NS	-13.33**	-1.62 NS	0.45 NS	-10.57**	-4.05**
38.	UHSB-29 × UHSB-33	27.37**	0.00 NS	53.44**	-5.63**	-18.89**	-7.91**	-2.01 NS	-12.75**	-6.40**
39.	UHSB-29 × UHSB-37	53.98**	20.90**	85.51**	-7.93**	-16.11**	-4.76**	-10.12**	-19.97**	-14.14**
40.	UHSB-30 × UHSB-32	-4.40**	-28.10**	10.33**	14.08**	-10.00**	2.16*	23.65**	-5.80**	1.07 NS
41.	UHSB-30 × UHSB-33	-5.88**	-33.88**	1.45 NS	1.43 NS	-21.11**	-10.42**	9.04**	-14.54**	-8.32**
42.	UHSB-30 × UHSB-37	73.33**	7.44**	64.86**	1.22 NS	-7.78**	4.67**	11.26**	-3.74*	3.27*
43.	UHSB-31 × UHSB-32	9.89**	-17.36**	26.81**	-19.44**	-19.44**	-8.54**	-20.93**	-20.90**	-15.14**
44.	UHSB-31 × UHSB-33	51.76**	6.61**	63.59**	-9.44**	-9.44**	2.79**	-5.63**	-5.60**	1.28 NS
45.	UHSB-31 × UHSB-37	65.79**	4.13**	59.78**	-5.56**	-5.56**	7.19**	-1.99 NS	-1.95 NS	5.19**
	S.Em ±	0.86	0.86	0.86	0.63	0.63	0.63	1.04	1.04	1.04
	C.D. at 5%	2.42	2.42	2.42	1.79	1.79	1.79	2.93	2.93	2.93
	C.D. at 1%	3.22	3.22	3.22	2.38	2.38	2.38	3.90	3.90	3.90

*and** indicate significance of values at p= 0.05 and p= 0.01, respectively. NS: Non significant, DAT: Days after transplanting

Number of primary branches per plant at 60 DAT ranged from 8.33 (UHSB-18) to 12.60 (UHSB-21 and UHSB-31) among lines, 9.80 (UHSB-33) to 11.48 (UHSB-37) among testers and 9.52 (UHSB-20 × UHSB-32) to 14.35 (UHSB-17 × UHSB-37) among crosses.

Magnitude of heterosis over better parent, best parent and the commercial check was significant in both the directions. Maximum heterosis over better parent (25.71 %) was observed in the cross UHSB-28 × UHSB-33. Maximum heterosis over best parent (13.89 %) was observed in the cross UHSB-17 × UHSB-37. The cross UHSB-17 × UHSB-37 exhibited maximum heterosis over the commercial check (29.20 %). Among 45 crosses studied, 32 crosses over better parent, five crosses over best parent and 23 crosses over the commercial check exhibited positive and significant heterosis for number of primary branches per plant at 60 DAT.

Number of primary branches per plant at 90 DAT ranged from 8.97 (UHSB-18) to 15.10 (UHSB-31) among lines, 11.50 (UHSB-32) to 13.06 (UHSB-37) among testers and 8.68 (UHSB-18 × UHSB-33) to 16.52 (UHSB-4 × UHSB-33) among crosses.

Magnitude of heterosis over better parent, best parent and the commercial check was significant in both the directions. Maximum positive significant heterosis over better parent (37.98 %) was observed in the cross UHSB-21 × UHSB-32. Maximum positive significant heterosis over best parent (9.44 %) was observed in the cross UHSB-4 × UHSB-33. The cross UHSB-4 × UHSB-33 exhibited maximum positive significant heterosis over the commercial check (17.41 %). Among 45 crosses studied, 32 crosses over better parent, five crosses over best parent and 23 crosses over the commercial check exhibited positive and significant heterosis for number of primary branches per plant at 60 DAT.

4.2.3 Days to flower initiation (Table 6 and 10)

Genotypes varied significantly among themselves for days to flower initiation, varied from 16.34 (UHSB-29) to 25.48 (UHSB-18) among lines, 21.24 (UHSB-33) to 21.88 (UHSB-32) among testers and 10.12 (UHSB-17 × UHSB-37) to 24.50 (UHSB-4 × UHSB-32) among crosses.

Table 10. Heterosis (%) over better parent, best parent and commercial check for earliness traits in tomato

Sl. No.	Crosses	Days to flower initiation			Days to fifty per cent flowering			Days to first fruit harvest		
		BP	BTP	CC	BP	BTP	CC	BP	BTP	CC
1	UHSB-4 × UHSB-32	13.64**	49.97**	7.17**	13.22**	30.33**	25.39**	3.54**	-0.47 NS	0.99 NS
2	UHSB-4 × UHSB-33	3.01**	33.93**	-4.29**	1.37 NS	16.70**	12.27**	2.03*	-1.92*	-0.48 NS
3	UHSB-4 × UHSB-37	-30.33**	-8.06**	-34.30**	-19.74**	-7.61**	-11.11**	-8.03**	-11.59**	-10.29**
4	UHSB-8 × UHSB-32	-4.61**	24.02**	-11.37**	-3.85**	13.64**	9.33**	-2.42*	-3.37**	-1.95*
5	UHSB-8 × UHSB-33	-15.44**	9.94**	-21.43**	-7.69**	9.09**	4.95**	-1.94*	-2.90**	-1.47 NS
6	UHSB-8 × UHSB-37	-47.74**	-32.05**	-51.44**	-21.82**	-7.61**	-11.11**	-11.81**	-13.52**	-12.24**
7	UHSB-11 × UHSB-32	-1.48 NS	30.01**	-7.09**	2.49**	25.79**	21.02**	0.45 NS	4.82**	6.36**
8	UHSB-11 × UHSB-33	-29.28**	-8.06**	-34.30**	-10.28**	6.03**	2.01*	-9.53**	-8.22**	-6.87**
9	UHSB-11 × UHSB-37	-28.76**	-5.98**	-32.81**	-13.88**	3.06**	-0.85 NS	-5.90**	-7.72**	-6.36**
10	UHSB-14 × UHSB-32	-8.96**	21.93**	-12.86**	0.00 NS	22.73**	18.07**	5.06**	-1.45 NS	0.00 NS
11	UHSB-14 × UHSB-33	-15.44**	9.94**	-21.43**	-5.10**	12.15**	7.90**	0.97 NS	-0.98 NS	0.48 NS
12	UHSB-14 × UHSB-37	-10.58**	18.02**	-15.66**	-6.28**	12.15**	7.90**	-7.37**	-9.17**	-7.83**
13	UHSB-15 × UHSB-32	10.17**	30.01**	-7.09**	6.44**	25.79**	21.02**	15.35**	5.32**	6.87**
14	UHSB-15 × UHSB-33	13.49**	33.93**	-4.29**	3.85**	22.73**	18.07**	5.83**	-3.37**	-1.95*
15	UHSB-15 × UHSB-37	-45.75**	-35.97**	-54.24**	-24.33**	-10.58**	-13.97**	-7.42**	-15.47**	-14.23**
16	UHSB-17 × UHSB-32	12.14**	30.01**	-7.09**	1.21 NS	24.21**	19.50**	4.35**	4.35**	5.88**
17	UHSB-17 × UHSB-33	12.14**	30.01**	-7.09**	6.44**	25.79**	21.02**	0.00 NS	0.00 NS	1.47 NS
18	UHSB-17 × UHSB-37	-46.57**	-38.05**	-55.73**	-17.67**	-1.48 NS	-5.22**	-7.89**	-9.67**	-8.34**
19	UHSB-18 × UHSB-32	8.96**	45.93**	4.29**	8.62**	33.30**	28.25**	7.72**	7.72**	9.30**
20	UHSB-18 × UHSB-33	13.84**	48.01**	5.77**	11.54**	31.82**	26.82**	4.35**	4.35**	5.88**
21	UHSB-18 × UHSB-37	-22.73**	1.98*	-27.12**	-7.60**	10.58**	6.38**	-6.89**	-8.70**	-7.35**
22	UHSB-20 × UHSB-32	-5.94**	25.97**	-9.97**	6.20**	30.33**	25.39**	-5.13**	-1.45 NS	0.00 NS
23	UHSB-20 × UHSB-33	6.12**	37.97**	-1.40 NS	6.44**	25.79**	21.02**	-8.10**	-6.77**	-5.40**
24	UHSB-20 × UHSB-37	-16.70**	9.94**	-21.43**	-10.08**	7.61**	3.53**	-2.46*	-4.35**	-2.94**

Contd……

Table 10 contd….

Sl. No.	Crosses	Days to flower initiation			Days to fifty per cent flowering			Days to first fruit harvest		
		BP	BTP	CC	BP	BTP	CC	BP	BTP	CC
25	UHSB-21 × UHSB-32	-17.13**	6.02**	-24.23**	-11.25**	7.61**	3.53**	-8.14**	-7.25**	-5.88**
26	UHSB-21 × UHSB-33	0.00 NS	30.01**	-7.09**	7.69**	27.27**	22.45**	0.94 NS	1.92*	3.42**
27	UHSB-21 × UHSB-37	-10.91**	13.98**	-18.55**	-7.60**	10.58**	6.38**	-9.85**	-11.59**	-10.29**
28	UHSB-22 × UHSB-32	14.85**	24.02**	-11.37**	0.00 NS	15.12**	10.75**	-1.97 NS	-4.35**	-2.94**
29	UHSB-22 × UHSB-33	14.85**	24.02**	-11.37**	2.66**	18.18**	13.70**	-4.46**	-6.77**	-5.40**
30	UHSB-22 × UHSB-37	16.67**	25.97**	-9.97**	-4.91**	16.70**	12.27**	-6.43**	-8.70**	-7.35**
31	UHSB-23 × UHSB-32	-8.13**	12.02**	-19.95**	-5.10**	12.15**	7.90**	-12.78**	-7.72**	-6.36**
32	UHSB-23 × UHSB-33	4.92**	27.93**	-8.57**	0.00 NS	19.67**	15.13**	-5.71**	-4.35**	-2.94**
33	UHSB-23 × UHSB-37	0.00 NS	21.93**	-12.86**	1.43 NS	12.15**	7.90**	-0.50 NS	-2.43*	-0.99 NS
34	UHSB-28 × UHSB-32	-1.55 NS	24.02**	-11.37**	6.88**	18.18**	13.70**	6.49**	2.90**	4.41**
35	UHSB-28 × UHSB-33	3.21**	30.01**	-7.09**	19.67**	19.67**	15.13**	-1.50 NS	-4.82**	-3.42**
36	UHSB-28 × UHSB-37	0.00 NS	25.97**	-9.97**	10.58**	10.58**	6.38**	-4.50**	-7.72**	-6.36**
37	UHSB-29 × UHSB-32	33.90**	33.93**	-4.29**	25.79**	25.79**	21.02**	12.50**	4.35**	5.88**
38	UHSB-29 × UHSB-33	21.91**	21.93**	-12.86**	16.70**	16.70**	12.27**	5.20**	-2.43*	-0.99 NS
39	UHSB-29 × UHSB-37	9.91**	9.94**	-21.43**	4.55**	4.55**	0.58 NS	-1.05 NS	-8.22**	-6.87**
40	UHSB-30 × UHSB-32	12.46**	25.97**	-9.97**	17.15**	24.21**	19.50**	3.65**	-4.35**	-2.94**
41	UHSB-30 × UHSB-33	8.85**	21.93**	-12.86**	12.86**	19.67**	15.13**	-0.54 NS	-8.22**	-6.87**
42	UHSB-30 × UHSB-37	-8.96**	1.98*	-27.12**	-8.57**	-3.06**	-6.74**	-2.63**	-10.14**	-8.82**
43	UHSB-31 × UHSB-32	4.48**	39.93**	0.00 NS	6.20**	30.33**	25.39**	-5.48**	0.00 NS	1.47 NS
44	UHSB-31 × UHSB-33	-26.18**	-4.02**	-31.41**	-16.64**	-1.48 NS	-5.22**	-10.96**	-9.67**	-8.34**
45	UHSB-31 × UHSB-37	-16.70**	9.94**	-21.43**	-7.60**	10.58**	6.38**	-6.41**	-8.22**	-6.87**
	S.Em ±	0.57	0.57	0.57	0.65	0.65	0.65	0.66	0.66	0.66
	C.D. at 5%	1.61	1.61	1.61	1.84	1.84	1.84	1.86	1.86	1.86
	C.D. at 1%	2.14	2.14	2.14	2.45	2.45	2.45	2.47	2.47	2.47

*and** indicate significance of values at p= 0.05 and p= 0.01, respectively. NS: Non significant, DAT: Days after transplanting

Magnitude of heterosis over better parent, best parent and the commercial check was significant in both the directions. Maximum negative heterosis over better parent (-47.74 %) was observed in the cross UHSB-8 × UHSB-37. Maximum negative heterosis over best parent (-38.05 %) was observed in the cross UHSB-17 × UHSB-37. The cross UHSB-17 × UHSB-37 exhibited maximum negative heterosis over the commercial check (-55.73 %). Among 45 crosses studied, 20 crosses over better parent, seven crosses over best parent and 40 crosses over the commercial check exhibited negative and significant heterosis for days to flower initiation.

4.2.4 Days to 50 per cent flowering (Table 6 and 10)

Genotypes varied significantly among themselves for days to 50 per cent flowering, varied from 21.56 (UHSB-29) to 28.42 (UHSB-18 and UHSB-20) among lines, 25.48 (UHSB-33) to 26.46 (UHSB- 32) among testers and 19.28 (UHSB-15 × UHSB-37) to 28.74 (UHSB-18 × UHSB-32) among crosses.

Magnitude of heterosis over better parent, best parent and the commercial check was significant in both the directions. Maximum negative heterosis over better parent (-24.33 %) was observed in the cross UHSB-15 × UHSB-37. Maximum negative heterosis over best parent (-10.58 %) was observed in the cross UHSB-15 × UHSB-37. The cross UHSB-15 × UHSB-37 exhibited maximum negative heterosis over the commercial check (-13.97 %). Among 45 crosses studied, 19 crosses over better parent, three crosses over best parent and seven crosses over the commercial check exhibited negative and significant heterosis for days to 50 per cent flowering.

4.2.5 Days to first harvest for earliness (Table 6 and 10)

Genotypes varied significantly among themselves for days to first harvest for earliness, varied from 61.74 (UHSB-15) to 72.20 (UHSB-23) among lines, 66.31 (UHSB-37) to 71.54 (UHSB-32) among testers and 57.16 (UHSB-15 × UHSB-37) to 72.84 (UHSB-18 × UHSB-32) among crosses.

Magnitude of heterosis over better parent, best parent and the commercial check was significant in both the directions. All the crosses over the best parent exhibited negative and significant heterosis. Maximum negative heterosis over better parent (-12.78 %) was observed in the cross UHSB-23 × UHSB-32. Maximum negative heterosis over best parent (-15.47 %) was observed in the cross UHSB-15 × UHSB-37. The cross UHSB-15 × UHSB-37 exhibited maximum negative heterosis over the commercial check (-14.23 %). Among 45 crosses studied, 23 crosses over better parent, all the 30 crosses over best parent and 26 crosses over the commercial check exhibited negative and significant heterosis for days to first harvest for earliness.

4.2.6 Average fruit weight (Table 7 and 11)

Genotypes varied significantly among themselves for average fruit weight, varied from 37.31 (UHSB-22) to 151.06 g (UHSB-20) among lines, 58.45 (UHSB-37) to 110.67 g (UHSB-33) among testers and 38.85 (UHSB-23 × UHSB-37) to 187.53 g (UHSB-20 × UHSB-32) among crosses.

Magnitude of heterosis over better parent and the commercial check was significant in both directions. The maximum positive and significant heterosis over better parent was observed in the cross UHSB-20 × UHSB-32 (24.14 %), in case of heterosis over best parent all the crosses exhibited negative significant heterosis and the cross UHSB-20 × UHSB-32 exhibited maximum heterosis over the commercial check (70.98 %). Among 45 crosses 10 and 11 crosses showed positive and significant heterosis over better parent and the commercial check respectively for average fruit weight.

4.2.7 Number of fruits per plant (Table 7 and 11)

Genotypes varied significantly among themselves for number of fruits per plant, varied from 29.19 (UHSB-4) to 58.87 (UHSB-21) among lines, 37.59 (UHSB-32) to 62.86 (UHSB-37) among testers and 36.05 (UHSB-23 × UHSB-32) to 77.00 (UHSB-23 × UHSB-37) among crosses.

Magnitude of heterosis over better parent, best parent and the commercial check was significant in both directions. The maximum positive and significant heterosis over better parent was observed in the cross UHSB-23 × UHSB-32 (52.28 %). The maximum positive and significant heterosis over best parent was observed in the cross UHSB-23 × UHSB-37 (30.80 %). The cross UHSB-23 × UHSB-37 exhibited maximum positive significunt heterosis over the commercial check (77.13 %).

Table 11. Heterosis (%) over better parent, the best parent and the commercial check for average fruit weight, number of fruits per plant and yield per plant parameters in tomato

Sl. No.	Crosses	Average fruit weight			Number of fruits per plant			Yield per plant		
		BP	BTP	CC	BP	BTP	CC	BP	BTP	CC
1	UHSB-4 × UHSB-32	12.67**	-20.48**	9.52**	1.86 NS	-34.96**	-11.92**	25.65**	-10.25**	-32.95**
2	UHSB-4 × UHSB-33	0.51 NS	-26.37**	1.41 NS	-24.17**	-34.72**	-11.59**	-15.64**	-14.60**	-36.19**
3	UHSB-4 × UHSB-37	-24.33**	-67.15**	-54.75**	-22.38**	-17.12**	12.24**	-17.31**	-46.58**	-60.09**
4	UHSB-8 × UHSB-32	-8.97**	-12.97**	19.86**	0.19 NS	-36.03**	-13.37**	-2.17**	-2.17**	-26.91**
5	UHSB-8 × UHSB-33	-26.51**	-29.75**	-3.25 NS	-20.99**	-31.99**	-7.89**	-11.04**	-9.94**	-32.71**
6	UHSB-8 × UHSB-37	-67.28**	-68.72**	-56.92**	-13.59**	-7.73**	24.96**	-45.96**	-45.96**	-59.63**
7	UHSB-11 × UHSB-32	-0.06 NS	-27.90**	-0.69 NS	-2.48 NS	-25.09**	1.45 NS	32.84**	11.80**	-16.47**
8	UHSB-11 × UHSB-33	-13.60**	-36.70**	-12.82**	-13.26**	-25.33**	1.13 NS	-5.52**	-4.35**	-28.54**
9	UHSB-11 × UHSB-37	-28.84**	-48.66**	-29.29**	4.12**	11.18**	50.56**	54.24**	29.81**	-3.02**
10	UHSB-14 × UHSB-32	14.74**	-16.68**	14.75**	9.87**	-29.85**	-4.99**	63.04**	16.46**	-12.99**
11	UHSB-14 × UHSB-33	-6.14*	-31.23**	-5.29*	- 80.33**	-32.10**	-8.05**	-100.00**	-6.83**	-30.39**
12	UHSB-14 × UHSB-37	-28.72**	-48.24**	-28.71**	-2.56 NS	4.04**	40.90**	-63.46**	16.77**	-12.76**
13	UHSB-15 × UHSB-32	-1.31 NS	-30.35**	-4.08 NS	27.37**	-18.67**	10.14**	16.56**	18.01**	-11.83**
14	UHSB-15 × UHSB-33	6.45*	-22.01**	7.41**	-4.14**	-17.48**	11.76**	27.61**	29.19**	-3.48**
15	UHSB-15 × UHSB-37	-46.98**	-63.02**	-49.07**	4.90**	12.01**	51.69**	51.44**	-2.17**	-26.91**
16	UHSB-17 × UHSB-32	10.90**	-21.73**	7.80**	-13.97**	-29.73**	-4.83**	41.47**	13.35**	-15.31**
17	UHSB-17 × UHSB-33	19.67**	-12.33**	20.75**	-9.53**	-22.12**	5.48**	42.94**	44.72**	8.12**
18	UHSB-17 × UHSB-37	-21.37**	-47.31**	-27.43**	8.80**	16.17**	57.33**	55.81**	24.84**	-6.73**
19	UHSB-18 × UHSB-32	-7.29**	-34.57**	-9.88**	5.59**	-32.58**	-8.70**	23.48**	-11.80**	-34.11**
20	UHSB-18 × UHSB-33	11.70**	-18.16**	12.71**	-23.62**	-34.24**	-10.95**	-0.61 NS	0.62 NS	-24.83**
21	UHSB-18 × UHSB-37	3.13NS	-37.49**	-13.90**	-8.24**	-2.02 NS	32.69**	90.38**	22.98**	-8.12**
22	UHSB-20 × UHSB-32	24.14**	24.14**	70.98**	8.01**	-31.03**	-6.60**	51.12**	46.89**	9.74**
23	UHSB-20 × UHSB-33	-21.92**	-21.92**	7.54**	-9.81**	-22.35**	5.15**	16.56**	18.01**	-11.83**

Contd…..

Table 11 contd…..

Sl. No.	Crosses	Average fruit weight			Number of fruits per plant			Yield per plant		
		BP	**BTP**	**CC**	**BP**	**BTP**	**CC**	**BP**	**BTP**	**CC**
24	UHSB-20 × UHSB-37	-71.78**	-71.78**	-61.13**	-13.14**	-7.25**	25.60**	-41.21**	-42.86**	-57.31**
25	UHSB-21 × UHSB-32	-32.44**	-52.32**	-34.33**	18.19**	18.19**	60.06**	-62.17**	20.19**	-10.21**
26	UHSB-21 × UHSB-33	-12.90**	-36.19**	-12.12**	1.90 NS	1.90 NS	38.00**	35.28**	36.96**	2.32**
27	UHSB-21 × UHSB-37	-32.57**	-73.91**	-64.07**	-15.70**	-9.99**	21.90**	-27.40**	-53.11**	-64.97**
28	UHSB-22 × UHSB-32	-1.71 NS	-30.63**	-4.46 NS	11.49**	-18.07**	10.95**	56.96**	12.11**	-16.24**
29	UHSB-22 × UHSB-33	-18.28**	-40.13**	-17.54**	-2.07 NS	-15.70**	14.17**	2.45**	3.73**	-22.51**
30	UHSB-22 × UHSB-37	-20.36**	-69.18**	-57.56**	-25.61**	-20.57**	7.57**	-32.21**	-56.21**	-67.29**
31	UHSB-23 × UHSB-32	-24.10**	-46.43**	-26.22**	52.28**	15.34**	56.20**	89.13**	35.09**	0.93 NS
32	UHSB-23 × UHSB-33	-25.76**	-45.61**	-25.09**	-1.10 NS	-14.86**	15.30**	-2.45**	-1.24 NS	-26.22**
33	UHSB-23 × UHSB-37	-52.36**	-74.28**	-64.58**	22.49**	30.80**	77.13**	-4.81**	-38.51**	-54.06**
34	UHSB-28 × UHSB-32	-20.17**	-31.60**	-5.80*	-5.68**	-38.76**	-17.07**	-12.13**	-25.78**	-44.55**
35	UHSB-28 × UHSB-33	10.06**	-5.70**	29.88**	-12.29**	-24.49**	2.25 NS	42.64**	44.41**	7.89**
36	UHSB-28 × UHSB-37	-51.49**	-58.43**	-42.75**	-10.58**	-4.52**	29.31**	-8.09**	-22.36**	-42.00**
37	UHSB-29 × UHSB-32	-10.76**	-36.61**	-12.69**	0.47 NS	-22.95**	4.35**	23.64**	-0.93 NS	-25.99**
38	UHSB-29 × UHSB-33	-5.50*	-30.77**	-4.65 NS	-2.35 NS	-15.93**	13.85**	20.25**	21.74**	-9.05**
39	UHSB-29 × UHSB-37	-51.01**	-65.20**	-52.07**	8.13**	15.46**	56.36**	9.30**	-12.42**	-34.57**
40	UHSB-30 × UHSB-32	17.93**	-16.77**	14.62**	11.23**	-24.61**	2.09 NS	76.09**	25.78**	-6.03**
41	UHSB-30 × UHSB-33	-17.27**	-39.39**	-16.52**	-11.33**	-23.66**	3.38*	-8.28**	-7.14**	-30.63**
42	UHSB-30 × UHSB-37	-35.74**	-65.01**	-51.81**	-474.83**	-16.29**	13.37**	-2.40**	-36.96**	-52.90**
43	UHSB-31 × UHSB-32	19.63**	-15.57**	16.28**	-4.91**	-24.02**	2.90*	63.48**	16.77**	-12.76**
44	UHSB-31 × UHSB-33	-30.42**	-49.03**	-29.80**	28.59**	10.70**	49.92**	13.19**	14.60**	-14.39**
45	UHSB-31 × UHSB-37	-30.76**	-63.81**	-50.15**	-5.68**	0.71	36.39**	9.46**	-24.53**	-43.62**
	S.Em ±	1.84	1.84	1.84	0.97	0.97	0.97	0.55	0.55	0.55
	C.D. at 5%	5.19	5.19	5.19	2.75	2.75	2.75	1.57	1.57	1.57
	C.D. at 1%	6.90	6.90	6.90	3.65	3.65	3.65	2.08	2.08	2.08

*and** indicate significance of values at p= 0.05 and p= 0.01, respectively. NS: Non significant, DAT: Days after transplanting

Among 45 crosses studied 13, nine and 30 crosses shown positive and significant heterosis over better parent, best parent and the commercial check, respectively for number of fruits per plant.

4.2.8 Yield per plant (Table 7 and 11)

Genotypes varied significantly among themselves for yield per plant ranged from 0.79 (UHSB-4) to 3.22 kg (UHSB-8) among lines, 2.08 (UHSB-37) to 3.26 kg (UHSB-33) among testers and 1.41 (UHSB-22 × UHSB-37) to 4.73 kg (UHSB-20 × UHSB-32) among crosses.

Magnitude of heterosis over better parent, best parent and the commercial check was significant in both directions. The maximum positive and significant heterosis over better parent was observed in the cross UHSB-18 × UHSB-37 (90.38%). The maximum positive and significant heterosis over best parent was observed in the cross UHSB-20 × UHSB-32 (46.89%). The cross UHSB-20 × UHSB-32 exhibited maximum positive and significant heterosis over the commercial check (9.74%). Among 45 crosses studied 26, 22 and four crosses shown positive and significant heterosis over better parent, best parent and the commercial check, respectively for yield per plant.

4.2.9 Yield per plot (Table 7 and 12)

Genotypes varied significantly among themselves for yield per plot, ranged from 6.69 (UHSB-4) to 29.40 kg (UHSB-8) among lines, 17.58 (UHSB-37) to 27.67 kg (UHSB-33) among testers and 11.96 (UHSB-22 × UHSB-37) to 40.16 kg (UHSB-20 × UHSB-32) among crosses.

Magnitude of heterosis over better parent, best parent and the commercial check was significant in both directions. The maximum positive and significant heterosis over better parent was observed in the cross UHSB-18 × UHSB-37 (91.41%). The maximum positive and significant heterosis over best parent was observed in the cross UHSB-20 × UHSB-32 (46.57%). The cross UHSB-20 × UHSB-32 expressed maximum positive and significant heterosis over the commercial check (9.67%). Among 45 crosses 26, 21 and three crosses shown positive and significant

Table 12. Heterosis (%) over better parent, the best parent and commercial check for yield per plot and yield per hectare parameters in tomato

Sl. No.	Crosses	Yield per plot			Yield per hectare		
		BP	BTP	CC	BP	BTP	CC
1	UHSB-4 × UHSB-32	25.52**	-10.44**	-32.99**	25.57**	-10.43**	-32.93**
2	UHSB-4 × UHSB-33	-15.50**	-14.67**	-36.16**	-15.48**	-14.66**	-36.10**
3	UHSB-4 × UHSB-37	-16.72**	-46.57**	-60.02**	-16.75**	-46.58**	-60.00**
4	UHSB-8 × UHSB-32	-2.26 NS	-2.26 NS	-26.87**	-2.28 NS	-2.28 NS	-26.83**
5	UHSB-8 × UHSB-33	-10.99**	-10.11**	-32.74**	-10.97**	-10.10**	-32.68**
6	UHSB-8 × UHSB-37	-45.91**	-45.91**	-59.53**	-45.93**	-45.93**	-59.51**
7	UHSB-11 × UHSB-32	32.91**	11.72**	-16.41**	32.94**	11.72**	-16.34**
8	UHSB-11 × UHSB-33	-5.49*	-4.56 NS	-28.59**	-5.48*	-4.56 NS	-28.54**
9	UHSB-11 × UHSB-37	54.23**	29.64**	-3.00 NS	54.26**	29.64**	-2.93 NS
10	UHSB-14 × UHSB-32	62.97**	16.28**	-13.00**	63.01**	16.28**	-12.93**
11	UHSB-14 × UHSB-33	-7.73**	-6.82**	-30.28**	-7.74**	-6.84**	-30.24**
12	UHSB-14 × UHSB-37	81.74**	16.61**	-12.75**	81.73**	16.61**	-12.68**
13	UHSB-15 × UHSB-32	65.27**	17.92**	-11.77**	65.30**	17.91**	-11.71**
14	UHSB-15 × UHSB-33	27.72**	28.98**	-3.50 NS	27.74**	28.99**	-3.42 NS
15	UHSB-15 × UHSB-37	50.79**	-2.26 NS	-26.87**	-51.72**	-2.28 NS	-26.83**
16	UHSB-17 × UHSB-32	41.44**	13.36**	-15.18**	41.46**	13.35**	-15.12**
17	UHSB-17 × UHSB-33	43.22**	44.64**	8.22**	43.22**	44.62**	8.29**
18	UHSB-17 × UHSB-37	55.65**	24.74**	-6.66**	55.71**	24.75**	-6.59*
19	UHSB-18 × UHSB-32	23.27**	-12.04**	-34.19**	23.29**	-12.05**	-34.15**
20	UHSB-18 × UHSB-33	-0.33 NS	0.66 NS	-24.69**	-0.32 NS	0.65 NS	-24.63**
21	UHSB-18 × UHSB-37	91.41**	22.81**	-8.11**	91.37**	22.80**	-8.05**
22	UHSB-20 × UHSB-32	50.98**	46.57**	9.67**	51.01**	46.58**	9.76**
23	UHSB-20 × UHSB-33	16.77**	17.92**	-11.77**	16.77**	17.91**	-11.71**

Contd……

Table 12 contd…..

Sl. No.	Crosses	Yield per plot			Yield per hectare		
		BP	BTP	CC	BP	BTP	CC
24	UHSB-20 × UHSB-37	-41.28**	-42.99**	-57.35**	-41.28**	-43.00**	-57.32**
25	UHSB-21 × UHSB-32	68.44**	20.18**	-10.08**	68.49**	20.19**	-10.00**
26	UHSB-21 × UHSB-33	35.49**	36.82**	2.38 NS	35.48**	36.81**	2.44 NS
27	UHSB-21 × UHSB-37	-26.91**	-53.10**	-64.91**	-26.90**	-53.10**	-64.88**
28	UHSB-22 × UHSB-32	57.03**	12.04**	-16.17**	57.07**	12.05**	-16.10**
29	UHSB-22 × UHSB-33	2.57 NS	3.58 NS	-22.50**	2.58 NS	3.58 NS	-22.44**
30	UHSB-22 × UHSB-37	-31.97**	-56.35**	-67.34**	-31.98**	-56.35**	-67.32**
31	UHSB-23 × UHSB-32	89.00**	34.85**	0.90 NS	89.04**	34.85**	0.97 NS
32	UHSB-23 × UHSB-33	-2.28 NS	-1.31 NS	-26.16**	-2.26 NS	-1.31 NS	-26.10**
33	UHSB-23 × UHSB-37	-4.04 NS	-38.43**	-53.93**	-4.06 NS	-38.44**	-53.90**
34	UHSB-28 × UHSB-32	-11.98**	-25.73**	-44.43**	-11.97**	-25.73**	-44.39**
35	UHSB-28 × UHSB-33	-65.52**	44.31**	7.97**	42.90**	44.30**	8.05**
36	UHSB-28 × UHSB-37	-8.13**	-22.48**	-42.00**	-8.11**	-22.48**	-41.95**
37	UHSB-29 × UHSB-32	23.54**	-0.99 NS	-25.91**	23.58**	-0.98 NS	-25.86**
38	UHSB-29 × UHSB-33	20.31**	21.50**	-9.09**	20.32**	21.50**	-9.02**
39	UHSB-29 × UHSB-37	9.34**	-12.37**	-34.43**	9.35**	-12.38**	-34.39**
40	UHSB-30 × UHSB-32	76.21**	25.73**	-5.93*	76.26**	25.73**	-5.85*
41	UHSB-30 × UHSB-33	-8.06**	-7.15**	-30.53**	-8.06**	-7.17**	-30.49**
42	UHSB-30 × UHSB-37	-1.99 NS	-37.12**	-52.95**	-2.03 NS	-37.13**	-52.93**
43	UHSB-31 × UHSB-32	63.43**	16.61**	-12.75**	63.47**	16.61**	-12.68**
44	UHSB-31 × UHSB-33	13.23**	14.34**	-14.45**	13.23**	14.33**	-14.39**
45	UHSB-31 × UHSB-37	9.51**	-24.74**	-43.69**	9.48**	-24.76**	-43.66**
	S.Em ±	1.60	1.60	1.60	1.87	1.87	1.87
	C.D. at 5%	4.52	4.52	4.52	5.28	5.28	5.28
	C.D. at 1%	6.01	6.01	6.01	7.02	7.02	7.02

*and** indicate significance of values at p= 0.05 and p= 0.01, respectively. NS: Non significant, DAT: Days after transplanting

heterosis over better parent, best parent and the commercial check respectively for yield per plot.

4.2.10 Yield per hectare (Table 7 and 12)

Genotypes varied significantly among themselves for yield per hectare, ranged from 73.56 (UHSB-4) to 301.10 quintal (UHSB-8) among lines, 193.21 (UHSB-37) to 304.04 quintal (UHSB-33) among testers and 131.42 (UHSB-22 × UHSB-37) to 441.35 quintal (UHSB-20 × UHSB-32) among crosses.

Magnitude of heterosis over better parent, best parent and the commercial check was significant in both directions. The maximum positive and significant heterosis over better parent was observed in the cross UHSB-18 × UHSB-37 (91.37%). The maximum positive and significant heterosis over best parent was observed in the cross UHSB-20 × UHSB-32 (46.58%). The cross UHSB-20 × UHSB-32 expressed maximum positive and significant heterosis over the commercial check (9.76 %). Among 45 crosses, 26, 21 and three crosses shown positive and significant heterosis over better parent, the best parent and the commercial check respectively for yield per hectare.

4.2.11 Number of locules per fruit (Table 7 and 13)

Genotypes varied significantly among themselves for number of locules per fruit, ranged from 2.94 (UHSB-14) to 4.10 (UHSB-28) among lines, 3.82 (UHSB-37) to 3.39 (UHSB-32 and UHSB-33) among testers and 3.07 (UHSB-20 × UHSB-37) to 5.12 (UHSB-11 × UHSB-32) among crosses.

Magnitude of heterosis over better parent was significant in both the directions, all the 45 crosses were showing positive and significant heterosis over best parent and all 45 crosses over commercial check. Negative heterosis for this trait and is desirable. Maximum negative heterosis over better parent (-13.66 %) was observed in the cross UHSB-20 × UHSB-37. Among 45 crosses studied 8 crosses over better parent exhibited negative and significant heterosis. Heterosis over best parent and commercial check of all crosses exhibited positive and significant heterosis.

Table 13. Heterosis (%) over better parent, the best parent and commercial check for number of locules per fruits, total soluble solid content of fruit and pericarp thickness of fruit parameters in tomato

Sl. No.	Crosses	Number of locules per fruit			Total soluble solids			Pericarp thickness		
		BP	BTP	CC	BP	BTP	CC	BP	BTP	CC
1	UHSB-4 × UHSB-32	4.79**	19.25**	22.81**	32.94**	8.83**	91.60**	0.41 NS	-17.53**	-17.25**
2	UHSB-4 × UHSB-33	45.21**	65.25**	70.18**	-9.91**	-26.25**	29.83**	7.16**	-10.02**	-9.72**
3	UHSB-4 × UHSB-37	19.16**	35.60**	39.65**	14.96**	15.51**	103.36**	-12.40**	-28.05**	-27.81**
4	UHSB-8 × UHSB-32	49.41**	72.57**	77.72**	39.72**	-15.63**	48.53**	10.81**	-9.68**	-9.38**
5	UHSB-8 × UHSB-33	10.03**	27.09**	30.88**	89.95**	-0.72*	74.79**	-10.43**	-19.70**	-19.43**
6	UHSB-8 × UHSB-37	33.77**	57.24**	61.93**	0.24 NS	0.72*	77.31**	-19.55**	-27.88**	-27.64**
7	UHSB-11 × UHSB-32	50.88**	74.28**	79.47**	-44.58**	-45.11**	-3.36**	5.96**	-11.02**	-10.72**
8	UHSB-11 × UHSB-33	17.99**	36.29**	40.35**	2.89**	1.91**	79.41**	-14.31**	-28.05**	-27.81**
9	UHSB-11 × UHSB-37	12.57**	31.18**	35.09**	-40.86**	-40.57**	4.62**	-12.13**	-26.21**	-25.96**
10	UHSB-14 × UHSB-32	37.07**	37.31**	41.40**	51.38**	-8.59**	60.92**	-15.84**	-17.53**	-17.25**
11	UHSB-14 × UHSB-33	34.35**	34.58**	38.60**	50.20**	-9.31**	59.66**	-11.07**	-12.85**	-12.56**
12	UHSB-14 × UHSB-37	63.27**	63.54**	68.42**	-42.99**	-42.72**	0.84**	-5.45**	-7.35**	-7.04**
13	UHSB-15 × UHSB-32	15.49**	33.39**	37.37**	36.73**	-4.06**	68.91**	-3.11**	-11.52**	-11.22**
14	UHSB-15 × UHSB-33	-5.60**	9.03**	12.28**	3.06**	-27.68**	27.31**	-6.58**	-14.69**	-14.41**
15	UHSB-15 × UHSB-37	24.72**	53.83**	58.42**	-46.08**	-45.82**	-4.62**	-8.78**	-16.69**	-16.42**
16	UHSB-17 × UHSB-32	44.99**	67.46**	72.46**	-9.21**	-20.05**	40.76**	13.57**	-9.18**	-8.88**
17	UHSB-17 × UHSB-33	17.40**	35.60**	39.65**	-42.55**	-49.40**	-10.92**	-4.57**	-19.87**	-19.60**
18	UHSB-17 × UHSB-37	-2.75**	26.58**	30.35**	-16.39**	-15.99**	47.90**	13.49**	-11.52**	-11.22**
19	UHSB-18 × UHSB-32	18.88**	37.31**	41.40**	0.00 NS	-25.54**	31.09**	-2.18**	-10.18**	-9.88**
20	UHSB-18 × UHSB-33	12.54**	29.98**	33.86**	2.24**	-23.87**	34.03**	9.45**	0.50 NS	0.84**
21	UHSB-18 × UHSB-37	14.84**	42.42**	46.67**	14.96**	15.51**	103.36**	-12.36**	-19.53**	-19.26**
22	UHSB-20 × UHSB-32	9.14**	26.06**	29.82**	51.18**	7.16**	88.66**	-13.19**	-13.19**	-12.90**
23	UHSB-20 × UHSB-33	-8.55**	5.62**	8.77**	4.71**	-25.78**	30.67**	-2.00**	-2.00**	-1.68**

Contd……

Table 13 contd…..

Sl. No.	Crosses	Number of locules per fruit			Total soluble solids			Pericarp thickness		
		BP	**BTP**	**CC**	**BP**	**BTP**	**CC**	**BP**	**BTP**	**CC**
24	UHSB-20 × UHSB-37	-13.66**	4.43**	7.54**	-0.71*	-0.24 NS	75.63**	-15.69**	-15.69**	-15.41**
25	UHSB-21 × UHSB-32	31.71**	52.13**	56.67**	65.61**	0.00 NS	76.05**	-1.25**	-21.04**	-20.77**
26	UHSB-21 × UHSB-33	7.67**	24.36**	28.07**	102.80**	21.00**	113.03**	-0.40 NS	-16.36**	-16.08**
27	UHSB-21 × UHSB-37	7.95**	29.47**	33.33**	24.94**	25.54**	121.01**	1.09**	-22.87**	-22.61**
28	UHSB-22 × UHSB-32	36.14**	57.24**	61.93**	73.91**	5.01**	84.87**	16.49**	-6.84**	-6.53**
29	UHSB-22 × UHSB-33	12.98**	30.49**	34.39**	2.45**	-50.12**	-12.18**	-2.19**	-17.86**	-17.59**
30	UHSB-22 × UHSB-37	-13.61**	12.44**	15.79**	15.44**	15.99**	104.20**	7.68**	-18.03**	-17.76**
31	UHSB-23 × UHSB-32	30.77**	44.80**	49.12**	-39.33**	-26.01**	30.25**	5.43**	-15.69**	-15.41**
32	UHSB-23 × UHSB-33	5.08**	16.35**	19.82**	-30.72**	-15.51**	48.74**	10.34**	-7.35**	-7.04**
33	UHSB-23 × UHSB-37	41.54**	56.73**	61.40**	-17.22**	0.95**	77.73**	3.73**	-21.04**	-20.77**
34	UHSB-28 × UHSB-32	-2.65**	12.44**	15.79**	-52.98**	-52.98**	-17.23**	22.34**	-2.17**	-1.84**
35	UHSB-28 × UHSB-33	25.81**	45.32**	49.65**	-22.91**	-22.91**	35.71**	-6.36**	-21.37**	-21.11**
36	UHSB-28 × UHSB-37	-1.83**	27.77**	31.58**	-91.92**	-44.15**	-1.68**	0.22 NS	-22.70**	-22.45**
37	UHSB-29 × UHSB-32	7.91**	23.17**	26.84**	-13.65**	-26.01**	30.25**	8.73**	-8.51**	-8.21**
38	UHSB-29 × UHSB-33	29.25**	47.53**	51.93**	21.73**	4.30**	83.61**	-3.17**	-18.53**	-18.26**
39	UHSB-29 × UHSB-37	42.24**	62.35**	67.19**	-35.87**	-35.56**	13.45**	-17.26**	-30.38**	-30.15**
40	UHSB-30 × UHSB-32	28.74**	46.51**	50.88**	-42.35**	-49.64**	-11.34**	1.24**	-18.20**	-17.92**
41	UHSB-30 × UHSB-33	229.64**	47.53**	51.93**	-22.13**	-31.98**	19.75**	-3.78**	-19.20**	-18.93**
42	UHSB-30 × UHSB-37	2.69**	16.87**	20.35**	-12.35**	-11.93**	55.04**	2.07**	-17.53**	-17.25**
43	UHSB-31 × UHSB-32	15.13**	32.20**	36.14**	50.20**	-8.59**	60.92**	18.84**	-4.17**	-3.85**
44	UHSB-31 × UHSB-33	-3.56**	10.73**	14.04**	-9.41**	-44.87**	-2.94**	14.91**	-3.51**	-3.18**
45	UHSB-31 × UHSB-37	9.79**	26.06**	29.82**	8.08**	8.59**	91.18**	-6.21**	-24.37**	-24.12
	S.Em ±	0.35	0.35	0.35	0.21	0.21	0.21	0.20	0.20	0.20
	C.D. at 5%	0.98	0.98*	0.98	0.59	0.59	0.59	0.57	0.57	0.57
	C.D. at 1%	1.30	1.30	1.30	0.78	0.78	0.78	0.75	0.75	0.75

*and** indicate significance of values at p= 0.05 and p= 0.01, respectively. NS: Non significant, DAT: Days after transplanting

4.2.12 Total soluble solids (Table 7 and 13)

Genotypes varied significantly among themselves for total soluble solid content of fruit and it ranged from 2.04 (UHSB-22) to 5.11 ^{0}brix (UHSB-23) among lines, 1.98 (UHSB-33) to 4.21 ^{0}brix (UHSB-37) among testers and 1.97 (UHSB-23 × UHSB-32) to 5.26 ^{0}brix (UHSB-21 × UHSB-37) among crosses studied.

Magnitude of heterosis over better parent, best parent and the commercial check was significant in both the directions. The maximum positive and significant heterosis over better parent was observed in the cross UHSB-21 × UHSB-33 (102.80 %). The maximum positive and significant heterosis over best parent was observed in the cross UHSB-21 × UHSB-37 (25.54 %). The cross UHSB-21 × UHSB-33 expressed maximum positive significant heterosis over the commercial check (113.03 %). Among 45 crosses 22, 13 and 37 crosses shown positive and significant heterosis over better parent, best parent and the commercial check, respectively for total soluble solids.

4.2.13 Pericarp thickness (Table 7 and 13)

Genotypes varied significantly among themselves for pericarp thickness ranged from 4.07 (UHSB-22) to 5.99 mm (UHSB-20) among lines, 4.56 (UHSB-37) to 5.03 mm (UHSB-33) among testers and 4.17 (UHSB-29 × UHSB-37) to 6.02 mm (UHSB-18 × UHSB-33) among crosses.

Magnitude of heterosis over better parent was significant in both directions. None of crosses exhibited positive and significant heterosis over best parent and commercial check. The maximum positive and significant heterosis over better parent was observed in the cross UHSB-23 × UHSB-32 (22.34 %). Among 45 crosses 18 crosses shown positive and significant heterosis over better parent for pericarp thickness. None of the crosses exhibited positive and significant heterosis among heterosis over best parent and commercial check for the trait total soluble solid content of fruit.

4.2.14 Fruit length (Table 7 and 14)

Genotypes varied significantly among themselves for fruit length ranged from 29.25 (UHSB-17) to 46.45 mm (UHSB-31) among lines, 31.85 (UHSB-37) to 39.43 mm (UHSB-32) among testers and 28.92 (UHSB-14 × UHSB-37) to 47.78 mm (UHSB-31 × UHSB-37) among crosses.

Magnitude of heterosis over better parent was significant in both directions. None of crosses exhibited positive and significant heterosis over best parent and commercial check. The maximum positive and significant heterosis over better parent was observed in the cross UHSB-15 × UHSB-37 (20.17 %). Among all crosses studied 11 crosses exhibited positive and significant heterosis over better parent.

4.2.15 Fruit girth (Table 7 and 14)

Genotypes varied significantly among themselves for fruit girth ranged from 26.37 (UHSB-31) to 50.28 mm (UHSB-11) among lines, 40.42 (UHSB-37) to 47.33 mm (UHSB-33) among testers and 29.55 (UHSB-22 × UHSB-37) to 50.22 mm (UHSB-21 × UHSB-33) among crosses.

Magnitude of heterosis over better parent and the commercial check was significant in both directions. None of crosses exhibited positive and significant heterosis over best parent. The maximum positive and significant heterosis over better parent was observed in the cross UHSB-17 × UHSB-37 (13.51 %). The cross UHSB-21 × UHSB-33 expressed maximum heterosis over the commercial check (21.23 %). Among 45 crosses, 13 and 41 crosses shown positive and significant heterosis over better parent and the commercial check respectively for fruit girth.

4.2.16 Fruit colour scoring (Table 7 and 14)

Genotypes varied significantly among themselves for the fruit colour, ranged from 4.07 (UHSB-4) to 6.27 (UHSB-30) among lines, 4.67 (UHSB-32) to 5.73 (UHSB-37) among testers and 4.83 (UHSB-4 × UHSB-32 and UHSB-4 × UHSB-33) to 6.83 (UHSB-29 × UHSB-32) among crosses.

Magnitude of heterosis over better parent, best parent and the commercial check was significant in both directions. The maximum positive and significant heterosis

Table 14. Heterosis (%) over better parent, the best parent and commercial check for fruit length, fruit girth and fruit colour traits in tomato

Sl. No.	Crosses	Fruit length			Fruit girth			Fruit colour		
		BP	BTP	CC	BP	BTP	CC	BP	BTP	CC
1	UHSB-4 × UHSB-32	-5.40**	-19.70**	-24.69**	6.61*	-7.02*	12.87**	3.43**	-22.91**	-3.40**
2	UHSB-4 × UHSB-33	-8.59**	-23.25**	-28.02**	-6.72*	-12.19**	6.59*	-10.06**	-22.91**	-3.40**
3	UHSB-4 × UHSB-37	1.57 NS	-16.62**	-21.80**	3.11NS	-10.07**	9.16**	-9.25**	-17.00**	4.00**
4	UHSB-8 × UHSB-32	5.56**	-10.05**	-15.65**	-2.69 NS	-7.69**	12.06**	26.34**	-5.83**	18.00**
5	UHSB-8 × UHSB-33	0.51 NS	-14.36**	-19.69**	-0.28 NS	-5.40*	14.84**	2.98**	-11.73**	10.60**
6	UHSB-8 × UHSB-37	-22.44**	-33.91**	-38.02**	-5.35*	-10.20**	9.01**	12.22**	2.63**	28.60**
7	UHSB-11 × UHSB-32	0.68 NS	-14.53**	-19.85**	-8.81**	-8.81**	10.70**	-88.65**	-11.73**	10.60**
8	UHSB-11 × UHSB-33	-4.71*	-19.99**	-24.96**	-2.12NS	-2.12 NS	18.82**	26.63**	8.54**	36.00**
9	UHSB-11 × UHSB-37	5.93**	-15.58**	-20.83**	-2.45 NS	-2.45 NS	18.42**	18.67**	8.54**	36.00**
10	UHSB-14 × UHSB-32	-3.86*	-16.65**	-21.84**	-1.26 NS	-9.81**	9.49**	14.49**	-11.73**	10.60**
11	UHSB-14 × UHSB-33	-6.80**	-19.20**	-24.23**	0.60 NS	-5.30 NS	14.96**	6.70**	-8.54**	14.60**
12	UHSB-14 × UHSB-37	-28.20**	-37.75**	-41.62**	1.13 NS	-7.62**	12.14**	15.71**	5.83**	32.60**
13	UHSB-15 × UHSB-32	4.18*	-11.56**	-17.06**	8.44**	-5.80**	14.35**	34.15**	0.00 NS	25.30**
14	UHSB-15 × UHSB-33	5.26**	-11.63**	-17.12**	-4.68 NS	-10.27**	8.92**	23.46**	5.83**	32.60**
15	UHSB-15 × UHSB-37	20.17**	-0.32 NS	-6.52**	-27.57**	-38.25**	-25.04**	9.34**	0.00 NS	25.30**
16	UHSB-17 × UHSB-32	0.60 NS	-14.61**	-19.92**	8.21**	-6.00*	14.11**	0.00 NS	-8.54**	14.60**
17	UHSB-17 × UHSB-33	-5.73**	-20.85**	-25.77**	-2.14 NS	-7.89**	11.82**	12.22**	2.63**	28.60**
18	UHSB-17 × UHSB-37	19.36**	-18.16**	-23.25**	13.51**	-3.94 NS	16.61**	2.97**	-5.83**	18.00**
19	UHSB-18 × UHSB-32	-5.87**	-20.10**	-25.07**	5.61*	-5.80*	14.35**	26.98**	-5.35**	18.60**
20	UHSB-18 × UHSB-33	2.13 NS	-14.25**	-19.58**	1.80 NS	-4.18 NS	16.32**	26.63**	8.54**	36.00**
21	UHSB-18 × UHSB-37	-13.43**	-29.46**	-33.85**	7.39**	-4.21 NS	16.28**	-6.37**	-14.37**	7.30**
22	UHSB-20 × UHSB-32	-3.80*	-18.34**	-23.42**	1.55 NS	-8.71**	10.82**	-6.27**	-11.73**	10.60**
23	UHSB-20 × UHSB-33	-2.49 NS	-18.13**	-23.22**	-5.42*	-10.97**	8.08**	-9.07**	-14.37**	7.30**

Contd…..

Table 14 contd…..

Sl. No.	Crosses	Fruit length			Fruit girth			Fruit colour		
		BP	**BTP**	**CC**	**BP**	**BTP**	**CC**	**BP**	**BTP**	**CC**
24	UHSB-20 × UHSB-37	11.62**	-15.22**	-20.49**	6.48*	-4.28 NS	16.20**	0.00 NS	-5.83**	18.00**
25	UHSB-21 × UHSB-32	1.23 NS	-14.07**	-19.41**	3.31 NS	-6.76*	13.18**	-11.86**	-17.00**	4.00**
26	UHSB-21 × UHSB-33	1.71 NS	-14.61**	-19.92**	6.10*	-0.13 NS	21.23**	12.37**	5.83**	32.60**
27	UHSB-21 × UHSB-37	-17.83**	-31.32**	-35.59**	5.55*	-4.73 NS	15.64**	-15.25**	-20.19**	0.00 NS
28	UHSB-22 × UHSB-32	1.95 NS	-13.46**	-18.84**	9.43**	-0.50 NS	20.79**	36.00**	8.54**	36.00**
29	UHSB-22 × UHSB-33	6.36**	-10.70**	-16.25**	-5.77*	-11.30**	7.68**	27.19**	9.02**	36.60**
30	UHSB-22 × UHSB-37	12.94**	-5.71**	-11.57**	-35.37**	-41.23**	-28.66**	-2.88**	-11.17**	11.30**
31	UHSB-23 × UHSB-32	-2.98 NS	-15.87**	-21.10**	-4.50 NS	-10.67**	8.44**	22.70**	-8.54**	14.60**
32	UHSB-23 × UHSB-33	-5.37**	-17.94**	-23.05**	0.42 NS	-5.47*	14.75**	26.63**	8.54**	36.00**
33	UHSB-23 × UHSB-37	-3.92*	-16.68**	-21.87**	-0.70 NS	-7.12**	12.75**	9.34**	0.00 NS	25.30**
34	UHSB-28 × UHSB-32	7.32**	-8.90**	-14.57**	6.16*	-6.46*	13.54**	18.67**	8.54**	36.00**
35	UHSB-28 × UHSB-33	6.79**	-10.33**	-15.91**	2.22 NS	-3.78 NS	16.80**	12.83**	3.19**	29.30**
36	UHSB-28 × UHSB-37	-5.45**	-35.17**	-39.20**	1.65 NS	-10.44**	8.72**	-5.76**	-13.81**	8.00**
37	UHSB-29 × UHSB-32	-2.64 NS	-15.01**	-20.29**	-0.38 NS	-4.50 NS	15.92**	19.74**	2.63**	28.60**
38	UHSB-29 × UHSB-33	0.99 NS	-11.84**	-17.32**	-5.95*	-9.84**	9.44**	9.87**	-5.83**	18.00**
39	UHSB-29 × UHSB-37	-0.99 NS	-13.56**	-18.94**	-1.49 NS	-5.57*	14.63**	6.46**	-2.63**	22.00**
40	UHSB-30 × UHSB-32	-8.43**	-20.10**	-25.07**	10.52**	-2.12 NS	18.82**	8.93**	9.02**	36.60**
41	UHSB-30 × UHSB-33	0.88 NS	-11.98**	-17.45**	-7.92**	-13.33**	5.21 NS	-0.64*	-0.56 NS	24.60**
42	UHSB-30 × UHSB-37	-20.92**	-31.00**	-35.29**	3.86 NS	-8.02*	11.66**	-10.69**	-10.61**	12.00**
43	UHSB-31 × UHSB-32	-11.05**	-11.05**	-16.59**	6.49*	-7.49**	12.30**	11.86**	5.35**	32.00**
44	UHSB-31 × UHSB-33	-10.44**	-10.44**	-16.01**	0.07 NS	-5.80*	14.35**	15.25**	8.54**	36.00**
45	UHSB-31 × UHSB-37	2.91 NS	2.86 NS	-3.53**	-23.52**	-38.51**	-25.36**	1.10**	-4.79**	19.30**
	S.Em ±	1.26	1.26	1.26	1.89	1.89	1.89	0.21	0.21	0.21
	C.D. at 5%	3.56	3.56	3.56	5.33	5.33	5.33	0.58	0.58	0.58
	C.D. at 1%	4.74	4.74	4.74	7.09	7.09	7.09	0.78	0.78	0.78

*and** indicate significance of values at p= 0.05 and p= 0.01, respectively. NS: Non significant, DAT: Days after transplanting

over better parent was observed in the cross UHSB-22 × UHSB-32 (36.00 %). The crosses UHSB-22 × UHSB-33 and UHSB-29 × UHSB-32 expressed maximum positive and significant heterosis over the best parent (9.02 %). The crosses UHSB-22 × UHSB-33 and UHSB-29 × UHSB-32 expressed maximum positive and significant heterosis over the commercial check (36.60 %). Among 45 crosses studied 31, 17 and 42 crosses shown positive and significant heterosis over better parent, best parent and the commercial check respectively for fruit colour.

4.3 Combining ability variance (Table 15)

The variance due to general combining ability (GCA), specific combining ability (SCA) and GCA to SCA ratio for various characters are presented in Table-15. Lowest GCA TO SCA ratio observed for TSS with (0.1213), Highest GCA:SCA observed for average fruit weight (2.1095), for plant height 30 DAT (0.4142), for plant height 60 DAT (0.5025), for plant height 90 DAT (0.5299), number of primary branches per plant 30 DAT (0.8477), number of primary branches per plant 60 DAT (0.4322), number of primary branches per plant 90 DAT (0.4625), days to flower initiation (0.6364), days to 50 per cent flowering (1.1311), days to first harvest for earliness (1.1139), number of fruits per plant (1.0424), yield per plant (0.8728), yield per plot (0.5134), yield per ha. (0.4897), number of locules per fruit (0.1405), pericarp thickness (0.5465), fruit length (0.1986), fruit girth (0.2250) and fruit colour (0.2025).

4.3.1 Plant height (Table 16 and 17)

For plant height at 30 DAT, four lines exhibited positive and significant gca effects. The maximum positive and significant gca effects was observed in the line UHSB-21 (5.48). Among testers only UHSB-37 (3.98) showed positive and maximum gca effects. Out of 45 crosses, seven crosses showed positive and significant sca effects and maximum sca effect was observed in the cross UHSB-29 × UHSB-33 (8.34).

With respect to plant height at 60 DAT, two lines expressed significant positive gca effects and the line UHSB-22 (4.92) exhibited maximum positive gca effects. Among testers, UHSB-37 (6.79) showing positive and significant gca effects and 12 crosses shown significant positive sca effects and maximum sca effect was observed in the cross UHSB-22 × UHSB-32 (13.49).

Table 15: Combining ability variance

Sl. No.	Character	GCA	SCA	GCA:SCA
1	Plant height at 30DAT	11.99	28.96	0.41
2	Plant height at 60 DAT	42.56	84.70	0.50
3	Plant height at 90 DAT	43.37	81.85	0.53
4	Number of primary branches 30 DAT	0.35	0.41	0.85
5	Number of primary branches 60 DAT	0.30	0.70	0.43
6	Number of primary branches 90 DAT	0.43	0.93	0.46
7	Days to flower initiation	4.88	7.66	0.64
8	Days to 50 per cent flowering	3.53	3.12	1.13
9	Days to first harvest for earliness	8.31	7.46	1.11
10	Average fruit weight	788.56	373.82	2.11
11	Number of fruits per plant	51.77	49.66	1.04
12	Yield per plant	0.26	0.30	0.87
13	Yield per plot	21.05	41.00	0.51
14	Yield per Ha.	2576.59	5261.35	0.49
15	Number of locules per fruit	0.02	0.17	0.14
16	TSS	0.09	0.74	0.12
17	Pericarp thickness	0.07	0.12	0.55
18	Fruit length	2.13	10.74	0.20
19	Fruit girth	3.32	14.75	0.23
20	Fruit colour	0.05	0.25	0.20

GCA- Variance due to general combining ability, SCA- Variance due to specific combining ability, DAT: Days after transplanting.

Table 16. Estimation of general combining ability for growth, earliness, yield and quality parameters in line × tester study of tomato parents

Sl. No.	Genotypes	Plant height			Number of primary branches per plant			Days to flower initiation	Days to 50 per cent flowering	Days to first fruit harvest for earliness	Average fruit weight	Number of fruits per plant	Yield per plant
	Lines	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT						
1	UHSB-4	-0.63NS	-2.50 NS	-4.08**	-0.26NS	0.09 NS	1.72**	1.26**	-0.41 NS	-0.26 NS	0.94 NS	-8.79**	-0.80*
2	UHSB-8	0.05 NS	-1.68 NS	-2.12*	0.63 NS	0.18 NS	-0.83 NS	-2.77**	-2.16**	-1.57**	2.23*	-6.62**	-0.66*
3	UHSB-11	-1.70NS	-3.06 NS	-3.36**	-0.75NS	-0.05 NS	-0.41 NS	-2.00**	-0.74*	0.38 NS	1.32 NS	0.55*	0.37 NS
4	UHSB-14	2.99**	4.62**	3.13**	0.00 NS	0.09 NS	-0.37 NS	-0.15 NS	0.13 NS	0.28 NS	9.93**	-3.12**	0.25 NS
5	UHSB-15	4.90**	1.54 NS	2.08*	0.02 NS	-0.14 NS	-0.82 NS	-1.35**	-0.52 NS	-0.16 NS	0.24 NS	3.51**	0.45 NS
6	UHSB-17	0.62 NS	-1.03 NS	-0.35NS	-0.28NS	0.64 NS	1.09 NS	-1.67**	0.24 NS	1.69**	17.37**	1.25*	0.86**
7	UHSB-18	-8.35**	-5.37**	-4.41**	-1.47**	-0.51NS	-1.90**	2.35**	2.19**	3.65**	12.91**	-5.26**	0.09 NS
8	UHSB-20	1.68 NS	3.01 NS	4.18**	-0.42NS	-1.24**	-0.16 NS	1.15**	1.33**	0.06 NS	23.32**	-3.65**	0.20 NS
9	UHSB-21	5.48**	1.73 NS	0.94 NS	0.56 NS	1.28**	1.65**	-0.15 NS	0.02 NS	-0.92*	-23.44**	10.23**	0.01 NS
10	UHSB-22	1.24 NS	4.92**	4.28**	0.28 NS	0.33 NS	-0.56 NS	1.16**	0.35 NS	-1.58**	-12.13**	-2.42**	-0.47 NS
11	UHSB-23	1.35 NS	11.88**	11.74**	1.21*	0.79*	0.68 NS	0.50 NS	-0.09 NS	-0.38 NS	-25.41**	14.38**	-0.08 NS
12	UHSB-28	-1.42NS	-11.06**	-11.64**	-0.23NS	0.00 NS	-0.47 NS	1.49**	0.23 NS	0.72 NS	10.14**	-5.05**	-0.07 NS
13	UHSB-29	-1.98*	2.68 NS	3.34**	0.78 NS	-0.82*	-0.44 NS	0.71*	0.13 NS	1.47**	-8.42**	3.65**	0.06 NS
14	UHSB-30	-6.02**	-0.63 NS	0.43 NS	-0.72NS	-0.42 NS	0.53 NS	-0.15 NS	-0.31 NS	-2.23**	-2.68*	-4.42**	-0.23 NS
15	UHSB-31	1.82*	-5.04**	-4.17**	0.63 NS	-0.23 NS	0.31 NS	-0.37 NS	-0.41 NS	-1.14**	-6.32**	5.77**	0.04 NS
	S.Em±	0.60	1.15	0.68	0.35	0.26	0.43	0.22	0.25	0.27	0.75	0.40	0.23
	C.D. at 5%	1.72	3.28	1.94	1.01	0.74	1.21	0.62	0.71	0.77	2.14	1.14	0.64
	C.D.at 1%	2.30	4.39	2.59	1.34	0.99	1.62	0.83	0.94	1.03	2.85	1.52	0.86
	Testers												
16	UHSB-32	-2.32**	0.04NS	-0.28NS	-0.15NS	-0.28 NS	-0.38 NS	1.74**	1.63**	2.85**	21.03**	-4.82**	0.32*
17	UHSB-33	-1.67**	-6.83**	-6.69**	-0.56*	-0.39*	-0.41NS	0.91**	0.63**	0.45*	13.50**	-3.62**	0.33*
18	UHSB-37	3.98**	6.79**	6.96**	0.71**	0.67**	0.79**	-2.66**	-2.27**	-3.30**	-34.53**	8.44**	-0.65**
	S.Em±	0.27	0.52	0.30	0.16	0.12	0.19	0.10	0.11	0.12	0.34	0.18	0.10
	C.D. at 5%	0.77	1.47	0.87	0.45	0.33	0.54	0.28	0.32	0.34	0.96	0.51	0.29
	C.D.at 1%	1.03	1.96	1.16	0.60	0.44	0.72	0.37	0.42	0.46	1.28	0.68	0.38

*and** indicate significance of values at p=0.05 and p=0.01, respectively. *Contd……*

Table 16 contd…….

Sl. No.	Genotypes	Yield per plot	Yield per ha.	Number of locules per fruit	TSS	Pericarp thickness	Fruit length	Fruit girth	Fruit colour
	Lines								
1	UHSB-4	-6.81**	-74.82**	0.10 NS	0.64**	-0.18 NS	-1.47 NS	-0.41 NS	-1.09**
2	UHSB-8	-5.59**	-61.42**	0.46*	0.45**	-0.22 NS	-1.28 NS	0.60 NS	-0.09 NS
3	UHSB-11	3.10**	34.05**	0.31 NS	-0.50**	-0.38**	0.00 NS	2.26*	0.34**
4	UHSB-14	2.12*	23.26**	0.25 NS	-0.18 NS	0.18 NS	-3.64**	0.69 NS	-0.08 NS
5	UHSB-15	3.81**	41.89**	-0.13 NS	-0.42**	0.07 NS	4.11**	-4.60**	0.35**
6	UHSB-17	7.29**	80.14**	0.19 NS	-0.53**	0.12 NS	-0.55 NS	1.51 NS	-0.02 NS
7	UHSB-18	0.78 NS	8.55**	0.00 NS	0.19 NS	0.35**	-2.13**	2.12 NS	-0.01 NS
8	UHSB-20	1.70 NS	18.68**	-0.72**	0.40**	0.31**	-0.25 NS	0.49 NS	-0.44**
9	UHSB-21	0.09 NS	1.02 NS	-0.04 NS	1.32**	-0.28*	-1.54*	2.55*	-0.43**
10	UHSB-22	-3.98**	-43.77**	-0.10 NS	0.26*	0.08 NS	3.13**	-4.39**	0.36**
11	UHSB-23	-0.71 NS	-7.80**	0.08 NS	0.10 NS	0.05 NS	-0.07 NS	0.60 NS	0.23 NS
12	UHSB-28	-0.62 NS	-6.82**	-0.24 NS	-1.01**	0.01 NS	-0.67 NS	1.03 NS	0.18 NS
13	UHSB-29	0.48 NS	5.28**	0.23 NS	-0.13 NS	-0.22 NS	1.50*	1.16 NS	0.10 NS
14	UHSB-30	-1.96*	-21.53**	0.01 NS	-0.64**	-0.17 NS	-2.01**	0.57 NS	0.18 NS
15	UHSB-31	0.30 NS	3.32**	-0.40*	0.04 NS	0.29*	4.87**	-4.18**	0.42**
	S.Em±	0.66	0.76	0.14	0.09	0.08	0.52	0.77	0.09
	C.D. at 5%	1.88	2.17	0.40	0.24	0.24	1.48	2.20	0.24
	C.D.at 1%	2.51	2.90	0.54	0.32	0.31	1.98	2.94	0.32
	Testers								
16	UHSB-32	2.73**	29.99**	0.17NS	-0.06NS	0.22**	0.82*	1.21*	-0.06NS
17	UHSB-33	2.81**	30.84**	-0.16NS	-0.17**	0.09NS	0.65NS	0.88NS	0.21**
18	UHSB-37	-5.54**	-60.83**	-0.01NS	0.24*	-0.31**	-1.46**	-2.09**	-0.15**
	S.Em±	0.29	0.34	0.06	0.04	0.04	0.23	0.35	0.04
	C.D. at 5%	0.84	0.97	0.18	0.11	0.11	0.66	0.99	0.11
	C.D.at 1%	1.12	1.30	0.24	0.15	0.14	0.88	1.32	0.15

*and** indicate significance of values at p=0.05 and p=0.01, respectively.

Table 17. Specific combining ability effects for growth, earliness, yield and quality parameters in tomato

Sl. No.	Genotypes	Plant height			Number of primary branches			Days to flower initiation	Days to 50 per cent flowering	Days to first fruit harvest for earliness	Average fruit weight
		30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT				
1.	UHSB-4 × UHSB-32	-6.09**	0.19 NS	0.53 NS	-1.02 NS	-0.35 NS	-0.84 NS	2.29**	2.07**	-0.01 NS	5.43**
2.	UHSB-4 × UHSB-33	0.34 NS	-7.22*	-7.41**	0.10 NS	0.46 NS	1.86 NS	0.50 NS	0.14 NS	1.41*	4.07*
3.	UHSB-4 × UHSB-37	5.75**	7.03*	6.87**	0.92 NS	-0.11 NS	-1.01 NS	-2.79**	-2.21**	-1.39*	-9.50**
4.	UHSB-8 × UHSB-32	-3.12*	8.55**	9.70**	-0.72 NS	1.03 NS	-0.79 NS	2.08**	0.22 NS	-0.67 NS	15.49**
5.	UHSB-8 × UHSB-33	-4.26**	-7.40*	-6.64**	0.75 NS	-0.49 NS	0.86 NS	0.61 NS	0.24 NS	2.05**	-2.32 NS
6.	UHSB-8 × UHSB-37	7.38**	-1.14 NS	-3.07 NS	-0.04 NS	-0.54 NS	-0.07 NS	-2.68**	-0.46 NS	-1.38*	-13.16**
7.	UHSB-11 × UHSB-32	0.66 NS	2.57 NS	2.75 NS	1.08 NS	-0.56 NS	-0.06 NS	2.29**	1.42*	2.92**	-6.15**
8.	UHSB-11 × UHSB-33	-3.56*	3.00 NS	3.84*	-0.74 NS	-0.38 NS	-0.93 NS	-3.10**	-1.84**	-3.50**	-11.91**
9.	UHSB-11 × UHSB-37	2.90 NS	-5.58 NS	-6.59**	-0.34 NS	0.94 NS	0.99 NS	0.81 NS	0.42 NS	0.58 NS	18.06**
10.	UHSB-14 × UHSB-32	1.29 NS	-5.24 NS	-5.77**	-0.72 NS	-0.84 NS	-1.23 NS	-0.88 NS	-0.11 NS	-1.21 NS	2.19 NS
11.	UHSB-14 × UHSB-33	-2.30NS	-1.94 NS	-2.37 NS	0.33 NS	-0.94 NS	-0.63 NS	-2.01**	-1.39*	1.51*	-12.26**
12.	UHSB-14 × UHSB-37	1.01 NS	7.19*	8.13**	0.39 NS	1.78**	1.85 NS	2.89**	1.51*	-0.29 NS	10.08**
13.	UHSB-15 × UHSB-32	0.99 NS	-2.44 NS	-3.04 NS	1.57 NS	-0.05 NS	0.20 NS	1.64**	1.20 NS	3.80**	-8.78**
14.	UHSB-15 × UHSB-33	-5.61**	-2.92 NS	-2.23 NS	-1.23 NS	-0.64 NS	-0.40 NS	3.11**	1.54*	0.32 NS	11.35**
15.	UHSB-15 × UHSB-37	4.63**	5.37 NS	5.26**	-0.34 NS	0.69 NS	0.20 NS	-4.74**	-2.74**	-4.12**	-2.57 NS
16.	UHSB-17 × UHSB-32	-1.38NS	-11.92**	-11.39**	0.34 NS	-1.32*	-0.70 NS	1.96**	0.10 NS	1.29 NS	-12.89**
17.	UHSB-17 × UHSB-33	-6.23**	-0.43 NS	-0.22 NS	-0.02 NS	-0.34 NS	-0.52 NS	2.79**	1.44*	0.75 NS	8.86**
18.	UHSB-17 × UHSB-37	7.61**	12.35**	11.61**	-0.32 NS	1.66*	1.21 NS	-4.76**	-1.54*	-2.04**	4.03*
19.	UHSB-18 × UHSB-32	-1.37NS	6.07*	4.92**	2.23*	0.18 NS	2.21*	0.54 NS	0.11 NS	1.61*	-27.82**
20.	UHSB-18 × UHSB-33	1.34 NS	13.29**	13.43**	-0.23 NS	1.28 NS	-2.37*	1.71**	0.79 NS	1.73*	4.49*
21.	UHSB-18 × UHSB-37	0.03NS	-19.37**	-18.35**	-2.00*	-1.46*	0.16 NS	-2.24**	-0.89 NS	-3.34**	23.33**
22.	UHSB-20 × UHSB-32	-4.34**	4.70 NS	4.73**	-0.72 NS	-0.35 NS	-0.09 NS	-1.52**	0.33 NS	-0.99 NS	50.46**
23.	UHSB-20 × UHSB-33	2.09 NS	-3.13 NS	-2.79 NS	0.54 NS	0.60 NS	0.25 NS	1.27*	0.35 NS	-2.20**	-11.59**
24.	UHSB-20 × UHSB-37	2.25 NS	-1.56 NS	-1.95 NS	0.18 NS	-0.25 NS	-0.16 NS	0.26 NS	-0.67 NS	3.19**	-38.88**
25.	UHSB-21 × UHSB-32	7.26**	6.47*	5.81**	0.34 NS	0.49 NS	1.32 NS	-3.48**	-3.26**	-3.93**	-18.28**
26.	UHSB-21 × UHSB-33	-1.23NS	-0.80 NS	-0.59 NS	-0.02 NS	-1.43*	-1.75 NS	1.27*	1.98**	4.67**	13.62**

Contd…..

Table 17 contd…..

Sl. No.	Genotypes	Plant height			Number of primary branches			Days to flower initiation	Days to 50 per cent flowering	Days to first fruit harvest for earliness	Average fruit weight
		30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT				
27.	UHSB-21 × UHSB-37	-6.04**	-5.67 NS	-5.21**	-0.32 NS	0.94 NS	0.42 NS	2.22**	1.28*	-0.73 NS	4.66*
28.	UHSB-22 × UHSB-32	1.43 NS	13.49**	12.34**	0.62 NS	0.95 NS	-0.11 NS	-1.85**	-1.97**	-1.32 NS	3.17 NS
29.	UHSB-22 × UHSB-33	1.41 NS	-11.28**	-10.79**	-0.51 NS	-0.12 NS	0.95 NS	-1.02 NS	-0.31 NS	-0.56 NS	-3.65 NS
30.	UHSB-22 × UHSB-37	-2.84NS	-2.22 NS	-1.55 NS	-0.11 NS	-0.83 NS	-0.83 NS	2.87**	2.27**	1.88**	0.49 NS
31.	UHSB-23 × UHSB-32	0.61 NS	-0.04 NS	-0.45 NS	-0.32 NS	-0.14 NS	1.23 NS	-3.15**	-2.17**	-4.80**	-7.42**
32.	UHSB-23 × UHSB-33	2.55 NS	7.32*	5.96**	0.24 NS	0.60 NS	-1.27 NS	0.28 NS	0.45 NS	-0.12 NS	1.36 NS
33.	UHSB-23 × UHSB-37	-3.17*	-7.28*	-5.52**	0.08 NS	-0.46 NS	0.04 NS	2.87**	1.73**	4.92**	6.07**
34.	UHSB-28 × UHSB-32	6.19**	-3.84 NS	-3.18 NS	0.85 NS	0.44 NS	-1.48 NS	-2.18**	-1.19 NS	1.29 NS	-20.57**
35.	UHSB-28 × UHSB-33	2.46 NS	10.38**	9.32**	-0.35 NS	1.33*	2.86**	-0.37 NS	0.13 NS	-1.54*	26.10**
36.	UHSB-28 × UHSB-37	-8.65**	-6.53*	-6.15**	-0.50 NS	-1.76**	-1.38 NS	2.55**	1.07 NS	0.25 NS	-5.53**
37.	UHSB-29 × UHSB-32	-5.22**	3.62 NS	4.24*	-1.70 NS	0.63 NS	0.96 NS	0.22 NS	0.55 NS	1.51*	-9.58**
38.	UHSB-29 × UHSB-33	8.34**	-0.29 NS	-1.60 NS	0.60 NS	0.04 NS	0.66 NS	-0.91 NS	-0.41 NS	-0.67 NS	6.78**
39.	UHSB-29 × UHSB-37	-3.12*	-3.34 NS	-2.65 NS	1.10 NS	-0.67 NS	-1.63 NS	0.70 NS	-0.13 NS	-0.84 NS	2.80 NS
40.	UHSB-30 × UHSB-32	2.95 NS	-10.00**	-9.85**	-0.69 NS	0.65 NS	0.72 NS	-0.22 NS	0.65 NS	-0.67 NS	14.65**
41.	UHSB-30 × UHSB-33	-3.58*	-5.37 NS	-4.21*	-0.77 NS	-0.64 NS	-0.58 NS	-0.05 NS	0.68 NS	-0.89 NS	-11.98**
42.	UHSB-30 × UHSB-37	0.64 NS	15.38**	14.06**	1.46 NS	-0.01 NS	-0.14 NS	0.27 NS	-1.33*	1.56*	-2.66 NS
43.	UHSB-31 × UHSB-32	0.15 NS	-12.17**	-11.35**	-1.14 NS	-0.73 NS	-1.34 NS	2.28**	2.07**	1.19 NS	20.11**
44.	UHSB-31 × UHSB-33	8.25**	6.81*	6.27**	1.31 NS	0.65 NS	1.00 NS	-4.07**	-3.79**	-2.96**	-22.90**
45.	UHSB-31 × UHSB-37	-8.39**	5.37 NS	5.08**	-0.18 NS	0.08 NS	0.35 NS	1.79**	1.71**	1.77*	2.80
	S.Em±	1.05	2.00	1.18	0.61	0.45	0.74	0.38	0.43	0.47	1.30
	C.D. at 5%	2.98	5.69	3.36	1.74	1.28	2.10	1.07	1.22	1.33	3.70
	C.D.at 1%	3.99	7.60	4.49	2.33	1.72	2.81	1.43	1.63	1.78	4.94

*and** indicate significance of values at p=0.05 and p=0.01, respectively.

Table 17 contd…..

Sl. No.	Crosses	Number of fruits per plant	Yield per plant	Yield per plot	Yield per Ha.	Number of locules per fruit	TSS	Pericarp thickness	Fruit length	Fruit girth	Fruit colour
1	UHSB-4 × UHSB-32	1.27 NS	0.12 NS	0.96 NS	10.55**	-0.78*	0.46*	-0.16 NS	-0.74 NS	0.17 NS	-0.06 NS
2	UHSB-4 × UHSB-33	0.22 NS	-0.03 NS	-0.28 NS	-3.05 NS	0.90*	-0.90**	0.42*	-2.22 NS	-2.10 NS	-0.34 NS
3	UHSB-4 × UHSB-37	-1.48 NS	-0.08 NS	-0.68 NS	-7.49**	-0.12 NS	0.44*	-0.26 NS	2.97*	1.94 NS	0.39 NS
4	UHSB-8 × UHSB-32	-1.53 NS	0.23 NS	1.98 NS	21.66**	0.43 NS	-0.37 NS	0.34 NS	3.54**	-1.17 NS	0.01 NS
5	UHSB-8 × UHSB-33	-0.35 NS	-0.03 NS	-0.25 NS	-2.73 NS	-0.58 NS	0.36 NS	-0.12 NS	1.71 NS	0.31 NS	-0.64**
6	UHSB-8 × UHSB-37	1.88 NS	-0.21 NS	-1.72 NS	-18.94**	0.15 NS	0.01 NS	-0.22 NS	-5.26**	0.87 NS	0.62**
7	UHSB-11 × UHSB-32	-2.25*	-0.34 NS	-2.88 NS	-31.63**	0.62 NS	-0.66**	0.42*	0.19 NS	-3.40 NS	-0.78**
8	UHSB-11 × UHSB-33	-3.59**	-0.87 NS	-7.42**	-81.51**	-0.16 NS	1.42**	-0.46*	-2.17 NS	0.30 NS	0.21 NS
9	UHSB-11 × UHSB-37	5.84**	1.21*	10.30**	113.14**	-0.47 NS	-0.77**	0.04 NS	1.98 NS	3.10 NS	0.57**
10	UHSB-14 × UHSB-32	-1.39 NS	-0.07 NS	-0.65 NS	-7.11**	-0.40 NS	0.55*	-0.52*	2.85*	-2.33 NS	-0.37 NS
11	UHSB-14 × UHSB-33	-3.92**	-0.83 NS	-7.06**	-77.59**	-0.15 NS	0.63**	-0.10 NS	1.83 NS	0.26 NS	-0.45*
12	UHSB-14 × UHSB-37	5.31**	0.91 NS	7.71**	84.70**	0.55 NS	-1.18**	0.62**	-4.68**	2.07 NS	0.81**
13	UHSB-15 × UHSB-32	-1.44 NS	-0.22 NS	-1.90 NS	-20.83**	-0.13 NS	0.98**	-0.06 NS	-2.55 NS	4.98*	-0.06 NS
14	UHSB-15 × UHSB-33	-1.93 NS	0.13 NS	1.06 NS	11.66**	-0.51 NS	0.10 NS	-0.11 NS	-2.41 NS	3.06 NS	0.03 NS
15	UHSB-15 × UHSB-37	3.37**	0.10S NS	0.84 NS	9.18**	0.64 NS	-1.07**	0.17 NS	4.95**	-8.04**	0.03 NS
16	UHSB-17 × UHSB-32	-5.68**	-0.78 NS	-6.63**	-72.81**	0.54 NS	0.42 NS	0.04 NS	0.70NS	-1.24 NS	-0.23 NS
17	UHSB-17 × UHSB-33	-2.40*	0.22 NS	1.87 NS	20.49**	-0.06 NS	-0.70**	-0.47*	-2.03 NS	-1.86 NS	0.20 NS
18	UHSB-17 × UHSB-37	8.08**	0.56 NS	4.76**	52.33**	-0.48 NS	0.29 NS	0.43*	1.33 NS	3.10 NS	0.03 NS
19	UHSB-18 × UHSB-32	-0.85 NS	-0.83 NS	-7.07**	-77.72**	-0.15 NS	-0.53*	-0.25 NS	-0.27 NS	-1.75 NS	-0.04 NS
20	UHSB-18 × UHSB-33	-3.03**	-0.44 NS	-3.67*	-40.32**	-0.03 NS	-0.35 NS	0.53*	2.61*	-0.60 NS	0.56*
21	UHSB-18 × UHSB-37	3.88**	1.26*	10.74**	118.04**	0.18 NS	0.89**	-0.28 NS	-2.34 NS	2.35 NS	-0.52*
22	UHSB-20 × UHSB-32	-1.55 NS	0.95 NS	8.07**	88.69**	0.24 NS	0.63**	-0.40 NS	-1.33 NS	-1.58 NS	0.00 NS
23	UHSB-20 × UHSB-33	2.36*	0.01 NS	0.14 NS	1.53 NS	-0.03 NS	-0.64**	0.41*	-1.06 NS	-2.38 NS	-0.45*
24	UHSB-20 × UHSB-37	-0.81 NS	-0.97 NS	-8.21**	-90.21**	-0.22 NS	0.02 NS	-0.01 NS	2.40 NS	3.96*	0.45*

Contd……

Table 17 contd……

Sl. No.	Crosses	Number of fruits per plant	Yield per plant	Yield per plot	Yield per Ha.	Numbero f locules per fruit	TSS	Pericarp thickness	Fruit length	Fruit girth	Fruit colour
25	UHSB-21 × UHSB-32	13.54**	0.29 NS	2.45 NS	26.89**	0.32 NS	-0.59**	-0.28 NS	1.94 NS	-2.66 NS	-0.35 NS
26	UHSB-21 × UHSB-33	2.76**	0.82 NS	6.93**	76.06**	-0.16 NS	0.40 NS	0.14 NS	1.86 NS	1.00 NS	0.81**
27	UHSB-21 × UHSB-37	-16.30**	-1.10 NS	-9.37**	-102.96**	-0.17 NS	0.18 NS	0.14 NS	-3.80**	1.66 NS	-0.46*
28	UHSB-22 × UHSB-32	4.84**	0.50 NS	4.29*	47.16**	0.53 NS	0.68**	0.22 NS	-2.44 NS	7.43**	0.47*
29	UHSB-22 × UHSB-33	5.05**	0.22 NS	1.89 NS	20.81**	0.08 NS	-1.52**	-0.30 NS	-0.99 NS	2.33 NS	0.22 NS
30	UHSB-22 × UHSB-37	-9.88**	-0.73 NS	-6.19**	-67.98**	-0.61 NS	0.84**	0.08 NS	3.44**	-9.75**	-0.69**
31	UHSB-23 × UHSB-32	7.71**	0.86 NS	7.27**	79.86**	-0.01 NS	-0.46*	-0.28 NS	-0.37 NS	-2.68 NS	-0.47*
32	UHSB-23 × UHSB-33	-11.27**	-0.32 NS	-2.72 NS	-29.86**	-0.51 NS	0.09 NS	0.35 NS	-1.16 NS	0.27 NS	0.32 NS
33	UHSB-23 × UHSB-37	3.56*	-0.54 NS	-4.55**	-49.99**	0.52 NS	0.37 NS	-0.07 NS	1.53 NS	2.41 NS	0.15 NS
34	UHSB-28 × UHSB-32	-4.70**	-1.11*	-9.42**	-103.54**	-0.64 NS	-0.48*	0.57**	3.47**	-0.99 NS	0.64**
35	UHSB-28 × UHSB-33	2.50*	1.14*	9.69**	106.47**	0.66 NS	0.89**	-0.44*	2.98*	0.69 NS	0.03 NS
36	UHSB-28 × UHSB-37	2.20*	-0.03 NS	-0.27 NS	-2.92 NS	-0.02 NS	-0.41 NS	-0.13 NS	-6.45**	0.31 NS	-0.67**
37	UHSB-29 × UHSB-32	-4.10**	-0.44 NS	-3.74*	-41.11**	-0.79*	-0.23 NS	0.41*	-1.53 NS	-0.14 NS	0.35 NS
38	UHSB-29 × UHSB-33	-1.16 NS	0.28 NS	2.34 NS	25.72**	0.26 NS	1.15**	-0.05 NS	0.11 NS	-2.49 NS	-0.46*
39	UHSB-29 × UHSB-37	5.26**	0.16NS	1.40 NS	15.39**	0.53 NS	-0.93**	-0.36 NS	1.42 NS	2.63 NS	0.10 NS
40	UHSB-30 × UHSB-32	3.00**	0.71 NS	6.02**	66.13**	0.11 NS	-0.71**	-0.22 NS	-0.39 NS	1.66 NS	0.67**
41	UHSB-30 × UHSB-33	2.36*	-0.36 NS	-3.07 NS	-33.78**	0.47 NS	0.14 NS	-0.14 NS	3.56**	-3.65 NS	-0.20 NS
42	UHSB-30 × UHSB-37	-5.36**	-0.34 NS	-2.94 NS	-32.34**	-0.58 NS	0.57**	0.36 NS	-3.17*	1.99 NS	-0.47*
43	UHSB-31 × UHSB-32	-6.85**	0.15 NS	1.26 NS	13.82**	0.10 NS	0.33 NS	0.17 NS	-3.07*	3.71 NS	0.21 NS
44	UHSB-31 × UHSB-33	12.40**	0.07 NS	0.56 NS	6.10**	-0.20 NS	-1.08**	0.34 NS	-2.61*	4.89*	0.13 NS
45	UHSB-31 × UHSB-37	-5.54**	-0.21 NS	-1.81 NS	-19.92**	0.10 NS	0.75**	-0.51*	5.68**	-8.59**	-0.34 NS
	S.Em±	0.69	0.39	1.14	1.32	0.25	0.15	0.14	0.90	1.34	0.15
	C.D. at 5%	1.97	1.11	3.25	3.76	0.70	0.42	0.41	2.56	3.82	0.42
	C.D. at 1%	2.64	1.49	4.34	5.02	0.94	0.56	0.54	3.42	5.10	0.56

*and** indicate significance of values at p=0.05 and p=0.01, respectively.

With respect to plant height at 90 DAT, six lines expressed significant positive gca effects and the line UHSB-23 (11.74) exhibited maximum positive gca effects. Among testers, UHSB-37 (6.96) showing positive and significant gca effects and 17 crosses shown significant positive sca effects and maximum sca effect was observed in the cross UHSB-30 × UHSB-37 (14.06).

4.3.2 Number of primary branches per plant (Table 16 and 17)

For number of primary branches per plant at 30 DAT, one line expressed significant positive gca effects and the line UHSB-23 (1.21) exhibited maximum positive gca effects. Among testers, UHSB-37 (0.71) showing positive and significant gca effects and one cross shown significant positive sca effects with maximum sca effects was observed in that cross UHSB-18 × UHSB-32 (2.23).

For number of primary branches per plant 60 DAT two lines expressed significant positive gca effects and the line UHSB-21 (1.28) exhibited maximum positive gca effects. Among testers, UHSB-37 (0.67) showing positive and significant gca effects and three crosses shown significant positive sca effects with maximum sca effect was observed in the cross UHSB-14 × UHSB-37 (1.78).

For number of primary branches per plant at 90 DAT, two lines expressed significant positive gca effects and the line UHSB-4 (1.72) exhibited maximum positive gca effects. Among testers, UHSB-37 (0.79) showing positive and significant gca effects and two crosses shown significant positive sca effects with maximum sca effect was observed in the cross UHSB-28 × UHSB-33 (2.86).

4.3.3 Days to flower initiation (Table 16 and 17)

For days to flower initiation six lines expressed significant positive gca effects and the line UHSB-18 (2.35) exhibited maximum positive gca effects. Among testers, UHSB-32 (1.74) showing maximum positive and significant gca effects and 17 crosses shown significant positive sca effects with maximum sca effect was observed in that cross UHSB-15 × UHSB-33 (3.11).

4.3.4 Days to 50 per cent flowering (Table 16 and 17)

For days to 50 per cent flowering two lines expressed significant positive gca effects and the line UHSB-18 (2.19) exhibited maximum positive gca effects. Among testers, UHSB-32 (1.63) showing maximum positive and significant gca effects and 11 crosses shown significant positive sca effects with maximum sca effects was observed in that cross UHSB-22 × UHSB-37 (2.27).

4.3.5 Days to first harvest for earliness (Table 16 and 17)

For days to first harvest for earliness three lines expressed significant positive gca effects and the line UHSB-18 (3.65) exhibited maximum positive sigificunt gca effects. Among testers, UHSB-32 (2.85) showing maximum positive and significant gca effects and 14 crosses shown significant positive sca effects with maximum sca effects was observed in that cross UHSB-23 × UHSB-37 (4.92).

4.3.6 Average fruit weight (Table 16 and 17)

For average fruit weight six lines expressed significant positive gca effects and the line UHSB-20 (23.32) exhibited maximum positive gca effects. Among testers, UHSB-32 (21.03) showing maximum positive and significant gca effects and 18 crosses shown significant positive sca effects with maximum sca effects was observed in that cross UHSB-20 × UHSB-32 (50.46).

4.3.7 Number of fruits per plant (Table 16 and 17)

For number of fruits per plant seven lines expressed significant positive gca effects and the line UHSB-23 (14.38) exhibited maximum positive gca effects. Among testers, UHSB-37 (8.44) showing maximum positive and significant gca effects and 18 crosses shown significant positive sca effects with maximum sca effect was observed in that cross UHSB-21 × UHSB-32 (13.54).

4.3.8 Yield per plant (Table 16 and 17)

For yield per plant one line expressed significant positive gca effects and the line is UHSB-17 (0.86). Among testers, UHSB-33 (0.33) showing maximum positive and significant gca effects and three crosses shown significant positive sca effects with maximum sca effect was observed in that cross UHSB-28 × UHSB-33 (1.14).

4.3.9 Yield per plot (Table 16 and 17)

For yield per plot four lines expressed significant positive gca effects and the line UHSB-17 (7.29) exhibited maximum positive gca effects. Among testers, UHSB-33 (2.81) showing maximum positive and significant gca effects and 10 crosses shown significant positive sca effects with maximum sca effects was observed in that cross UHSB-18 × UHSB-37 (10.74).

4.3.10 Yield per hectare (Table 16 and 17)

For yield per hectare eight lines expressed significant positive gca effects and the line UHSB-17 (80.14) exhibited maximum positive gca effects. Among testers, UHSB-33 (30.84) showing maximum positive and significant gca effects and 21 crosses shown significant positive sca effects with maximum sca effect was observed in that cross UHSB-18 × UHSB-37 (118.04).

4.3.11 Number of locules per fruit (Table 16 and 17)

For number of locules per fruit one line expressed significant positive gca effects and the line is UHSB-8 (0.46). Among testers none of them shown positive and significant gca effects and one cross shown significant positive sca effects, that is in the cross UHSB-4 × UHSB-33 (0.90).

4.3.12 Total soluble solids (Table 16 and 17)

For total soluble solid content five lines expressed significant positive gca effects and the line UHSB-21 (1.32) exhibited maximum positive gca effects. Among testers UHSB-37 (0.24) showing maximum positive and significant gca effects and 14 crosses shown significant positive sca effects with maximum sca effect, was observed in the cross UHSB-11 × UHSB-33 (1.42).

4.3.13 Pericarp thickness (Table 16 and 17)

For pericarp thickness three lines expressed significant positive gca effects and the line UHSB-18 (0.35) exhibited maximum positive gca effects. Among testers UHSB-32 (0.22) showing maximum positive and significant gca effects and eight crosses shown significant positive sca effects with maximum sca effect was observed in the cross UHSB-14 × UHSB-37 (0.62).

4.3.14 Fruit length (Table 16 and 17)

For fruit length four lines expressed significant positive gca effects and the line UHSB-31 (4.87) exhibited maximum positive significunt gca effects. Among testers UHSB-32 (0.82) showing maximum positive and significant gca effects and 10 crosses shown significant positive sca effects with maximum sca effect was observed in that cross UHSB-31 × UHSB-37 (5.68).

4.3.15 Fruit girth (Table 16 and 17)

For fruit girth two lines expressed significant positive gca effects and the line UHSB-21 (2.55) exhibited maximum positive significunt gca effects. Among testers UHSB-32 (1.21) showing maximum positive and significant gca effects and four crosses shown significant positive sca effects with maximum sca effect was observed in that cross UHSB-22 × UHSB-32 (7.43).

4.3.16 Fruit colour scoring (Table 16 and 17)

For fruit colour four lines expressed significant positive gca effects and the line UHSB-31 (0.42) exhibited maximum positive gca effects. Among testers UHSB-32 (0.21) showing maximum positive and significant gca effects and nine crosses shown significant positive sca effects with maximum sca effect was observed in that cross UHSB-14 × UHSB-37 (0.81).

5. DISCUSSION

The increasing human population and urbanization resulting in reducing the land resources. Insufficient land resources leads to a difficult task to produce the vegetables and insufficient amount of nutritional and food security for this larger population. Therefore, enhancing the productivity by genetic means is the only best alternate way to overcome these problems. Yield is a complex character and selection for yield and quality parameters deserves considerable attention. Hence the ultimate aim of any plant breeder is to develop high yielding variety or hybrids with novel characters. The information so obtained in the experiment helps to know about gene action and form the basis for developing precise breeding programmes.

The fruit yield and quality in tomato is a complex character and is dependent on number of yield components. The parental genotypes were selected not only on the basis of their *per se* performance but also on the basis of their combining ability. Genetic constitution of the parents involved in hybridization governs the nature of gene action in the hybrid. To incorporate desirable yield and quality traits in a variety/hybrid, there is a need to know the inter-relationship of different characters. Moreover, knowledge of inter character relationship helps in the identification of important attributes, which in other words is used to design suitable plant type with improved characters and for multiple trait selection. For exploitation of heterosis, choice of suitable parents is an important pre-requisite.

The recent trend in tomato breeding has been towards the development of hybrids to meet the specific purposes (*viz.*, earliness, growth habit, disease or pest resistance, fruit quality for processing, fresh market *etc.*) coupled with high yield as it may be difficult to develop a hybrid having all the characters. However, it is reasonable to search one which can have maximum number of useful characters keeping yield as primary motto. The parents for the present investigation were selected on the basis of their performance with a view to develop productive hybrids. The superiority of the hybrids in crosses was estimated over better parent, best parent and a commercial check for all the 20 characters studied.

In the present investigation, variance due to genotypes was highly significant for all the growth, earliness, yield and quality parameters studied and variance due to parents was highly significant for majority of characters studied (Table-5) indicating the presence of diversity among parents used in the study.

Plant height is an important growth trait which serves as the platform for developing primary branches, which in turn gives out secondary branches. This trait determines ideotype and contributes towards higher yield. Plant height and number of branches per plant are important traits to determine the economic yield and considerable genetic variation in plants. Heterosis for the growth parameters is an indication for heterosis for the yield as growth and yield parameters are strongly associated (Mahendrakar, 2004). In the present study, significant and higher magnitude of heterosis over better parent, best parent and the commercial check was observed in desirable direction for plant height at 30, 60 and 90 DAT. The crosses UHSB-15 × UHSB-37 (81.71%), UHSB-30 × UHSB-37 (69.45%) and UHSB-30 × UHSB-37 (55.72%) recorded maximum significant heterosis over commercial check for plant height at 30, 60 and 90 DAT respectively. In case of number of primary branches per plant, almost all the hybrids exhibited maximum heterosis over better parent, best parent and commercial checks indicating additive gene action.

The crosses UHSB-29 × UHSB-37 (85.51%), UHSB-17 × UHSB-37 (29.20%) and UHSB-4 × UHSB-33 (17.41%) recorded maximum significant heterosis over commercial check for number of primary branches per plant at 30, 60 and 90 DAT respectively.

Similarly, heterosis over commercial check was reported for plant height and number of primary branches per plant in tomato by Patil (1998), Kulkarni (1999), Kumari and Sharma (2011) and Sunil *et al.* (2013), Sajjan (2002), Kulkarni (2003), Ashwini (2005),Virupannavar (2009), Singh and Mishra (2010), Ahmad *et al.* (2011), Singh and Asati (2011) and Marbhal *et al.* (2016) in tomato.

Earliness is one of the most important factors which decide how early the fruits reach the market. Earliness is much desirable character in which we inspect for heterosis in negative direction. Magnitude of heterosis over better parent, best parent and the commercial check was significant in both the directions in present experiment. Among 45 crosses studied 40 crosses for days to flower initiation, seven crosses for days to 50 per cent flowering and 26 crosses for days to first fruit harvest for earliness showed significant negative heterosis over commercial check. The crosses UHSB-17 × UHSB-37 (-55.73%), UHSB-15 × UHSB-37 (-13.97%) and UHSB-15 × UHSB-37 (-14.23%) recorded maximum significant heterosis over commercial check for days to flower initiation, days to 50 per cent flowering and days to first harvest for earliness respectively. The hybrids are flowering earlier compared to their parents. Such parents can be utilized for the further earliness work in these tomato genotypes. Similar results had also been reported earlier by Kulkarni (2003), Duhan *et al.* (2005), Yashvanthakumar (2008) and Saeed *et al.* (2014).

Fruit weight has direct effect on yield and this is a character which appeals to the consumers. For average fruit weight positive heterosis is considered as desirable. The cross UHSB-20 × UHSB-32 (70.98%) recorded maximum positive significant heterosis over commercial check. Similar results had also been reported earlier by Kulkarni (2003), Duhan *et al.* (2005), Yashvanthakumar (2008) and Saeed *et al.* (2014).

Number of fruits per plant is a major yield contributing character. It was evident from the results that there was a considerable degree of heterosis for number of fruits per plant. The cross UHSB-23 × UHSB-37 (77.13%) recorded maximum positive significant heterosis over commercial check. The results are in close conformity with the findings of several workers such as Mahendrakar (2004), Hannan *et al.* (2007), Premalakshmi (2010), Akshay (2011), Yadav and Venkat (2013), Saleem *et al.* (2015) and Aisyah *et al.* (2016) in tomato.

The magnitude of variation for *per se* performance of parents and hybrids was remarkable for yield per plant. The cross UHSB-20 × UHSB-32 (9.74 per cent) recorded maximum positive significant heterosis over commercial check. Same wise for both the traits yield per plot and yield per hectare the cross UHSB-20 × UHSB-32 recorded maximum positive significant heterosis over commercial check with (9.67 per cent and 9.76 per cent) respectively. The results are in conformation with the findings of Joshi and Thakur (2003), Tiwari and Lal (2004), Ashwini (2005), Dharmatti *et al.* (2006), Virupannavar (2009), Singh and Mishra (2010), Akshay (2011), Akram *et al.* (2012), Saleem *et al.* (2015) and Aisyah *et al.* (2016) in tomato.

The hybrid UHSB-20 × UHSB-32 was the best hybrid selected for yield per hectare as it exhibited maximum standard heterosis of 9.76 per cent and its estimated total yield was 441.35 q per hectare as compared to 402.12 q per hectare of the commercial check (Arka Rakshak). Performance of this hybrid with respect to total yield is attributed to its significant heterosis observed over the commercial check in the desirable direction for plant height at 30, 60 and 90 DAT, number of primary branches per plant at 30 DAT, days to flower initiation, average fruit weight, yield per plant, yield per plot, yield per hectare, total soluble solid content of the fruit, fruit girth and fruit colour. This hybrid is also identified as a good specific combiners for plant height at 90 DAT, days to flower initiation, average fruit weight, yield per plot, yield per hectare and total soluble solid content of the fruit. The parent UHSB-20 involved in the development of this hybrid was found to be good general combiners for plant height at 90DAT, average fruit weight, yield per hectare, number of locules per fruit, total soluble solid content and pericarp thickness. The other parent UHSB-32 exhibited significant gca effects in the desirable direction for average fruit weight, yield per plant, yield per plot, yield per hectare, pericarp thickness, fruit length and fruit girth. As this hybrid (UHSB-20 × UHSB-32) was the good specific combiner for yield possessing maximum heterosis over the commercial check and it can be commercially exploited after assessing its stability for yield.

The second best hybrid was UHSB-17 × UHSB-33 and its estimated yield per hectare is 435.46 q with 8.29 per cent standard heterosis. Its performance is attributed to significant standard heterosis observed in the desirable direction for plant height at 30 DAT, plant height at 60 DAT, plant height at 90 DAT, number of primary branches per plant at 30 DAT, number of primary branches at 60 DAT, days to flower initiation, average fruit weight, number of fruits per plant, yield per plant, yield per plot, yield per hectare, fruit girth and fruit colour. This hybrid (UHSB-17 × UHSB-33) is also identified as a good specific combiner for average fruit weight and yield per hectare. Among the two parents involved in the development of this hybrid, UHSB-17 showed significant gca effects in the desirable direction for days to flower initiation, average fruit weight, number of fruits per plant, yield per plant, yield per plot and yield per hectare. The other parent UHSB-33 showed significant gca effects in the desirable direction only for average fruit weight, yield per plant, yield per plot, yield per hectare and fruit colour. As this hybrid (UHSB-17 × UHSB-33) also possessed significant sca effects for yield possessing second highest standard heterosis, it can also be assessed for stability for commercial exploitation.

The next best hybrid was UHSB-28 × UHSB- 33 and its estimated yield per hectare is 434.48 q with 8.05 per cent standard heterosis. Its performance is attributed to significant standard heterosis observed in the desirable direction for plant height at 30 DAT, plant height at 60 DAT, plant height at 90 DAT, number of primary branches per plant at 30 DAT, number of primary branches per plant at 60 DAT, number of primary branches per plant at 90 DAT, days to flower initiation, days to first harvest, average fruit weight, yield per plant, yield per plot, yield per hectare, total soluble solid content and fruit colour. This hybrid (UHSB-28 × UHSB- 33) is also identified as a good specific combiners for plant height at 60 DAT, plant height at 90 DAT, number of primary branches per plant at 60 DAT, number of primary branches at per plant at 90 DAT, days to first harvest for earliness, average fruit weight, number of fruits per plant, yield per plant, yield per plot, yield per hectare, total soluble solid content and fruit length. Among the two parents involved in the development of this hybrid, UHSB-28 is identified as a good specific combiner for average fruit weight. The other parent UHSB-33 showed significant gca effects in the desirable direction only for average fruit weight, yield per plant, yield per plot, yield per hectare and fruit colour. As this hybrid (UHSB-28 × UHSB- 33) also possessed significant sca effects for yield possessing third highest standard heterosis, it can also be assessed for stability for commercial exploitation.

The tomato products such as paste, puree, sauce, soup, ketchup and juice are increasingly gaining popularity and have become an integral part of the daily diet. Improvement of tomato through breeding for processing attributes is being vigorously pursued worldwide and also in India. To meet these commitments, breeder will have to look in for such types that have qualities essential for processing *i.e.*, less number of locules, maximum pericarp thickness, high TSS, high colour or lycopene in addition to high yield.

Tomato ranks first among processed vegetables in the world. Less number of locules, high pericarp thickness and high total soluble solid content (TSS) are the major factors considered for manufacture of processed products. One per cent increase in TSS content of fruits results in 20 per cent increase in recovery of processed product (Berry and Uddin, 1991).

The minimum number of locules per fruit is desirable character, which is the key quality parameter for processing purpose. None of crosses exhibited negative and significant heterosis over commercial check, the cross UHSB-20 × UHSB-37 (7.54%) recorded minimum significant heterosis over commercial check. Similar results obtained by Mahendrakar *et al.,* 2004.

Total soluble solids content is also one of the most important quality parameter in the processing industry. The cross UHSB-21 × UHSB-33 (113.03%) recorded maximum positive significant heterosis over commercial check. The results are in confirmation with the findings of Kulkarni (2003), Prashanta (2004), Mahendrakar (2004) and Virupannavar (2009) in tomato.

Pericarp thickness has been globally identified as an important component of keeping quality and whole fruit firmness in tomato and also influence on the appearance of the fruit. None of the crosses shown positive significant heterosis over best parent and commercial check except the cross UHSB-28 × UHSB-32 (0.84%), recorded maximum significant heterosis over commercial check. These results were similar with the findings of Kulkarni (2003), Prashanth (2004), Kumar *et al.* (2006), Sharma *et al.* (2010) and Aisyah *et al.* (2016) in tomato.

Fruit length and girth is an important parameter, which directly contributes to the fruit weight, thereby affecting the total yield and also affects on the appearance of the fruit.

Positive significant heterosis over commercial check was not reported for fruit length but maximum positive significant heterosis over better parent was reported in the cross UHSB-15 × UHSB-37 (20.17%) and for fruit girth positive significant heterosis over commercial check was reported for the cross UHSB-21 × UHSB-33 (21.23%). These results were similar with the findings Sharma *et al.,* 2001, Mahendrakar (2004) and Sunil *et al.,* 2013.

Fruit colour as a component of quality, important to the grower, as it affects product appearance and ultimately consumer acceptance inmarket. The crosses

UHSB-22 × UHSB-33 and UHSB-30 × UHSB-32 recorded maximum significant heterosis over commercial check with (36.60 %). Heterosis was observed at greater range in all hybrids. Heterosis for this character was reported by Patil and Bojappa (1988), Patil (1998), Kurian and Peter (2001), Naveen *et al.* (2008).

Combining ability studies

The combining ability analysis helps in diagnosing or identifying the additive or non-additive gene action would in turn leads a breeder to select desirable parents or cross combinations that would be exploited for crop improvement.

When the analysis of variance for combining ability with respect to yield were looked into it revealed that line × tester combinations was higher than that of lines and testers contribution individually. GCA variance was greater than SCA variance indicating the predominance of additive gene action. Similar results were found by Rai *et al.* (2003), Asati *et al.* (2007) and Yashvantakumar (2008) for all the studied traits.

Growth parameters

The parent UHSB-21 (5.48) and UHSB-15 (4.90) were good general combiners for increasing plant height among lines, the parent UHSB-37 (3.98) was good general combiner for increasing plant height at 30 DAT among testers. The GCA to SCA ratio was less than unity indicating the preponderance of non-additive gene action and it was 0.4142. The hybrid UHSB-29 × UHSB-33 (8.34) manifested highest significant positive sca effect for plant height at 30 DAT and this might be due to non additive or dominance effect. The results are in close conformity with the findings of Sharma *et al.* (2006), Pandey *et al.* (2006) and Kamalveer *et al.* (2006) Izge and Garba (2012), Saleem *et al.* (2013), Akram *et al.* (2012) and Gabry *et al.* (2014).

But plant height at 60 DAT the parents UHSB- 23 (11.88) and UHSB- 22 (4.92) were good general combiner among lines and UHSB- 37 (6.79) were good general combiner among testers. The hybrid UHSB-22 × UHSB-32 (13.49) manifested highest significant positive sca effect for plant height at 60 DAT and this might be due to additive effect. The GCA to SCA ratio was less than unity indicating the preponderance of non additive gene action and it was 0.5025. The results are in close conformity with the findings of Sharma *et al.* (2006), Pandey *et al.* (2006) and Kamalveer *et al.* (2006) Izge and Garba (2012), Saleem *et al.* (2013), Akram *et al.* (2013) and Gabry *et al.* (2014).

For plant height at 90 DAT the parents UHSB- 23 (11.74) and UHSB- 22 (4.28) were good general combiner among lines, UHSB- 37 (6.96) was good general combiner among testers. The hybrid UHSB-30 × UHSB-37 (14.06) manifested highest significant positive sca effect for plant height at 90 DAT and this might be due to additive effect. The GCA to SCA ratio was less than unity indicating the preponderance of non additive gene action and it was 0.5299. The results are in close conformity with the findings of Sharma *et al.* (2006), Pandey *et al.* (2006) and Kamalveer *et al.* (2006) Izge and Garba (2012), Saleem *et al.* (2013), Akram *et al.* (2013) and Gabry *et al.* (2014).

The parent UHSB-23 (1.21) was good general combiner for number of primary branches per plant among lines, parent UHSB-37 (0.71) was good general combiner for number of primary branches per plant at 30 DAT among testers. Whereas, hybrid UHSB-18 × UHSB-32 (2.23) was found to be good specific combiner for the trait number of primary branches per plant at 30 DAT. The ratio of GCA to SCA variance indicated the presence of non-additive gene action for number of primary branches per plant at 30 DAT and it was 0.8477. The results are in accordance with the findings of Prashant (2004), Premalakshmi *et al.* (2006), Pandey *et al.* (2006), Singh *et al.* (2008), Yashvantakumar (2008), Virupannavar (2009), Singh and Mishra (2010) and Akshay (2011) in tomato for number of primary branches per plant at 30 DAT.

The parents UHSB-21 (1.28), UHSB-23 (0.79) were good general combiners for number of primary branches per plant among lines, parent UHSB-37 (0.67) was good general combiner among testers. Whereas, hybrids UHSB-14 × UHSB-37 (1.78) was found to be good specific combiner followed by UHSB-17 × UHSB-37 (1.66) for the trait number of primary branches per plant 60 DAT. The ratio of GCA to SCA variance indicated the presence of non-additive gene action and it was 0.4322. The results are in accordance with the findings of Prashant (2004), Premalakshmi *et al.* (2006), Pandey *et al.* (2006), Singh *et al.* (2008), Yashvantakumar (2008), Virupannavar (2009), Singh and Mishra (2010) and Akshay (2011) and for number of primary branches per plant at 60 DAT.

The parents UHSB-4 (1.72), UHSB-21 (1.65) were good general combiners for number of primary branches per plant among lines, parent UHSB-37 (0.79) was good general combiner among testers. Whereas, hybrids UHSB-28 × UHSB-33 (2.86) was found to be a good specific combiner followed by UHSB-18 × UHSB-32 (2.21). The ratio of GCA to SCA variance indicated the presence of non-additive gene action for number of primary branches per plant at 90 DAT and it was 0.4625. The results are in accordance with the findings of Prashant (2004), Premalakshmi *et al.* (2006), Pandey *et al.* (2006), Singh *et al.* (2008), Yashvantakumar (2008), Virupannavar (2009), Singh (2010) and Akshay (2011) for number of primary branches per plant at 90 DAT in tomato.

Among the parents six lines showed significant gca effects for days to flower initiation among them UHSB-18 (2.35) followed by UHSB-28 (1.49) were found maximum positive and significant among lines and UHSB-32 (1.74) followed by UHSB-33 (0.91) among testers. There were 15 crosses exhibited positive and significant sca effects for the trait days to flower initiation. The cross UHSB-15 × UHSB-33 (3.11) exhibited maximum positive significant sca effect followed by UHSB-14 × UHSB-37 (2.89). The ratio of GCA to SCA variance indicated the presence of non-additive gene action for days to flower initiation and it was 0.6364. Similar results were obtained by Anbu *et al.* (1981), Jamwal *et al.* (1984), Laksmi (1997), Srivathsva *et al.* (1998), Dhaliwal *et al.* (2000), Thakur and Joshi (2000), Gaikwad *et al.* (2002), Akram *et al.* (2012) and Kumar *et al.* (2013).

Among the parents for days to 50 per cent flowering UHSB-18 (2.19) followed by UHSB-20 (1.33) were found maximum positive and significant gca effects among lines and UHSB-32 (1.63) followed by UHSB-33 (0.63) among testers. There were 11 crosses exhibited positive and significant sca effects for the trait days to 50 per cent flowering. The cross UHSB-22 × UHSB-37 (2.27) exhibited maximum positive significant sca effect. The ratio of GCA to SCA variance indicated the presence of additive gene action and it was 1.1311. Similar results were obtained by Tendulkar (1994), Patil (1998), Roopa *et al.* (2001), Kulkarni (2003) and Adhi *et al.* (2013).

Among the parents three lines showed significant gca effects for days to first harvest for earliness, among them UHSB-18 (3.65) followed by UHSB-15 (1.69) were found maximum positive and significant gca effects among lines and UHSB-32 (2.85) followed by UHSB-33 (0.45) among testers. There were 13 crosses exhibited positive and significant sca effects for the trait days to first harvest for earliness. The cross UHSB-23 × UHSB-37 (4.92) exhibited maximum positive significant sca effect followed by UHSB-21 × UHSB-33 (4.67). The ratio of GCA to SCA variance indicated the presence of additive gene action for days to first harvest for earliness and it was 1.1139. Similar results were obtained by Mittal *et al.* (1974), Viredelwala *et al.* (1987), Sharma (1996) and Saleem *et al.* (2013).

Among the parents six lines showed significant gca effects for average fruit weight, among them UHSB-20 (23.32) followed by UHSB-17 (17.37) were found maximum positive and significant gca effects among lines and UHSB-32 (21.03) followed by UHSB-33 (13.50) among testers. There were 18 crosses exhibited positive and significant sca effects for the trait average fruit weight. The cross UHSB-20 × UHSB-32 (50.46) exhibited maximum positive significant sca effect followed by UHSB-28 × UHSB-33 (26.10). The ratio of GCA to SCA variance indicated the presence of additive gene action for average fruit weight and it was 2.1095. Similar results were obtained by Mittal *et al.* (1974), Dixit *et al.* (1980), Lakshmi (1997), Patil (1998), Rai *et al.* (1998), Dhaliwal *et al.* (2000), Gaikwad *et al.* (2002), Asati *et al.* (2007), Singh and Asati (2011) and Aisyah *et al.* (2016).

Among the parents seven lines showed significant gca effects for number of fruits per plant, among them UHSB-23 (14.38) followed by UHSB-17 (0.86) were found maximum positive and significant gca among lines and UHSB-33 (0.33) among testers. There were three crosses exhibited positive and significant sca effects for the trait number of fruits per plant. The cross UHSB-18 × UHSB-37 (1.26) exhibited maximum positive significant sca effect followed by UHSB-11 × UHSB-37 (1.21). The ratio of GCA to SCA variance indicated the presence of additive gene action for number of fruits per plant and it was 1.0424. Similar results were obtained by Kalloo *et al.* (1973), Dudi *et al.* (1979), Dixit *et al.* (1980), Sidhu *et al.* (1981), Jamwal *et al.* (1984), Raijadhav and Kale (1987), Tendulkar (1994), Dharmatti (1995), Kulkarni (1999), Dhaliwal *et al.* (2000), Bhatt *et al.* (2001), Dharmatti *et al.* (2001), Gaikwad *et al.* (2002), Padma *et al.* (2002), Premalakshmi *et al.* (2006), Singh *et al.* (2008), Yashavantakumar (2008) and Izge and Garba (2012).

Among the parents four lines showed significant gca effects for yield per plant, among them UHSB-17 (0.86) was found maximum positive and significant gca effect among lines and UHSB-33 (0.33) among testers. There were three crosses exhibited positive and significant sca effects. The cross UHSB-18 × UHSB-37 (1.26) exhibited maximum positive significant sca effect followed by UHSB-28 × UHSB-33 (1.14). The ratio of GCA to SCA variance indicated the presence of non-additive gene action for yield per plant and it was 0.8728. Similar results were obtained by Mittal *et al.* (1974), Anbu *et al.* (1980), Govindarasu *et al.* (1982), Tendulkar (1994), Dharmatti (1995), Kulkarni (1999), Dhaliwal *et al.* (2000), Bhatt *et al.* (2001), Dharmatti *et al.* (2001), Gaikwad *et al.* (2002), Padma *et al.* (2002), Premalakshmi *et al.* (2006), Singh *et al.* (2008), Yashavantakumar (2008) and Izge and Garba (2012).

Among the parents four lines showed significant gca effects for yield per plot, among them UHSB-17 (7.29) followed by UHSB-15 (3.81) were found maximum positive and significant gca effects among lines and UHSB-33 (2.81) among testers. There were 10 crosses exhibited positive and significant sca effects for the trait yield per plot. The cross UHSB-18 × UHSB-37 (10.74) exhibited maximum positive significant sca effect followed by UHSB-11 × UHSB-37 (10.30). The ratio of GCA to SCA variance indicated the presence of non-additive gene action for yield per plot and it was 0.5134.

Among the parents eight lines showed significant gca effects for yield per ha., among them UHSB-17 (80.14) followed by UHSB-15 (41.89) were found maximum positive and significant gca effects among lines and UHSB-33 (30.84) among testers. There were 23 crosses exhibited positive and significant sca effects for the trait yield per hactare. The cross UHSB-18 × UHSB-37 (118.04) exhibited maximum positive significant sca effect followed by UHSB-11 × UHSB-37 (113.14). The ratio of GCA to SCA variance indicated the presence of non-additive gene action for yield per hectare and it was 0.4897.

Among the parents only one line showed significant gca effects for number of locules per fruit, that is UHSB-8 (0.46) was found maximum positive and significant gca effects among lines and no one tester found positive significant gca effect. There was one cross exhibited positive and significant sca effects for the trait number of locules per fruit that is UHSB-4 × UHSB-33 (0.90) exhibited maximum positive significant sca effect. The ratio of GCA to SCA variance indicated the presence of non-additive gene action for number of locules per fruit and it was 0.1405. Similar results were obtained by Mittal *et al.* (1974), Govindarasu *et al.* (1981), Rai *et al.* (1998), Patil (1998), Joshi and Thakur (2003), Yashavantakumar (2008), Kumar *et al.* (2013) and Saeed *et al.* (2014).

Among the parents five lines showed significant gca effects for total soluble solid content of fruit, among them UHSB-21 (1.32) were found maximum positive and significant gca effects followed by UHSB-4 (0.64) among lines and UHSB-37 (10.24) among testers found maximum positive significant gca effects. There were 12 crosses exhibited positive and significant sca effects for the trait total soluble solid content of fruit, that is UHSB-11 × UHSB-33 (1.42) exhibited maximum positive significant sca effect followed by UHSB-29 × UHSB-33 (1.15). The ratio of GCA to SCA variance indicated the presence of non-additive gene action for total soluble solid content of fruit and it was 0.1213. Similar results were obtained by Kalloo *et al.* (1973), Govindarasu *et al.* (1982), Sidhu *et al.* (1981), Raijadhav and Kale (1987), Sathyanarayana and Anand (1992), Tendulkar (1994), Dharmatti (1995), Kurian and Peter (1995), Lakshmi (1997), Dhaliwal *et al.* (2000), Roopa *et al.* (2001), Prashanth (2004), Kumar *et al.* (2013), and Saeed *et al.*, 2014.

Among the parents three lines showed significant gca effects for pericarp thickness, among them UHSB-18 (0.35) were found maximum positive and significant gca effects followed by UHSB-20 (0.31) among lines and UHSB-32 (0.22) among testers found maximum positive significant gca effect. There were eight crosses exhibited positive and significant sca effects for the trait pericarp thickness that is UHSB-14 × UHSB-37 (0.62) exhibited maximum positive significant sca effect followed by UHSB-28 × UHSB-32 (0.57). The ratio of GCA to SCA variance indicated the presence of non-additive gene action for pericarp thickness and it was 0.5465. Similar results were obtained by Tendulkar (1994), Roopa *et al.* (2001), Chadha *et al.* (2002) and Mahendrakar (2004).

Among the parents four lines showed significant gca effects for fruit length, among them UHSB-31 (4.87) were found maximum positive and significant gca effects, followed by UHSB-15 (4.11) among lines and UHSB-32 (0.82) found maximum positive significant gca effects among testers. There were 10 crosses exhibited positive and significant sca effects for the trait fruit length, UHSB-13 × UHSB-37 (5.68) exhibited maximum positive significant sca effect followed by UHSB-15 × UHSB-37 (4.95). The ratio of GCA to SCA variance indicated the presence of non-additive gene action and it was 0.1986. Similar results were obtained by Srivastava *et al.* (1998), Sharma *et al.* (1999), Kaur *et al.* (2002), Mahendrakar (2004) and Saeed *et al.* (2014).

Among the parents two lines showed significant gca effects for fruit girth, among them UHSB-21 (2.55) were found maximum positive and significant gca effects followed by UHSB-11 (2.26) and UHSB-32 (1.21) was found maximum positive significant gca effects among testers. There were four crosses exhibited positive and significant sca effects for the trait fruit girth, among them UHSB-22 × UHSB-32 (7.43) exhibited maximum positive significant sca effect followed by UHSB-15 × UHSB-32 (4.98). The ratio of GCA/SCA variance indicated the presence of non-additive gene action for fruit girth and it was 0.2250.Similar results were obtained by Sharma (1996), Srivastava *et al.* (1998), Kaur *et al.* (2002) and Saeed *et al.* (2014).

Among the parents four lines showed significant gca effects for fruit colour, among them UHSB-31 (0.42) were found maximum positive and significant gca effects followed by UHSB-22 (0.36) among lines and UHSB-33 (0.21) found maximum positive significant gca effect among testers. There were seven crosses exhibited positive and significant sca effects for the trait fruit colour among them UHSB-14 × UHSB-37 (0.81) exhibited maximum positive significant sca effect followed by UHSB-28 × UHSB-32 (0.64). The ratio of GCA to SCA variance indicated the presence of non-additive gene action for fruit colour and it was 0.2025. Similar results were obtained by Bhutani (1980), Bhutani and Kalloo (1989), Raijadhav and Kale (1987) and Sathyanarayana and Anand (1992).

Table 18. Overall analysis of general combining ability status of the parents in tomato

Parent	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total		gca
Lines																					+ve	-ve	status
UHSB-4	0	0	-1	0	0	+1	-1	0	0	0	-1	-1	-1	-1	0	+1	0	0	0	-1	2	7	L
UHSB-8	0	0	-1	0	0	0	+1	+1	+1	+1	-1	-1	-1	-1	-1	+1	0	0	0	0	5	6	L
UHSB-11	0	0	-1	0	0	0	+1	+1	0	0	+1	0	+1	+1	0	-1	-1	0	+1	+1	7	3	H
UHSB-14	+1	+1	+1	0	0	0	0	0	0	+1	-1	0	+1	+1	0	0	0	-1	0	0	6	2	H
UHSB-15	+1	0	+1	0	0	0	+1	0	0	0	+1	0	+1	+1	0	-1	0	+1	-1	+1	8	2	H
UHSB-17	0	0	0	0	0	0	+1	0	-1	+1	+1	+1	+1	+1	0	-1	0	0	0	0	6	2	H
UHSB-18	-1	-1	-1	-1	0	-1	-1	-1	-1	+1	-1	0	0	+1	0	0	+1	-1	0	0	3	10	L
UHSB-20	0	0	+1	0	-1	0	-1	-1	0	+1	-1	0	0	+1	+1	+1	+1	0	0	-1	6	5	H
UHSB-21	+1	0	0	0	+1	+1	0	0	+1	-1	+1	0	0	0	0	+1	-1	-1	+1	-1	7	4	H
UHSB-22	0	+1	+1	0	0	0	-1	0	+1	-1	-1	0	-1	-1	0	+1	0	+1	-1	+1	6	6	A
UHSB-23	0	+1	+1	+1	+1	0	0	0	0	-1	+1	0	0	-1	0	0	0	0	0	0	5	2	H
UHSB-28	0	-1	-1	0	0	0	-1	0	0	+1	-1	0	0	-1	0	-1	0	0	0	0	1	6	L
UHSB-29	-1	0	+1	0	-1	0	-1	0	-1	-1	+1	0	0	+1	0	0	0	+1	0	0	4	5	L
UHSB-30	-1	0	0	0	0	0	0	0	+1	-1	-1	0	-1	-1	0	-1	0	-1	0	0	1	7	L
UHSB-31	+1	-1	-1	0	0	0	0	0	+1	-1	+1	0	0	+1	+1	0	+1	+1	-1	+1	8	4	H
Testers																							
UHSB-32	-1	0	0	0	0	0	-1	-1	-1	+1	-1	+1	+1	+1	0	0	+1	+1	+1	0	7	5	H
UHSB-33	-1	-1	-1	-1	-1	0	-1	-1	-1	+1	-1	+1	+1	+1	0	-1	0	0	0	+1	5	10	L
UHSB-37	+1	+1	+1	+1	+1	+1	+1	+1	+1	-1	+1	-1	-1	-1	0	+1	-1	-1	-1	-1	11	8	H

1 Plant height at 30 DAT
2 Plant height 60 DAT
3 Plant height 90 DAT
4 No. of primary branches 30 DAT
5 No. of primary branches 60 DAT
6 No. of primary branches 90 DAT
7 Days to flower initiation
8 Days to 50 per cent flowering
9 Days to first harvest for earliness
10 Average fruit weight

11 No. of fruits per plant
12 Yield per plant
13 Yield per plot
14 Yield per hectare
15 Number. of locules per fruit
16 TSS
18 pericarp thickness
19 Fruit length
20 Fruit girth
21 Colour of fruit (scoring)

H High combiners
0 Non-significant gca effects
+1 gca effects in desirable direction,
-1 gca effects in undesirable direction,
DAT Days after transplanting
L Low general combiner
A Average general combiner

Table 19. Overall analysis of the standard heterosis status of hybrids in tomato

Crosses	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total		Status	
																					+ve	-ve	CH	PG
UHSB-4 × UHSB-32	+1	+1	+1	+1	-1	-1	-1	-1	0	+1	-1	-1	-1	-1	-1	+1	-1	-1	+1	-1	7	12	L	L × H
UHSB-4 × UHSB-33	+1	+1	+1	+1	+1	+1	+1	-1	0	0	-1	-1	-1	-1	-1	+1	-1	-1	+1	-1	9	9	A	L × L
UHSB-4 × UHSB-37	+1	+1	+1	+1	+1	+1	+1	+1	+1	-1	+1	-1	-1	-1	-1	+1	-1	-1	+1	+1	13	7	H	L × H
UHSB-8 × UHSB-32	+1	+1	+1	+1	+1	-1	+1	-1	+1	+1	-1	-1	-1	-1	-1	+1	-1	-1	+1	+1	11	9	H	L × H
UHSB-8 × UHSB-33	+1	+1	+1	+1	-1	-1	+1	-1	0	0	-1	-1	-1	-1	-1	+1	-1	-1	+1	+1	8	10	L	L × L
UHSB-8 × UHSB-37	+1	+1	+1	+1	+1	-1	+1	+1	+1	-1	+1	-1	-1	-1	-1	+1	-1	-1	+1	+1	12	8	H	L × H
UHSB-11 × UHSB-32	+1	+1	+1	+1	-1	-1	+1	-1	-1	0	0	-1	-1	-1	-1	-1	-1	-1	+1	+1	7	11	L	H × H
UHSB-11 × UHSB-33	+1	+1	+1	0	-1	-1	+1	-1	+1	-1	0	-1	-1	-1	-1	+1	-1	-1	+1	+1	8	10	L	H × L
UHSB-11 × UHSB-37	+1	+1	+1	+1	+1	+1	+1	0	-1	-1	+1	-1	0	0	-1	+1	-1	-1	+1	+1	11	6	H	H × H
UHSB-14 × UHSB-32	+1	+1	+1	+1	-1	-1	+1	-1	0	+1	-1	-1	-1	-1	-1	+1	-1	-1	+1	+1	9	10	L	H × H
UHSB-14 × UHSB-33	+1	+1	+1	+1	-1	-1	+1	-1	0	-1	-1	-1	-1	-1	-1	+1	-1	-1	+1	+1	8	11	L	H × L
UHSB-14 × UHSB-37	+1	+1	+1	+1	+1	+1	+1	-1	+1	-1	+1	-1	-1	-1	-1	+1	-1	-1	+1	+1	12	8	H	H × H
UHSB-15 × UHSB-32	+1	+1	+1	+1	0	-1	+1	-1	-1	0	+1	-1	-1	-1	-1	+1	-1	-1	+1	+1	9	9	A	H × H
UHSB-15 × UHSB-33	+1	+1	+1	+1	-1	-1	+1	-1	+1	+1	+1	-1	0	0	-1	+1	-1	-1	+1	+1	11	7	H	H × L
UHSB-15 × UHSB-37	+1	+1	+1	+1	+1	-1	+1	+1	+1	-1	+1	-1	-1	-1	-1	-1	-1	-1	-1	+1	10	10	A	H × H
UHSB-17 × UHSB-32	+1	+1	+1	+1	-1	-1	+1	-1	-1	+1	-1	-1	-1	-1	-1	+1	-1	-1	+1	+1	9	11	L	H × H
UHSB-17 × UHSB-33	+1	+1	+1	+1	+1	-1	+1	-1	0	+1	+1	+1	+1	+1	-1	-1	-1	-1	+1	+1	13	6	H	H × L
UHSB-17 × UHSB-37	+1	+1	+1	+1	+1	+1	+1	+1	+1	-1	+1	-1	-1	-1	-1	+1	-1	-1	+1	+1	13	7	H	H × H
UHSB-18 × UHSB-32	+1	+1	+1	+1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	+1	-1	-1	+1	+1	7	13	L	L × H
UHSB-18 × UHSB-33	+1	+1	+1	0	+1	-1	-1	-1	-1	+1	-1	-1	-1	-1	-1	+1	+1	-1	+1	+1	9	10	L	L × L
UHSB-18 × UHSB-37	+1	0	+1	+1	-1	-1	+1	-1	+1	-1	+1	-1	-1	-1	-1	+1	-1	-1	+1	+1	9	10	L	L × H
UHSB-20 × UHSB-32	+1	+1	+1	+1	-1	-1	+1	-1	0	+1	-1	+1	+1	+1	-1	+1	-1	-1	+1	+1	12	7	H	H × H
UHSB-20 × UHSB-33	+1	+1	+1	+1	-1	-1	0	-1	+1	+1	+1	-1	-1	-1	-1	+1	-1	-1	+1	+1	10	9	H	H × L
UHSB-20 × UHSB-37	+1	+1	+1	+1	-1	0	+1	-1	+1	-1	+1	-1	-1	-1	-1	+1	-1	-1	+1	+1	10	9	H	H × H
UHSB-21 × UHSB-32	+1	+1	+1	+1	+1	-1	+1	-1	+1	-1	+1	-1	-1	-1	-1	+1	-1	-1	+1	+1	11	9	H	H × H
UHSB-21 × UHSB-33	+1	+1	+1	+1	-1	-1	+1	-1	-1	-1	+1	+1	0	0	-1	+1	-1	-1	+1	+1	10	8	H	H × L

Contd.....

Table 19 contd.....

Crosses	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total		Status	
																					+ve	-ve	CH	PG
UHSB-21 × UHSB-37	+1	+1	+1	+1	+1	+1	+1	-1	+1	-1	+1	-1	-1	-1	-1	+1	-1	-1	+1	0	11	8	H	H × H
UHSB-22 × UHSB-32	+1	+1	+1	+1	+1	-1	+1	-1	+1	0	+1	-1	-1	-1	-1	+1	-1	-1	+1	+1	11	8	H	A × H
UHSB-22 × UHSB-33	+1	+1	+1	+1	0	-1	+1	-1	+1	-1	+1	-1	-1	-1	-1	-1	-1	-1	+1	+1	9	10	L	A × L
UHSB-22 × UHSB-37	+1	+1	+1	+1	+1	-1	+1	-1	+1	-1	+1	-1	-1	-1	-1	+1	-1	-1	-1	+1	10	10	A	A × H
UHSB-23 × UHSB-32	+1	+1	+1	+1	+1	+1	+1	-1	+1	-1	+1	0	0	0	-1	+1	-1	-1	+1	+1	12	5	H	H × H
UHSB-23 × UHSB-33	+1	+1	+1	+1	+1	-1	+1	-1	+1	-1	+1	-1	-1	-1	-1	+1	-1	-1	+1	+1	11	9	H	H × L
UHSB-23 × UHSB-37	+1	+1	+1	+1	+1	+1	+1	-1	0	-1	+1	-1	-1	-1	-1	+1	-1	-1	+1	+1	11	8	H	H × H
UHSB-28 × UHSB-32	+1	+1	+1	+1	+1	-1	+1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	+1	+1	8	12	L	L × H
UHSB-28 × UHSB-33	+1	+1	+1	+1	+1	+1	+1	-1	+1	+1	0	+1	+1	+1	-1	+1	-1	-1	+1	+1	15	4	H	L × L
UHSB-28 × UHSB-37	+1	+1	+1	+1	-1	-1	+1	-1	+1	-1	+1	-1	-1	-1	-1	-1	-1	-1	+1	+1	9	11	L	L × H
UHSB-29 × UHSB-32	+1	+1	+1	+1	0	-1	+1	-1	-1	-1	+1	-1	-1	-1	-1	+1	-1	-1	+1	+1	9	10	L	L × H
UHSB-29 × UHSB-33	+1	+1	+1	+1	-1	-1	+1	-1	0	0	+1	-1	-1	-1	-1	+1	-1	-1	+1	+1	9	9	A	L × L
UHSB-29 × UHSB-37	+1	+1	+1	+1	-1	-1	+1	0	+1	-1	+1	-1	-1	-1	-1	+1	-1	-1	+1	+1	10	9	H	L × H
UHSB-30 × UHSB-32	+1	+1	+1	+1	+1	0	+1	-1	+1	+1	0	-1	-1	-1	-1	-1	-1	-1	+1	+1	10	8	H	L × H
UHSB-30 × UHSB-33	+1	+1	+1	0	-1	-1	+1	-1	+1	-1	+1	-1	-1	-1	-1	+1	-1	-1	0	+1	8	10	L	L × L
UHSB-30 × UHSB-37	+1	+1	+1	+1	+1	+1	+1	+1	+1	-1	+1	-1	-1	-1	-1	+1	-1	-1	+1	+1	13	7	H	L × H
UHSB-31 × UHSB-32	+1	0	+1	+1	-1	-1	0	-1	0	+1	+1	-1	-1	-1	-1	+1	-1	-1	+1	+1	8	9	L	H × H
UHSB-31 × UHSB-33	+1	+1	+1	+1	+1	0	+1	+1	+1	-1	+1	-1	-1	-1	-1	-1	-1	-1	+1	+1	11	8	H	H × L
UHSB-31 × UHSB-37	+1	+1	+1	+1	+1	+1	+1	-1	+1	-1	+1	-1	-1	-1	-1	+1	-1	-1	-1	+1	11	9	H	H × H

1 Plant height at 30 DAT
2 Plant height 60 DAT
3 Plant height 90 DAT
4 No. of primary branches 30 DAT
5 No. of primary branches 60 DAT
6 No. of primary branches 90 DAT
7 Days to flower initiation
8 Days to 50 per cent flowering
9 Days to first harvest for earliness
10 Average fruit weight
11 Number of fruits per plant
12 Yield per plant
13 Yield per plot
14 Yield per hectare

15 Number of locules per fruit
16 TSS
17 pericarp thickness
18 Fruit length
19 Fruit girth
20 Colour of fruit(scoring)
H High heterotic
L Low heterotic
A Average heterotic
0 Non-significant gca effects
+1 Heterosis in desirable direction
CH Heterosis of crosses
PG Partental gca status
A Average heterotic

DAT Days after transplanting
-1 Heterosis in undesirable direction

Future line of work

- The crosses UHSB-20 × UHSB-32, UHSB-17 × UHSB-33 and UHSB-28 × UHSB- 33 are found to be the superior hybrids selected for yield since, these crosses exhibited significant heterosis over the commercial check for yield and also exhibited significant sca effects for yield per hectare. These crosses can be further assessed for their yield stability to confirm their potentiality and also their adaptability to different agro-climatic conditions before exploiting them on commercial scale.

- The parents UHSB-11, UHSB-14, UHSB-15, UHSB-17, UHSB-18, UHSB-20, UHSB-29 and UHSB-31 are found to be the good general combiners for yield per hectare and these can be used for the identifying superior new heterotic combinations.

- The parents UHSB-11, UHSB-14, UHSB-15, UHSB-17, UHSB-20, UHSB-21, UHSB-23 and UHSB-31 are found to be the good general combiners over all characters and can be used to develop gene pool subjecting them to recurrent selection for improving the combining ability for exploitation of heterosis.

- For the development of highly heterotic crosses from the existing genetic stock, generally the parental combinations of high × low or low × high, average × high and low × low, combining ability can be more beneficial since non-additive component is predominant for commercial traits.

- The plant height at 30 DAT, plant height at 60 DAT, plant height at 90 DAT, number of primary branches per plant at 30 DAT, number of primary branches per plant at 60 DAT, number of primary branches per plant at 90 DAT, days to flower initiation, yield per plant, yield per plot, yield per hectare, number of locules per fruit, TSS, pericarp thickness, fruit length, fruit girth, fruit colour are predominantly controlled by non-additive gene action and hence heterosis breeding and recurrent selection can be employed for improvement.

- Direct selection or recurrent selection can be employed for the improvement of the traits days to 50 per cent flowering, days to first harvest for earliness, average fruit weight and number of fruits per plant, as the additive and non additive component of genetic variances are controlling these traits.

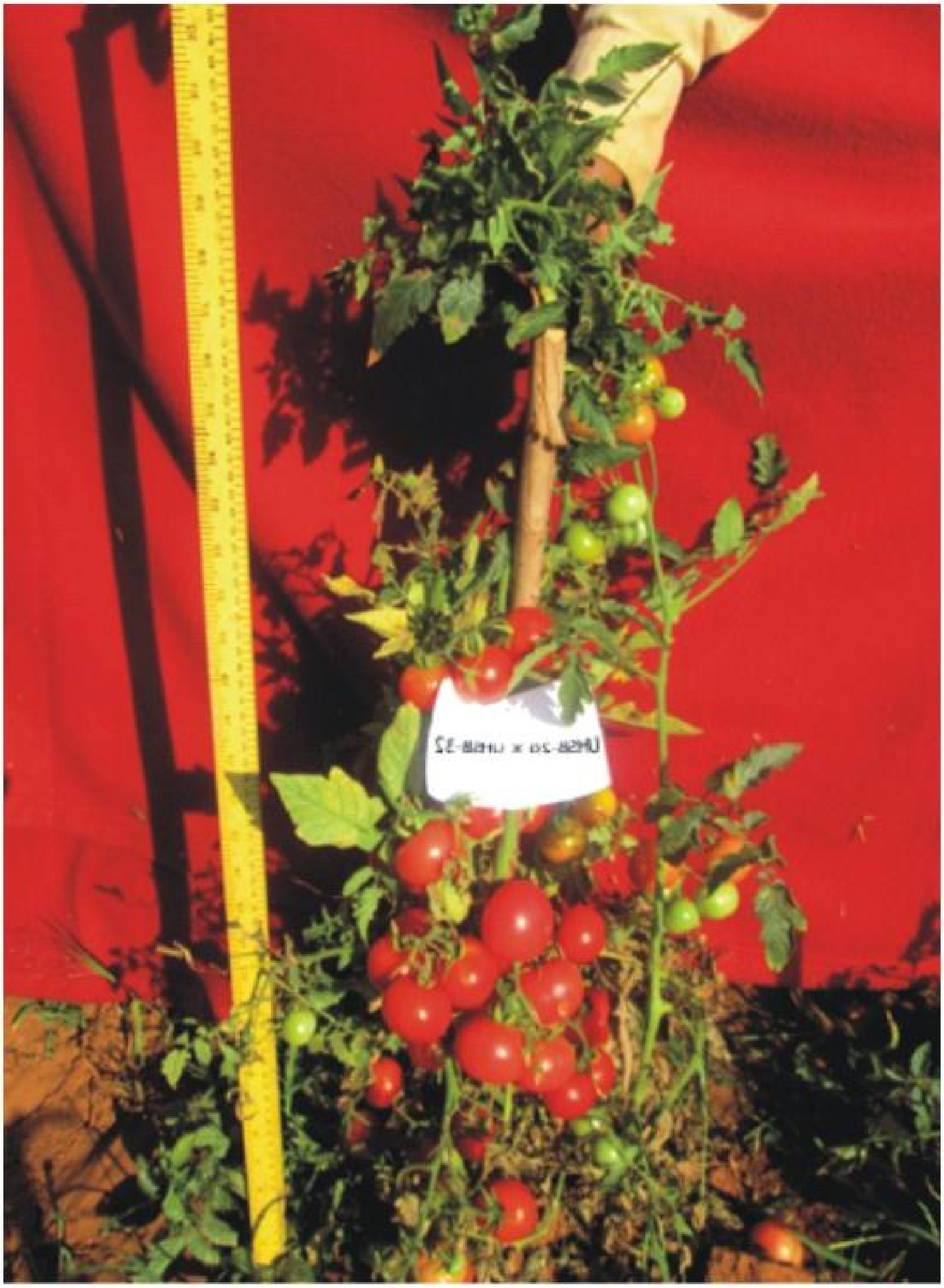


Plate 4. Best performing hybrid for the trait yield per hectare

6. SUMMARY AND CONCLUSIONS

The present investigation on ôEvaluation of F_1 hybrids in tomato (*Solanum lycopersicum* L.) ô was undertaken at Regional Horticultural Research and Extension Centre (RHREC), Dharwad, (Karnataka). Forty five crosses were developed by crossing 15 lines with each of three testers. All the crosses were evaluated along with the parents in RBD design with two replications with the objective of evaluation of F_1 hybrids along with that assessing the magnitude and direction of heterosis and identifying good combiners for growth, earliness, yield and quality parameters. Various growth, earliness, yield and quality parameters recorded were subjected to line × tester analysis. The variance due to the genotype was significant for all the growth, earliness, yield and quality parameters.

The magnitude of heterosis over the commercial check (Arka Rakshak) was very high in desirable direction and it ranged from 3.07 to 55.72 per cent for plant height at 90 DAT, -38.31 to 17.41 per cent for number of primary branches per plant at 90 DAT, -55.73 to 7.17 per cent for days to flower initiation, -13.97 to 28.25 per cent for days to fifty per cent flowering, -14.23 to 9.30 per cent for days to first fruit harvest for earliness, -64.58 to 70.98 per cent for average fruit weight, -17.07 to 60.06 per cent for number of fruits per plant, -67.29 to 9.74 per cent for yield per plant, -67.32 to 9.76 per cent for yield per hectare, 7.54 to 79.47 per cent for number of locules per fruits, -17.23 to 121.01 per cent for total soluble solids content of fruit, -30.15 to 0.84 per cent for pericarp thickness, -3.53 to 41.62 per cent for fruit length, -28.66 to 21.23 per cent for fruit girth and -3.40 to 36.60 per cent for fruit colour.

The hybrid UHSB-20 × UHSB-32 was the best hybrid selected for yield per ha as it exhibited maximum standard heterosis of 9.76 per cent and its estimated total yield was 441.35 q per hectare as compared to 402.12 q per hectare of the commercial check (Arka Rakshak) in this experiment. This hybrid also showed significant standard heterosis in the desirable direction for plant height at 30, 60 and 90 DAT, number of primary branches per plant at 30 DAT, days to flower initiation, average fruit weight, yield per plant, yield per plot, yield per hectare, total soluble solids content of the fruit, fruit girth and fruit colour.

The second best hybrid was UHSB-17 × UHSB-33 and its estimated yield per hectare was 435.46 q with 8.29 per cent standard heterosis. This hybrid also showed significant standard heterosis in the desirable direction for plant height at 30 DAT, plant height at 60 DAT, plant height at 90 DAT, number of primary branches per plant at 30 DAT, number of primary branches per plant at 60 DAT, days to flower initiation, average fruit weight, number of fruits per plant, yield per plant, yield per plot, yield per ha, fruit girth and fruit colour.

The next best hybrid was UHSB-28 × UHSB-33 and its estimated yield per hectare was 434.48 q with 8.05 per cent standard heterosis. This hybrid also showed significant standard heterosis in the desirable direction for plant height at 30 DAT, plant height at 60 DAT, plant height at 90 DAT, number of primary branches per plant at 30 DAT, number of primary branches per plant at 60 DAT, number of primary branches per plant at 90 DAT, days to flower initiation, days to first harvest, average fruit weight, yield per plant, yield per plot, yield per ha, total soluble solids content of fruit and fruit colour.

Lines UHSB-14, UHSB-15 and UHSB-21 were identified as good general combiners for plant height at 30 DAT, lines UHSB-14, UHSB-22 and UHSB-23 for 60 DAT, lines UHSB-14, UHSB-15, UHSB-20, UHSB-22, UHSB-23 and UHSB-29 for 90 DAT, the line UHSB-23 for number of primary branches per plant at 30 DAT, lines UHSB-21 and UHSB-23 for 60 DAT, lines UHSB-4 and UHSB-21 for 90 DAT, lines UHSB-8, UHSB-11, UHSB-15 and UHSB-17 for days to flower initiation, lines UHSB-8 and UHSB-11 for days to fifty per cent flowering, lines UHSB-8, UHSB-21, UHSB-22, UHSB-30 and UHSB-31 for days to first fruit harvest, lines UHSB-8, UHSB-14, UHSB-17, UHSB-18, UHSB-20, UHSB-28 for average fruit weight, lines UHSB-11, UHSB-15, UHSB-17, UHSB-21, UHSB-23, UHSB-29 and UHSB-31 for number of fruits per plant, the line UHSB-17 for yield per plant, lines UHSB-11, UHSB-14, UHSB-15 and UHSB-17 for yield per plot, lines UHSB-11, UHSB-14, UHSB-15 and UHSB-17 for yield per ha. The line UHSB-8 for number of locules per fruit, lines UHSB-4, UHSB-8, UHSB-20, UHSB-21 and UHSB-22 for total soluble solids content of fruit, lines UHSB-18, UHSB-20 and UHSB-31 for pericarp thickness, lines UHSB-15, UHSB-22, UHSB-29 and UHSB-31 for fruit length, lines UHSB-11, UHSB-21 for fruit girth, lines UHSB-11, UHSB-15, UHSB-22 and UHSB-31 for fruit colour.

The tester UHSB-37 considered as best general combiner for plant height at 30, 60 and 90 DAT, number of primary branches per plant at 30, 60 and 90 DAT, days to flower initiation, days to fifty per cent flowering and days to first fruit harvest and number of fruits per plant and total soluble solids content of fruit. The testers UHSB-32 and UHSB-33 considered as best general combiners for average fruit weight and yield per plant, yield per plot and yield per ha and also the tester UHSB-32 considered as best general combiner for pericarp thickness, fruit length and fruit girth.

The crosses UHSB-18 × UHSB-37, UHSB-11 × UHSB-37, UHSB-28 × UHSB-33, UHSB-20 × UHSB-32 and UHSB-14 × UHSB-37 are identified as the good specific combiners for yield per ha.

By comprehensive assessment of parents by considering gca effects of 20 characters has resulted into identification of lines, *viz.*, UHSB-11, UHSB-14, UHSB-15, UHSB-17, UHSB-20, UHSB-21, UHSB-23 and UHSB-31 and among the testers UHSB-32 and UHSB-37 as good combiners for over all characters. Comprehensive assessment of crosses by considering heterosis values of 20 characters revealed that, out of 45 crosses 24 crosses were highly heterotic, 16 crosses were low heterotic and four crosses were average heterotic. Among 24 highly heterotic crosses, 21 crosses involved high × low or low × high parental combinations for overall gca status, 17 crosses involved high × high parental combinations.

Studies on combining ability variance revealed that, non-additive gene action was predominant for plant height at 30 DAT, plant height at 60 DAT, plant height at 90 DAT, number of primary branches per plant at 30 DAT, number of primary branches per plant at 60 DAT, number of primary branches per plant at 90 DAT, days to flower initiation, yield per plant, yield per plot, yield per ha, number of locules per fruit, total soluble solids content of fruit, pericarp thickness, fruit length, fruit girth, fruit colour and hence heterosis breeding and recurrent selection can be employed for improvement.

REFERENCES

Adhi, S., Reddy, V. S., Sujatha, M. and Pratap M., 2013, Combining ability and gene action studies for yield and yield contributing traits in tomato (*Solanum lycopersicum* L.). *Helix*, **6**: 431ï 435.

Ahmad, S., Quamruzzaman, A. K. and Islam, M. R., 2011, Estimate of heterosis in tomato (*Solanum lycopersicum* L.). *Bangladesh J. Agric. Res*., **36**(3): 521-527.

Ahmed, S. V., Sha, H. K. and Sharfeuddin, A. F. M., 1988, Study on heterosis and correlation in tomato. *Thaiwan J. Agric. Sci*., **21**: 117-123.

Aisyah, S. I., Wahyuni, S., Syukur, M. and Witono, J. R., 2016, The estimation of combining ability and heterosis effect for yield and yield components in tomato (*Lycopersicon esculentum* Mill.) at lowland. *Ekin Int. biannual peer-reviewed J.,* **2**(1): 23-29.

Akram, F., Hossein, N., Hossein, A., Amin, M. K. and Navid, V., 2012, The estimate of combining ability and heterosis for yield and yield components in tomato (*Lycopersicon esculentum* Mill.). *J. Biol. Environ. Sci.,* **6**(17):129-134.

Akshay, A., 2011, Heterosis and combining ability analysis for productivity related traits in tomato. *M. Sc. (Agri.) Thesis,* Univ. Agric. Sci., Dharwad (India).

Alice, K., Peter, K. V. and Rajan, S., 2011, Heterosis for yield components and fruit character in tomato. *J. Tropical Agric*., **39**(10): 5-8.

Anbu, S., Muthukrishnan, C. R. and Irulappan, I., 1981, Line x tester analysis in tomato (*Lycopersicon esculentum* Mill.). *South Indian Hort.,* **29**: 49-53.

Anbu, S., Muthukrishnan, C. R. and Irulappan, I., 1980, Line x tester analysis in tomato (*Lycopersicon esculentum* Mill.) Part-I, Combining ability. *South Indian Hort.,* **2**(10): 280-285.

Anonymous, 2016, *www.nhb.gov.in*. National Horticulture Board, Statistical data.

Arunachalam, V. and Bandopadhay, A., 1979, Arc multiple cross pollen ï an answer for productivity population in *Brassica compestris* var. Brown Serson. *Theoretical and Applied Genet.*, **54**: 203-207.

Asati, B. S., Singh, G., Rai, N. and Chaturvedi, A. K., 2007, Heterosis and combining ability studies for yield and quality traits in tomato. *Veg. Sci*., **34:** 92-94.

Ashwini, M. C., 2005, Heterosis and combining ability studies for heat tolerance in tomato. *M. Sc. (Agri.) Thesis,* Univ. Agric. Sci., Dharwad (India).

Baishya, K. C., Syamal, M. M. and Singh, K. P., 2001, Heterosis studies in tomato (*Lycopersicon esculentum* Mill.). *Veg. Sci*., **28:** 168-169.

Bajendra, S., Naorem, P., Amitava, W., Shabir, H. and Laishram, J. M., 2013, Heterosis studies for quality traits in tomato (*Solanum lycopersicum* L.) using bacterial wilt tolerant and high yielding varieties. *J. Plant Sci. Res*., **29**(1): 67-71.

Berry and Uddin, 1991, Breeding tomato for quality and processing attributes. *In Genetic improvement of tomato. Ed. Kallo, G., Springer-Verlag,* pp. 196-206.

Bhatt, R. P., Biswas, V. R. and Kumar, N., 2001, Combining ability studies in tomato (*Lycopersicon esculentum* Mill.) under mid hill conditions of central himalaya. *Indian J. Genet.,* **61**: 74-75.

Bhatt, R. P., Adhekari, R. S. and Narendra, K., 2004, Genetical analysis for quantitative and qualitative traits in tomato (*Lycopersicon esculentum* Mill.) under open and protected environment. *The Indian J. Genet. Pl. Breed.,* **64**: 125-129.

Bhatt, R. P., Biswas, V. R. and Kumar, N., 1999, Studies on heterosis for certain characters in tomato (*Lycopersicon esculentum* L.) (Karsten) under mid hill condition. *Prog. Hort*., **36**(1-2): 41-43.

Bhutani, R. D., Kalloo, G., Pandita, M. L. and Singh, G. P., 1973, Studies on heterosis in tomato. *Haryana J. Hort. Sci.,* **2**: 156-163.

Bhutani, R. D. and Kallo, G., 1989, Genetics of carotenoids and lycopene in tomato (*Lycopersicon esculentum* Mill.). *Genetica agraria*, **37**: 1-6.

Bhutani, R. D., 1980, Diallel analysis for yield and quality traits in tomato (*Lycopersicon esculentum* Mill.). *Ph.D. Thesis*, Haryana Agric. Uni., Hisar.

Bose, T. K., Bose, J., Kabir, T. K., Maity, V. A. and Som, M. G., 2002, Vegetable crops, bhumani mitra publication, Calcutta, *India.1st Edn., pp*. 456-471.

Chadha, S., Vidyasagar and Kumar, J., 2001, Combining ability and gene action studies for some fruit characters in bacterial wilt resistant tomato lines. *South Indian Hort.,* **50**: 65-71.

Clinton, S. K., 2005, Tomatoes or lycopene: a role in prostate carcinogenesis. *J. of Nutrition*. **135**(8): 2057-2059.

Dechin, D., Kumar, R., Subodh, J. and Yadav, R. K., 2012, Genetic studies of quality traits in tomato (*Solanum lycopersicum* L.) under low temperature. *Veg. Sci*., **39**(2): 189-191.

Dhaliwal, M. S., Singh, S. and Cheema, D. S., 2000, Estimating combining ability effects of the genetic male sterile lines of tomato for their use in hybrid breeding. *J. Genet. Pl. Breed*., **54**: 199-205.

Dharmatti, P. R., 1995, Investigations on summer tomatoes with special reference to tomato leaf curl virus (ToLCV). *Ph. D. Thesis*, Uni. Agric. Sci., Dharwad (India).

Dharmatti, P. R., Madalageri, B. B., Mannikeri, I. M. and Patil, R. V., 1999, Combining ability for tomato leaf curl virus resistance in summer tomatoes (*Lycopersicon esculentum* Mill.). *Adv. Agric. Res. India*, **11**: 67-72.

Dharmatti, P. R., Madalageri, B. B., Mannikeri, I. M., Patil, R. V. and Patil, G., 2001, Genetic studies in summer tomatoes. *Karnataka J. Agric. Sci*., **14**: 407-411.

Dharmatti, P. R., Kulkarni, G. P. and Patil, R. V., 2006, Heterosis for yield and bacterial wilt incidence in tomato. *J. Asian Hort*., **2**(3):151-154.

Dixit, J., Kalloo, G., Bhutani, R. D. and Sidhu, A. S., 1980, Line x tester analysis for the study of heterosis and combining ability in tomato. *Haryana J. Hort. Sci.,* **28**: 128-135.

Dod, V. N. and Kale, P. B., 1992, Heterosis for certain quality traits in tomato (*Lycopersicum esculentum* Mill.). *Crop Res.*, **5**: 302-308.

Dod, V. N., Kale, P. B. and Wankhade, R. V., 1995, Heterosis and combining ability in tomato (*Lycopersicon esculentum* Mill.). *PKV. Res. J.*, **19**: 125-129.

Dorgan, J. F., Sowell, A., Swanson, C. A., Potischman, N., Miller, R., Schussler, N. and Stephenson, J. H., 1998 Relationship of serum carotenoids, retinol, alpha tocopherol and selenium with breast cancer risk : results from a prospective study in Columbia, Missouri (USA). *Cancer Causes Control.* **9**(1): 89-97.

Dudi, B. S. and Sanwal, S. K., 2004, Evaluation for potential F_1 hybrids of tomato (*Solanum lycopersicum* L.) in respect of fruit yield and component traits. *Haryana J. Hort. Sci.,* **33**(1&2):98-99.

Dudi, B. S., Kalloo, G. and Pandita, M. L., 1979, Line x tester analysis for the study of combining ability in tomato (*Lycopersicon esculentum* Mill.). *Haryana J. Hort. Sci.*, **8**(3-4): 117-123.

Dundi, K.B., 1991, Development of F_1 hybrids in tomato (*Lycopersicon esculentum* Mill.). M.Sc. (Agri.) Thesis, Uni. Agric. Sci., Dharwad (India).

Duhan, D., Partap, P. S., Rana, M. K. and Dahiya, M. S., 2005, Heterosis study for quality characters in a line x tester set of tomato. *Haryana J. Hort. Sci.,***34**: 371-375.

Dundi, K. B., Madalageri, B. B., Kanamadi, V. C. and Dharmatti, P. R., 1991, Studies on general and specific combining ability for total soluble solids in tomato. *Progr. Hort.*, **23** (1-4): 108-109.

East, E. M. and Hayes, H. K., 1912, Heterosis in evolution and in plant breeding. *United Dept. Agric. Bullet*, pp. 243.

Fageria, M. S., Kohli, U. K. and Dhaka, R. S., 2001, Studies on heterobeltiosis for fruit yield and yield attributing traits in tomato (*Lycopersicon esculentum* Mill.). *Haryana. J. Hort. Sci.,* **30**: 131-133.

*Fonseka, A. and Patterson, F. L., 1968, Hybrid vigour in a seven diallel cross in common winter wheat (*Triticum aesticum* L.). *Crop Sci*., 8: 85.

Gabry, M. A. H., Solieman, T. I. H. and Abido, A. I. A., 2014, Combining ability and heritability of some tomato (*Solanum lycopersicum* L.) cultivars. *Scientia Hort*., 168:1-2.

Gaikwad, S. P., Raijadhav, S. B., Dumbre, A. D. and Bhor, T. J., 2002, Combining ability analysis in tomato by use of line x tester technique. *J. Maharashtra Agric. Uni*., **27**(3): 308-310.

Gaikwad, S. P. and Cheema, S., 2012, Studies on hybrid vigour of F_1 and its retention in F_2 generation of tomato. *Crop*. **5**: 302-308.

Ghosh, P. K., Syamal, M. M. and Rath, S., 1997, Heterosis studies in tomato. *Haryana J. Horti. Sci*., **26**: 114-117.

Govindarasu, P., Muthukrishnan, C. R. and Irulappan, I., 1981, Combining ability for yield and its components in tomato. *Scientia Hort.*, **14**: 125-130.

Govindarasu, P., Muthukrishnan, C. R. and Irulappan, I., 1982, Studies on heterosis in tomato (*Lycopersicon esculentum* Mill.). *South Indian Hort.*, **30**: 9-12.

Gul, R., Rahman, H., Tahir, M., Naeem, M. and Ghafoor, A., 2013, Estimates of heterosis for morphological and flavor attributes in tomato. *African J. Biot*., **10**(28): 5244-5251.

Gul, R., Rahman, H. U., Khalil, H. I., Shah, A. S. and Abdul., 2010, Heterosis for flower and fruit traits in tomato (*Lycopersicon esculentum* Mill.). *African J. Biot*., **9**(27): 4144-4151.

Hannan, M. M., Ahmed, M. B., Razvy, M. A., Karim, R., Khatum, M., Hayder, A., Hussain, M., and Roy, U. K., 2007, Heterosis and correlation of yield and yield components in tomato. *Am-Eurasian J. Sci. Res*. **2** (2): 46-150.

Islam, M. R., Ahmad, S. and Rahman, M. M., 2012, Heterosis and qualitative attributes in winter tomato (*Solanum lycopersicum* L.) hybrids. *Bangladesh J. Agric. Res*., **37**(1): 39-48.

Izge, A. U. and Garba, Y. M., 2012, Combining ability for fruit worm resistance in some commercially grown tomatoes in lake Alau near Maiduguri and Hong in Adamawa state, Nigeria. *J. Environ. issues and Agric. in developing countries,* **4**(1): 332-338.

Jamwal, R. S., Rattan, R. S. and Saini, S. S., 1984, Hybrid vigour and combining ability in tomato. *South Indian Hort*., **32**: 67-74.

Joshi, A. and Thakur, M. C., 2003, Exploitation of heterosis and combining ability for yield and yield contributing traits in tomato (*Lycopersicon esculentum* Mill.). *Prog. Hort.,* **35**: 64-68.

Joshi, A., Thakur, M.C. and Kohli, U.K., 2005, Heterosis and combining ability for shelf-life, whole fruit firmness and related traits in tomato. *Indian J. Hort*.,**62**: 33-36.

Kalloo, G., Singh, R. K. and Bhutani, R. D., 1973, Combining ability studies in tomato (*Lycopersicon esculentum* Mill.). *Theoretical Appl. Genet.,* **44**: 358-363.

Kamalveer, Vinodkumar, S. and Uniyal, S. P., 2006, Combining ability studies in tomato (*Solanum lycopersicum* L.). *Veg. Sci*., **33**(1): 76-78.

Kanthaswamy, V. and Balakrishnan, R., 1989, Studies on hybrid vigour of F_1 and its retention in F_2 generation of tomato. *South Indian Hort*., **37**: 77-83.

Kaur, P., Dhaliwal, M. S., Surjan, S. and Singh, S., 2002, Genetic analysis of some parameters associated with fruit firmness in tomato by involving genetic male sterile lines. *Veg. Sci*., **29**(1): 20-23.

Kavitha, S., Sekar, K. and Kalyanasundaram, 2007, Combining ability and gene action studies for salinity tolerance in tomato (*Solanum lycopersicum* Mill.). *Veg. Sci.,* **34**: 37-39.

Kempthorne, O., 1957, An Introduction to genetic statistics, New York, John Wiley and Sons.

Khoja, H. and Ahmad, N. A., 2008, Study of general and specific combining ability and heterosis for earliness characteristic at six tomato varieties (*Lycopersicon esculentum L.*) and their hybrids. *Tishreen Univ. J. Res. And Sci. Studies – Bio. Sci. Series*., **22**(30):160-166.

Kulkarni, G. P., 1999, Heterosis, combining ability and reaction to tomato leaf curl virus in tomato. *M.Sc. (Agri.) Thesis,* Uni. Agric. Sci., Dharwad (India).

Kulkarni, G. P., 2003, Investigations on bacterial wilt resistance in tomato. *Ph.D. Thesis,* Uni. Agric. Sci., Dharwad (India).

Kumar, N., Bisht, J. K. and Joshi, M. C., 1988, Genetic studies of quantitative traits in pear shape tomato. *Prog. Hort*., **20**: 105-108.

Kumar, P. T., Tewari, R. N. and Pachauri, D. C., 1997, Line x tester analysis for processing characters in tomato. *Veg. Sci*., **2**: 34-38.

Kumar, R. K., Srivastava, N., Pal, S., Vasistha, N. K., Singh, R. K. and Singh, M. K., 2013, Combining ability analysis for yield and quality traits in tomato (*Solanum lycopersicum* L.). *J. Agric. Sci*., **5:** 2.

Kumar, R., Mishra, N. K., Singh, J., Rai, G. K., Verma, A. and Rai, M., 2006, Studies on yield and quality traits in tomato (*Solanum lycopersicon* Mill.).*Veg. Sci.,* **33**:126- 132.

Kumar, S. And Ramanjinigowda, P. H., 2016, Estimation of heterosis and combining ability in tomato for fruit shelf life yield component traits using line × tester method. *Int. J. of agric. and Environ. Res*. **2**(3):455-467

Kumari, S. and Sharma, K. M., 2011, Exploitation of heterosis for yield and its contributing traits in tomato (*Solanum lycopersicum* L.). *Inter. J. Farm Sci*., **1**(2):45-55.

Kurian, A. and Peter, K. V., 2001, Line x tester analysis for yield and processing characters in tomato. *J. Trop. Agric*., **33**: 23-25.

Lakshmi, B. L., 1997, Studies on the production and evaluation of triple cross F_1 hybrids resistant to bacterial wilt caused by *Pseudomonas solanacearum* in tomato (*Lycopersicon esculentum* Mill.). *M. Sc. (Hort.) Thesis*, Uni. Agric. Sci., Bangalore (India).

Mageswari, K. and Natarajan, S., 1999, Studies on heterosis for yield and quality in tomato (*Lycopersicon esculentum* Mill.). *South Indian Hort.*, **47**: 216-217.

Mahendrakar, P., 2004, Development of F_1 hybrids in tomato (*Lycopersicon esculentum* Mill.). *M. Sc. (Hort.) Thesis*, Uni. Agric. Sci., Dharwad (India).

Marbhal, S. K., Ranpise, S. A. and Kshirsagar, D. B., 2016, Heterosis study in cherry tomato (*Solanum lycopersicum* var. *cerasiforme*) for quantitative traits. *Int. Res. J. of Multidisciplinary Studies*., **2**: 2454-2499.

Mittal, R. K., Singh, H. N., Singh, R. R. and Singh, J. B., 1974, Combining ability in tomato. *Haryana J. Hort. Sci*., **3**: 168-176.

Mishra, C. H. and Khanna, K. R., 1977, Heterosis and combining ability studies for some vegetative character in tomato. *Indian J. Hort.,* **34**: 396-403.

Nagaraja, T. E., 1995, Studies on genetic architecture of fruit yield, its components and inheritance of leaf curl virus resistance in inter-specific crosses of tomato (*Lycopersicon esculentum* Mill.). *Ph. D. Thesis,* Uni. Agric. Sci., Bangalore (India).

Narasimhamurthy, Y. K. and Gowda, P. H. R., 2017, Line × tester analysis in tomato (*Solanum lycopersicum* L.). *Inter. J. of Pl. Breed*., **7**(1), 50-54.

Naveen, G., Devinder, S. C., and Ajmer S. D., 2008, Genetics of yield, quality and shelf life characteristics in tomato under normal and late planting conditions. *Euphytica,* **159**:275ï 288.

Padma, E., Senkar, C. R. and Rao, B. V., 2002, Heterosis and combining ability in tomato (*Lycopersicon esculentum* Mill.). *The Andhra Agric. J.*, **49**(3-4): 285-292.

Pandey, S. K., Dixit, J., Pathak, V. N. and Singh, P. K., 2006, Line x tester analysis for yield and quality characters in tomato [*Solanum lycopersicon* (Mill.) Wettsd.]. *Veg. Sci.,* **33**: 13-17.

Patagaonkar, D. R., Ingavale, M. T., Mangave, K. and Kadam, D. D., 2003, Heterosis studies for fruit characters in heat tolerant lines of tomato (*Lycopersicon esculentum* Mill.). *South Indian Hort.*, **51**(1-6): 134-136.

Patil, A. A., 1985, Studies on correlation, path analysis, genetic divergence, heterosis and combining ability in ten parental diallel cross of tomato. *Ph.D. Thesis*, Univ. Agric. Sci., Bangalore.

Patil, A. A. and Bojappa, K. M., 1988, Studies on heterosis as influenced by genetic diversity and combining ability. *J. Maharashtra Agric. Uni*., **13**(2): 150-151.

Patil, A. A. and Patil, S. S., 1988, Preliminary studies on combiners and combinations for quality traits in tomato *(Lycopersicon esculentum* Mill.). *Plant Foods for Human Nutrition*., **38**:43-49.

Patil, M. G., 1996, Investigation on genetic improvement and production practices in processing tomato *(Lycopersicon esculentum* Mill.). *Ph.D. Thesis,* Uni. Agric. Sci., Dharwad (India).

Patil, S. S., 1998, Studies on association of characters, heterosis and combining ability in processing tomato *(Lycopersicon esculentum* Mill.). *M. Sc. (Agri.) Thesis*, Uni. Agric. Sci., Dharwad (India).

Peter, K. V. and Rai, B., 1978, Heterosis as a function of genetic distance in tomato. *Indian J. Genet. Pl. Breed.*, **38**: 173-178.

Prabhushankar, H. R., 1990, Genetic analysis of yield and yield components in tomato (*Lycopersicon esculentum* Mill.). *M.Sc. (Agri.) Thesis*, Univ. Agric. Sci., Dharwad (India).

Prashanth, H., 2004, Heterosis and combining ability analysis for higher lycopene content in tomato. *M. Sc.(Agri.) Thesis*. Uni. Agric. Sci., Dharwad (India).

Premalakshmi, V., 2010, Heterosis and combining ability analysis in tomato (*Lycopersicon esculentum* Mill.) for yield and yield contributing traits. *South Indian Hort.,* **50**: 360-369.

Premalakshmi, V., Thargaraj, T., Veeranagavathatham, D. and Armugam, T., 2003, Heterosis and combining ability analysis in tomato (*Solanum lycopersicon* Mill.) for yield and yield contributing traits. *Veg. Sci.,* **33**: 5-9.

Pujari, C. V. and Kale, P. N., 1994, Heterosis studies in tomato. *J. Mahrashtra Agric. Univ.,* **19**: 83-85.

Rai, N., Syamal, M. M., Joshi, A. K. and Ghosh, P. K., 1998, Diallel analysis for pericarp thickness and storability of tomato (*Lycopersicon esculentum* Mill.). *Annu.Agric. Res*., **18**: 71-75.

Raijadhav, S. B., Chaudhari, K. G., Kale, P. N. and Patil, R. S., 1996, Heterosis in tomato under high temperature stress. *J. Maharashtra Agric. Uni*., **21**(2): 229-231.

Raijadhav, S. B. and Kale, P. N., 1987, Combining ability for processing characters in tomato. *J. Maharashtra Agric. Uni.,* **12**(3): 379-380.

Rajput, J. C., 1987, Exploitation of F_2 heterosis for yield and processing qualities in tomato (*Lycopersicon esculentum* Mill.). *Ph.D. Thesis*, Univ. Agric. Sci., Bangalore.

Ramamohan, 1988, Genetics of heat tolerance in tomato. *M.Sc.(Agri.) Thesis*, Univ Agric. Sci., Bangalore.

Reddy, V. V. D. and Reddy, B. M. M., 1994, Heterosis for fruit characters in tomato. *J. Maharashtra Agric. Univ*., **19**: 312-314.

Roopa, S. A. T., Reddy, K. M., Gopalakrishnarao, K. P. and Narasimha, P., 2001, Combining ability studies for long shelf-life in tomato. *Veg. Sci.,* **28**: 24-26.

Saeed, A. S. C., Khan, A. A., Sadiaand. and Khan, I. F., 2008, Analysis of combining ability for yield, yield components and quality characters in tomato. *J. Agric. Res*., **46**(4): 325-332.

Saeed, A., Hasan, N., Shakeel, A., Saleem, M. F., Khan, N. H., Zaif, K., Rana, A. M. K. and Nadeem, S., 2014, Genetic analysis to find suitable parents for development of tomato hybrids. *www.sciencepub.net/researcher.,* **6**(6): 77-82.

Sajjan, M. N., 2002, Heterosis, combining ability, RAPD analysis and resistance breeding for leaf use virus and bacterial wilt in tomato (*Lycopersicon esculentum* Mill.). *M.Sc. (Agri.) Thesis*, Uni. Agric. Sci., Dharwad (India).

Saleem, M. Y., Akhtar, K. P., Iqbal, Q., Asghar, M. and Shoaib, M., 2015, Development of high yielding and blight resistant hybrids of tomato. *Pak. J. Agri. Sci.,* **52**(2): 293-299.

Saleem, M. Y., Muhammad, A, Q., Attiq, U. and Muhammad, A., 2013, Diallel analysis of yield and some yield components in tomato (*Solanum lycopersicum* L.). *Pak. J. Bot*., **45**(4): 1247-1250.

Santosh and Manish, 2011, Exploitation of heterosis for yield and its contributing traits in tomato (*Solanum lycopersicum* L.). *International J. Farm Sci.,* **1**(2): 45-55.

Sathyanarayana, H. V. and Anand, N., 1992, Combining ability studies in bacterial wilt resistant tomato (*Lycopersicon esculentum* Mill.) for processing qualities and yield. *Veg. Sci*., **19**(2): 192-200.

Sekar, L., Prakash, B. G., Salimath, P. M., Channayya, P., Hiremath, O., Srideviand, P. A. A., 2010, Implications of heterosis and combining ability among productive single cross hybrids in tomato. *Electronic J. Plant Breeding,* **1**(4):706-711.

Septa, N. K., Septa, S. R., Septa, S. and Kumar, A., 2013, Energy use efficiency and cost analysis of tomato under greenhouse and open field production system at Nubra valley of Jammu and Kashmir. *Int. J. of Environ Sci.,* **3**(4): 1233-1241.

Sharma, D. and Sharma, H. R., 2010, Combining ability analysis for yield and other horticultural traits in tomato. *Indian J. Hort*. **67**(3): 402-405.

Sharma, D. and Thakur, M. C., 2008, Evaluation of diallel progenies for yield and its contributing traits in tomato under mid-hill conditions. *Indian J. Hort*., **65**: 297-301.

Sharma, D. K., Chaudhary, D. R. and Pandey, D. P., 2001, Studies on hybrid vigour in tomato (*Lycopersicon esculentum* Mill.). *Haryana J. Hort. Sci.,* **30**: 236-238.

Sharma, D. K., Chaudhary, D. R. and Sharma, P. P., 1999, Line x tester analysis for study of combining ability of quantitative traits in tomato. *Indian J. Hort.,* **56**: 163-168.

Sharma G. D., Devi, N. and Raj, D., 2006, Relative susceptibility of tomato genotypes to fruit borer, *Helicoverpa armigera. Hübner.J. Entomological Res*., **30**(4): 309-312.

Sharma, J. P., Jha, A. K., Singh, A. K., Pan, R. S., Mathurarai and Kumar, S., 2006, Evaluation of tomato against bacterial wilt (*Rastonia solanocearum*) in Jharkhand. *Indian Phytopath*., **59**(4): 405-409.

Sharma, S., 1996, Screening of international set of tomato genotypes to bacterial wilt disease. *Agric. Res. Centre,* **96**: 17.

Shull, G. H., 1908, What is heterosis?. *Genetica,* **33**: 430-446.

Shull,G. H., 1914, Duplicate genes for capsule form in *Bursabursa postoris*. *Zeitschriftfuer Induktive Abstammungs und Verrebungslehre*, **12**: 97-149.

Sidhu, A. S., Kalloo, G., Dixit, J. and Bhutani, R. D., 1981, Heterosis and combining ability in pear shaped tomato (*Lycopersicon esculentum* Mill.). *Haryana Agric. Uni. J. Res*., **11**(1): 1-7.

Singh, A. K. and Asati, B. H., 2011, Combining ability and heterosis studies in tomato under bacterial wilt condition. *Bangladesh J. Agril. Res*. **36**(2): 313-318.

Singh, A. K., Pan, R. S. and Rai, M., 2007, Heterosis for fruit yield and its components in tomato (*Solanum lycopersicum* Mill.). *Veg. Sci.,* **34**:108.

Singh, B., Joshi, S. and Kumar, N., 1976, Heterosis and combining ability in tomato. *Veg. Sci.,* **3**: 91.

Singh, B., Kumar, N. and Joshi, S., 1978, Hybrid vigour in tomato. *Prog. Hort.,* **10**: 20.

Singh, B. R. and Mishra, K., 2010, combining ability for yield and its contributing characters in tomato. *Indian J. Horticulture*., **67**: 240-243.

Singh, B., Shabir, H., Haribhushan, A. and Nongthombam, R., 2012, Heterosis studies for yield and its components in tomato (*Solanum lycopersicum* L.) under valley conditions of Manipur. *J. Veg. Sci*., **25**(2): 257-265.

Singh, C. B., Rai, N., Singh, R. K., Singh, M. C., Singh, A. K. and Chaturvedi, A. K., 2008, Heterosis combining ability and gene action studies in tomato (*Solanum lycopersicum* L.). *Veg. Sci.,* **35**: 132-135.

Singh, N. P., Bharadwaj, A. K., Abnish Kumar and Singh K. M., 2004, Modern technology on vegetable production, *Int. Book distribution Co., Lucknow*, pp. 84-98.

Singh, R. K. and Singh, V. K., 1993, Heterosis breeding in tomato (*Lycopersicon esculentum* Mill.). *Ann. Agric. Res*., **14**: 416-420.

Sprague, G. F. and Tatum, L. A., 1942, General vs specific combining ability in single crosses of corn. *J. Amer. Soc. Agron*., **34**: 923-932.

Srivastava, J. P., Singh, H., Srivastava, B. P. and Verma, H. P. S., 1998, Heterosis in relation to combining ability in tomato. *Veg. Sci*., **25**(1): 43-47.

Sunil, K. Y., Singh, B. K., Baranwal, D. K. and Solankey, S. S., 2013, Genetic study of heterosis for yield and quality components in tomato (*Solanum lycopersicum*). *Afr. J. Agric. Res*., **8**(44): 5585-5591.

Sureshkumar, B. M. K. and Pratap, P. S., 1995, Heterosis study for fruit yield and its components in tomato. *Ann. Agric. Res*., **16**: 212-217.

Tendulkar, S. K., 1994, Studies on line x tester analysis for development of F_1 hybrids in tomato. *M. Sc. (Agri.) Thesis,* Univ. Agric. Sci., Dharwad (India).

Thakur, A. K. and Kohli, U. K., 2005, Studies on genetics of shelf-life in tomato. *Indian J. Hort.,* **62**: 163-167.

Thakur, M. C. and Joshi, A., 2000, Combining ability analysis of yield and other horticultural traits in tomato. *Haryana J. Hort. Sci*., **29**: 214-216.

Tiwari, A. and Lal, G., 2004, Studies on heterosis for quantitative and qualitative characters in tomato (*Lycopersicon esculentum* Mill.). *Prog. Hort.,* **36**: 122-127.

Uppal, G. S., Tarsem, L., Cheema, D. S. and Lal, T., 1997, Performance of tomato hybrids with regard to yield and quality characters. *Punjab Agric. Uni. J. Res.,* **34** (1): 45- 56.

Vinod, K. R., Nandan, S. K., Sharma, K., Srivastava., Ravindra, K. and Singh, M. K., 2013, Heterosis study for quality attributing traits in different crosses in tomato (*Solanum lycopersicum* L.). *Plant Archives*., **13**(1): 21-26.

Viredelwala, H. A., Nandpuri, K. S. and Singh, S., 1987, Heterosis and combining ability in tomato, *Veg. Sci.,* **8**: 120-129.

Virupannavar, H. S., 2009, Genetic studies for productivity and bacterial wilt resistance in tomato. *M. Sc. (Agri.) Thesis,* Univ. Agric. Sci., Dharwad (India).

Yadav and Venkat., 2013, Genetic study of heterosis for yield and quality components in tomato (*Solanum lycopersicum*). *African J. Agri Res*., **8** (44):558-559

Yadav, E. D., Kale, P. N. and Wavhal, K. N., 1989, Heterosis for yield, fruit number and weight of fruiting tomato. *J. Maharashtra Agric. Univ*., **14**: 338-340.

Yashavantakumar, K. H., 2008, Heterosis and combining ability for resistance against tospo virus in tomato (*Solanum lycopersicon* (Mill.) Wettsd.). *M. Sc. (Agri.) Thesis,* Univ. Agric. Sci., Dharwad (India).

** - Original not seen.*

Appendix I: Meteorological data recorded during the period of experimentation (2016-2017) from Agricultural Research Station, Dharwad

Month	Temperature (^{0}C)		Relative Humidity (%)		Evaporation (mm)	Rainfall (mm)
	Minimum	Maximum	Morning	Evening		
June 2016	21.74	30.95	87.73	66.33	4.1	11.70
July 2016	21.22	28.02	93	80	1.87	53.50
August 2016	20.35	28.69	91	71	2.63	31.30
September 2016	20.39	29.48	91.03	66.20	2.97	77.20
October 2016	19.77	30.13	92	60	3.14	83.80
November 2016	13.76	29.40	93.33	47.23	3.38	0.00
December 2016	11.13	28.28	91	42	2.95	0.00
January 2017	12.85	31.25	88	32	3.2	0.00
February 2017	13.97	32.45	92.07	32.93	3.15	3.60
March 2017	15.63	35.49	81	23	4.76	0.00
April 2017	19.14	34.53	72.67	30.83	6.55	6.10
May 2017	22.41	37.63	85	47	7.18	87.80

Appendix II: Tomato fruit colour scoring (IBPGR, Italy)

Character	Scale
Light red colour	3
Medium red colour	5
Bright red colour	7

EVALUATION OF F_1 HYBRIDS IN TOMATO (*Solanum lycopersicum* L.)

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ABSTRACT

The field experiment was conducted at Regional Horticultural Research and Extension Centre (RHREC), Kumbapur, Dharwad. Forty five hybrids were derived from 15 lines and three testers were evaluated through RCBD design and analysed by line × tester analysis in order to estimate heterosis for growth, earliness, yield and quality parameters in tomato. The magnitude of heterosis over the commercial check (Arka Rakshak) was highly desirable in positive direction and it ranged from 3.07 to 55.72 per cent for plant height at 90 DAT, -38.31 to 17.41 per cent for number of primary branches per plant at 90 DAT, -55.73 to 7.17 per cent for days to flower initiation, -13.97 to 28.25 per cent for days to fifty per cent flowering, -14.23 to 9.30 per cent for days to first fruit harvest for earliness, -64.58 to 70.98 per cent for average fruit weight, -17.07 to 60.06 per cent for number of fruits per plant, -67.29 to 9.74 per cent for yield per plant, -67.32 to 9.76 per cent for yield per hectare, 7.54 to 79.47 per cent for number of locules per fruits, -17.23 to 121.01 per cent for total soluble solids content of fruit, -30.15 to 0.84 per cent for pericarp thickness, -3.53 to 41.62 per cent for fruit length, -28.66 to 21.23 per cent for fruit girth and -3.40 to 36.60 per cent for fruit colour. The hybrid UHSB-20 × UHSB-32 was the best hybrid selected for yield per hectare as it exhibited maximum standard heterosis of 9.76 per cent and its estimated total yield was 441.35 q per hectare as compared to 402.12 q per hectare of the commercial check (Arka Rakshak) in this experiment. The second best hybrid was UHSB-17 × UHSB-33 and its estimated yield per hectare was 435.46 q with 8.29 per cent standard heterosis. Line UHSB-17 was identified as good general combiner for yield per plant, lines UHSB-11, UHSB-14, UHSB-15 and UHSB-17 for yield per plot, lines UHSB-11, UHSB-14, UHSB-15 and UHSB-17 for yield per hectare. The testers UHSB-32 and UHSB-33 considered as best general combiners for average fruit weight, yield per plant, yield per plot and yield per hectare. The crosses UHSB-18 × UHSB-37, UHSB-11 × UHSB-37, UHSB-28 × UHSB-33, UHSB-20 × UHSB-32 and UHSB-14 × UHSB-37 are identified as the good specific combiners for yield per hectare. By comprehensive assessment of parents by considering gca effects of 20 characters has resulted into identification of lines, *viz.*, UHSB-11, UHSB-14, UHSB-15, UHSB-17, UHSB-20, UHSB-21, UHSB-23 and UHSB-31 and among the testers UHSB-32 and UHSB-37 as good combiners for over all characters.

ಟೊಮ್ಯಾಟೊದಲ್ಲಿ ಎಫ್–೧ ಸಂಕರಣ ತಳಿಗಳ ಮೌಲ್ಯಮಾಪನ

ಸಂತೋಷಕುಮಾರ ಹೆಗಡೆ ೨೦೧೭ ಯಶವಂತಕುಮಾರ ಕೆ. ಎಚ್.

ಪ್ರಧಾನ ಸಲಹೆಗಾರರು

ಸಾರಾಂಶ

ಟೊಮ್ಯಾಟೊದಲ್ಲಿ ಎಫ್–೧ ಸಂಕರಣ ತಳಿಗಳ ಮೌಲ್ಯಮಾಪನವನ್ನು ಪ್ರಾದೇಶಿಕ ತೋಟಗಾರಿಕಾ ಸಂಶೋಧನೆ ಮತ್ತು ವಿಸ್ತರಣಾ ಕೇಂದ್ರ, ಕುಂಭಾಪುರ, ಧಾರವಾಡದಲ್ಲಿ ಕೈಗೊಳ್ಳಲಾಯಿತು. ಹದಿನೈದು ಪ್ರಭೇದ ಮತ್ತು ಮೂರು ಪರೀಕ್ಷಕಗಳ ನಡುವೆ ಸಂಕರಣ ಮಾಡಿ ಪಡೆದ ೪೫ ಸಂಕರಣ ತಳಿಗಳನ್ನು ಯಾದೃಚ್ಛಿಕ ಬ್ಲಾಕ ವಿನ್ಯಾಸದಲ್ಲಿ (RCBD) ಪ್ರಭೇದ × ಪರೀಕ್ಷಕ ದತ್ತಾಂಶ ವಿಶ್ಲೇಷಣೆಯೊಂದಿಗೆ ಮೌಲ್ಯಮಾಪನ ಮಾಡಿ ಬೆಳವಣಿಗೆ, ಆರಂಭಿಕತೆ, ಇಳುವರಿ ಮತ್ತು ಗುಣಮಟ್ಟದ ನಿಯತಾಂಕಗಳನ್ನು ಅಂದಾಜಿಸಲಾಯಿತು. ಸಂಕರಣತೆಯ ಪರಿಮಾಣವನ್ನು ಪ್ರಚಲಿತ ಸಂಕರಣ ತಳಿಗೆ (ಅರ್ಕಾ ರಕ್ಷಕ) ಹೋಲಿಸಿದಾಗ ಕಂಡುಬಂದ ಮಾಹಿತಿಯೆಂದರೆ, ನಾಟಿ ಮಾಡಿ ೯೦ ದಿನಗಳ ನಂತರದ ಸಸ್ಯದ ಎತ್ತರವು ಧನಾತ್ಮಕ ದಿಕ್ಕಿನಲ್ಲಿ, ಅತ್ಯಂತ ಅಪೇಕ್ಷಣೀಯವಾಗಿದೆ (೩.೦೭ ರಿಂದ ೫೫.೭೨ %). ಅದೇ ರೀತಿ ನಾಟಿ ಮಾಡಿ ೯೦ ದಿನಗಳ ನಂತರದ ಸಸ್ಯದ ಪ್ರಾಥಮಿಕ ರೆಂಬೆಗಳು (–೩೮.೩೧ ರಿಂದ ೧೭.೪೧ %), ಹೂವು ಉಗಮಿಸುವ ದಿನಗಳು (–೫೫.೭೩ ರಿಂದ ೭.೧೭ %), ೫೦% ಹೂವುಗಳಿರುವ ದಿನಗಳು (–೧೩.೯೩ ರಿಂದ ೨೮.೨೫ %), ಮೊದಲ ಕಟಾವಿಗೆ ತೆಗೆದುಕೊಂಡ ದಿನಗಳು(–೧೪.೨೩ ರಿಂದ ೯.೩೦ %), ಸರಾಸರಿ ಹಣ್ಣಿನ ತೂಕ (–೧೭.೦೭ ರಿಂಧ ೬೦.೦೬ %), ಪ್ರತಿ ಗಿಡದ ಇಳುವರಿ (–೬೭.೨೯ ರಿಂದ ೯.೭೪ %), ಪ್ರತಿ ಹೆಕ್ಟರ್ ಇಳುವರಿ (–೬೭.೩೨ ರಿಂದ ೯.೭೬ %), ಪ್ರತಿ ಹಣ್ಣಿನ ಲೋಕ್ಯೂಲ್‌ಗಳ ಸಂಖ್ಯೆ (೭.೫೪ ರಿಂದ ೭೯.೪೭ %), ಒಟ್ಟು ಕರಗಬಹುದಾದ ಘಣಗಳು (–೧೭.೨೩ ರಿಂದ ೧೨೧.೦೧ %), ಹಣ್ಣಿನ ಸಿಪ್ಪೆಯ ದಪ್ಪ (–೩೦.೧೫ ರಿಂದ ೦.೮೪ %), ಹಣ್ಣಿನ ಉದ್ದ (–೩.೫೩ ರಿಂದ –೪೧.೬೨ %), ಹಣ್ಣಿನ ಅಗಲ (–೨೮.೬ ರಿಂದ ೨೧.೩೩ %), ಹಣ್ಣಿನ ಬಾಹ್ಯಬಣ್ಣ (–೩.೪೦ ರಿಂದ ೩೬.೬೦ %).

ಪ್ರತಿ ಹೆಕ್ಟರ್ ಇಳುವರಿಗೆ ಯುಎಚ್‌ಎಸ್‌ಬಿ–೨೦ × ಯುಎಚ್‌ಎಸ್‌ಬಿ–೩೨ ಸಂಕರಣ ತಳಿಯು ಪ್ರಚಲಿತ ಸಂಕರಣ ತಳಿಗೆ (ಅರ್ಕಾ ರಕ್ಷಕ) ಹೋಲಿಸಿದಾಗ ಅತ್ಯಧಿಕ ಸಂಕರಣತೆ (೯.೭೬ %) ಹೊಂದಿದ್ದು, ಅದರ ಅಪೇಕ್ಷಣೀಯ ಇಳುವರಿಯು ೪೪೧.೩೫ ಕ್ವಿಂಟಾಲ್‌ನಷ್ಟಿದ್ದು, ಆದರೆ ಪ್ರಚಲಿತ ಸಂಕರಣ ತಳಿಯ (ಅರ್ಕಾ ರಕ್ಷಕ) ಇಳುವರಿಯು ೪೦೨.೧೨ ಕ್ಟಿಂಟಾಲ್‌ನಷ್ಟು ಇದೆ ಎಂದು ಕಂಡು ಬಂದಿದೆ. ಎರಡನೆ ಅತ್ಯುತ್ತಮ ಸಂಕರಣ ತಳಿಯಾದ ಯುಎಚ್‌ಎಸ್‌ಬಿ–೧೭ × ಯುಎಚ್‌ಎಸ್‌ಬಿ–೩೩ ರ ಅಪೇಕ್ಷಣೀಯ ಇಳುವರಿಯು ೪೩೫.೪೬ ಕ್ವಿಂಟಾಲ್‌ನಷ್ಟಿದ್ದು, ೮.೨೯% ಸಂಕರಣೆತೆಯನ್ನು ಹೊಂದಿದೆ. ಯುಎಚ್‌ಎಸ್‌ಬಿ–೧೭ ಪ್ರಭೇದವು ಪ್ರತಿ ಗಿಡದ ಇಳುವರಿಗೆ ಅತ್ಯಂತ ಹೆಚ್ಚು ಸಾಮಾನ್ಯ ಸಂಯೋಜನಾ ಸಾಮರ್ಥ್ಯವನ್ನು ಹೊಂದಿದೆ. ಅದೇ ರೀತಿ ಯುಎಚ್‌ಎಸ್‌ಬಿ–೧೧, ೧೪, ೧೫ ಮತ್ತು ೧೭ ಪ್ರಭೇಧಗಳು ಪ್ರತಿ ಹೆಕ್ಟರ್ ಇಳುವರಿಗೆ ಅತ್ಯಂತ ಹೆಚ್ಚು ಸಂಯೋಜನಾ ಸಾಮರ್ಥ್ಯವನ್ನು ಹೊಂದಿವೆ. ಸಂಕರಣ ತಳಿಗಳಾದ ಯುಎಚ್‌ಎಸ್‌ಬಿ–೧೮ ೦ ಯುಎಚ್‌ಎಸ್‌ಬಿ–೩೭, ಯುಎಚ್‌ಎಸ್‌ಬಿ–೧೧ × ಯುಎಚ್‌ಎಸ್‌ಬಿ–೩೭, ಯುಎಚ್‌ಎಸ್‌ಬಿ–೨೮ × ಯುಎಚ್‌ಎಸ್‌ಬಿ–೩೩, ಯುಎಚ್‌ಎಸ್‌ಬಿ–೨೦ × ಯುಎಚ್‌ಎಸ್‌ಬಿ–೩೨ ಮತ್ತು ಯುಎಚ್‌ಎಸ್‌ಬಿ–೧೪ × ಯುಎಚ್‌ಎಸ್‌ಬಿ–೩೭ ಗಳು ಪ್ರತಿ ಹೆಕ್ಟರ್ ಇಳುವರಿಗೆ ಕ್ರಮೇಣವಾಗಿ ಅತ್ಯಂತ ಹೆಚ್ಚು ನಿರ್ದಿಷ್ಟ ಸಂಯೋಜನಾ ಸಾಮರ್ಥ್ಯನ್ನು ಹೊಂದಿವೆ ಎಂದು ಗುರುತಿಸಲಾಗಿದೆ. ಇಪ್ಪತ್ತು ನಿಯತಾಂಕಗಳ ಸಾಮಾನ್ಯ ಸಂಯೋಜನಾ ಸಾಮರ್ಥ್ಯವನ್ನು ಗಣನೆಗೆ ತೆಗೆದುಕೊಂಡು ಪ್ರಭೇಧಗಳೆಲ್ಲವನ್ನು ಸಮಗ್ರವಾಗಿ ನಿರ್ಣಯಿಸಿ ನೋಡಿದಾಗ

ಪ್ರಭೇಧಗಳಾದ ಯುಎಚ್‌ಎಸ್‌ಬಿ–೧೧, ೧೪, ೧೫, ೧೬, ೨೦, ೨೧, ೨೩ ಮತ್ತು ೩೧, ಅದೇ ರೀತಿ ಪರೀಕ್ಷಕಗಳಾದ ಯುಎಚ್‌ಎಸ್‌ಬಿ–೩೨ ಮತ್ತು ೩೬ ಗಳನ್ನು ಒಟ್ಟಾರೆ ಎಲ್ಲಾ ನಿಯತಾಂಕಗಳಿಗೆ ಒಳ್ಳೆ ಸಂಯೋಜಕವೆಂದು ಗುರುತಿಸಲಾಯಿತು.