Affectionately

Dedicated to

My Beloved

Family and Parents

.... Santosh

HETEROSIS, COMBINING ABILITY AND EVALUATION OF F_1 HYBRIDS OF CHERRY TOMATO UNDER DIFFERENT GROWING CONDITIONS

By

SANTOSH KISAN MARBHAL
(Reg. No. 10/79)

A thesis submitted to the
MAHATMA PHULE KRISHI VIDYAPEETH
RAHURI-413 722, DIST. AHMEDNAGAR
MAHARASHTRA, INDIA

in partial fulfillment of the requirements for the degree

of

DOCTOR OF PHILOSOPHY (AGRICULTURE)

in

HORTICULTURE (VEGETABLE SCIENCE)

DEPARTMENT OF HORTICULTURE
POST GRADUATE INSTITUTE
MAHATMA PHULE KRISHI VIDYAPEETH
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2014

CANDIDATE'S DECLARATION

I hereby declare that this thesis or part thereof has not been submitted by me or other person to any other University or Institute for a Degree or Diploma

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Date: / /2014 **(S.K. Marbhal)**

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CERTIFICATE

This is to certify that the thesis entitled, “**HETEROSIS, COMBINING ABILITY AND EVALUATION OF F_1 HYBRIDS OF CHERRY TOMATO UNDER DIFFERENT GROWING CONDITIONS”**, submitted to the Faculty of Agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar, Maharashtra State in partial fulfillment of the requirements for the degree of **DOCTOR OF PHILOSOPHY (AGRICULTURE)** in **HORTICULTURE** (**VEGETABLE SCIENCE),** embodies the results of a *bona fide* research work carried out by **Mr. SANTOSH KISAN MARBHAL** under my guidance and supervision and that no part of the thesis has been submitted to any other university for degree or diploma.

The assistance received by him during the course of investigation and sources of literature have been duly acknowledged.

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Place: Rahuri
Date: / /2014

(**B.R. Ulmek**)
Associate Dean (PGI)

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Date: / /2014 **(S.K. Marbhal)**

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LIST OF ABBREVIATIONS

Av.	:	Average
BP	:	Better parent
C.D.	:	Critical Difference
cm	:	Centimeter(s)
cv.	:	Cultivar
D.F.	:	Degree of Freedom
et al.	:	et allii :and others
etc.	:	Etcetera
F_1	:	First filial generation
F_2	:	Second filial generation
g	:	Gram(s)
gca	:	General combining ability
ha	:	hectare(s)
i.e.	:	That is
IU	:	International unit
L.S.D.	:	Least Significant Difference
LCV	:	Leaf curl virus
m	:	Meter(s)
M.P.	:	Mid parent
M.S.S.	:	Mean Sum of Squares
Max.	:	Maximum
mg	:	Milligram(s)
Min.	:	Minimum
N.S.	:	Non-significant
NVP	:	Naturally ventilated polyhouse
q	:	Quintal(s)
S.D.	:	Standard Deviation
S.E.	:	Standard Error
sca	:	Specific combining ability
SES	:	Suncherry Extra Sweet
SH	:	Commercial hybrid
SS	:	Sum of Squares
t	:	tones
TLCV	:	Tomato leaf curl virus
TP	:	Top parent
TSS	:	Total soluble solids
TSWV	:	Tomato spotted wilt virus
var.	:	Variety
viz.,	:	Namely
σ^2 gca	:	Variance for general combining ability
σ^2 sca	:	Variance for specific combining ability
µg	:	Microgram(s)

ABSTRACT

HETEROSIS, COMBINING ABILITY AND EVALUATION OF F_1 HYBRIDS OF CHERRY TOMATO UNDER DIFFERENT GROWING CONDITIONS

by

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A candidate for the degree of

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in

HORTICUTLURE (VEGETABLE SCIENCE)

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Research Guide	:	Dr. S.A. Ranpise
Department	:	Horticulture

The present investigation entitled “Heterosis, combining ability and evaluation of F_1 hybrids of cherry tomato under different growing conditions” was undertaken to develop the cherry tomato hybrids having better yield and quality characters, highly heterotic and highly stabilized under different growing conditions. Seven diverse genotypes and their 21 F_1s obtained by half diallel mating system were evaluated during *rabi*, 2010-11 in a Randomized Block Design with three replications. The data was recorded on yield and quality components.

Significant heterosis in favourable direction was recorded for fruits per cluster (25.00 %), clusters per plant (24.91 %), acidity (14.43 %) and lycopene (11.74 %) over better parent, while, polar diameter (-19.96 %), clusters per plant (101.10 %), acidity (13.27 %) and lycopene (-31.31 %) over commercial hybrid by the cross combination EC 128021 x EC 163615, for fruits per cluster (24.07 %), fruit yield (21.91 %), reducing sugars (11.19 %) over better parent, however, clusters per plant (81.87 %) and lycopene (18.11 %) over commercial hybrid by EC 163615 x EC 128618, for fruit yield (41.06 %) and acidity (11.24 %) over better parent, while, clusters per plant (65.93 %) over commercial hybrid by EC 539 x EC 128021.

Significant positive GCA effects for fruits per cluster (0.31), clusters per plant (3.79), TSS (0.17) and ascorbic acid (1.56), whereas, significant negative gca effects for fruit weight (-1.86) and seeds per fruit (-10.02) recorded by the parent EC 128021. The parent EC 163615 exhibited significant positive GCA effects for clusters per plant (2.80), TSS (0.35), acidity (0.03) and lycopene (0.36), while, significant negative gca effects for fruit weight (-1.13) and seeds per fruit (-9.47). Parent EC 128618 exhibited significant positive gca effects for clusters per plant (1.64), yield per plant (0.06), juice (1.09) and ß-carotene (0.94), however, significant negative gca effects for fruit weight (-0.26).

Significant SCA effects in favourable direction for fruit weight (-1.09), clusters per plant (0.60), yield per plant (0.18) and TSS (0.67) recorded by the cross combination EC 163615 x EC 128618, for fruit weight (-0.70), cluster length (1.16), clusters per plant (15.16), yield per plant (0.40) and juice (5.01) by CL 15-61-6-0-5 x EC 163615, for clusters per plant (4.97), yield per plant (0.19), TSS (0.59) and acidity (0.06) by EC 128021 x EC 163615.

On the basis heterosis over better parent for yield and quality characters seven promising hybrids were selected and evaluated with one commercial hybrid under different growing conditions *viz.*, polyhouse, shade net house and open field during *summer*, 2011-12.

Under polyhouse condition, significantly maximum yield and less incidence of thrips (1.11) and white fly (0.73) per leaf was recorded by the hybrid CL 15-61-6-0-5 x EC 163615. Under shade net house condition, maximum yield per plant (1.33 kg) and per hectare (591.11 q) with lowest incidence of white fly per leaf (1.10) and leaf curl (9.85 %) was recorded by the hybrid CL 15-61-6-0-5 x EC 163615. Under open field condition, maximum clusters per plant (27.00), yield per plant (1.33 kg) and per hectare (493.83 q) and less incidence of thrips per leaf (2.69) was recorded by the hybrid EC 163615 x EC 128618.

On the basis of stability parameters, the hybrid EC 163615 x EC 128618 found most stable over all three environments for fruit weight, yield per plant, TSS, whereas, the hybrid EC 128021 x EC 163615 for yield per plant, ascorbic acid content, hybrid EC 539 x EC 128021 for cluster per plant and yield per plant and hybrid CL 15-61-6-0-5 x EC 163615 for fruits per cluster, shelf life and β-carotene content.

The crosses *viz.,* EC 539 x EC 128021 (41.06 %) and EC 128021 x EC 163615 (38.32 %) and EC 163615 x EC 128618 (21.91 %) recorded high heterosis, similarly, these crosses are also found stable for yield, which can be exploited as commercial hybrid. The parents EC 128021, EC 163615, EC 128618 and EC 539 were observed good general combiners for most of the characters, which can be used in future breeding programme.

Pages 1 to 199

1. INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is one of the most important vegetable in the world and is the dietary source of vitamins, minerals and fiber, which are important for human nutrition and health. Fresh fruits are used in salads, various culinary preparations and juices or processed in the form of purees, concentrates, condiments and sauces. Although, a ripe tomato has 94 per cent water, good source of vitamin A and B and excellent source of vitamin C and having good nutritive value. It is very appetizing, removes constipation and has a pleasing taste.

In India, tomato is cultivated on an area of 8.65 lakh hectare with production 165.26 lakh metric tonnes with productivity 19.1 tonnes per hectare (Anon., 2011). It is cultivated in Maharashtra, Bihar, Karnataka, Uttar Pradesh, Orissa, Andhra Pradesh, Madhya Pradesh and Assam. In Maharashtra, tomato is cultivated on an area of 52,000 ha with production of 7.38 lakh metric tonnes and productivity 14.2 tonnes per hectare (Anon., 2011). In Maharashtra it is grown in Nasik, Pune, Solapur, Sangli, Satara, Ahmednagar and Nagpur districts.

Cherry tomato (*Solanum lycopersicum* var. *cerasiforme*) is becoming popular and has the potential of becoming a valuable cash crop. The ancestor of cultivated tomato is the wild cherry tomato (*Solanum lycopersicum* var. *cerasiforme*) (Rick and Holle, 1990). It is generally accepted that cultivated tomato lines were derived from cherry tomato (formerly *Lycopersicum esculentum* var. *cerasiforme*) through domestication (Jenkins, 1948). The *cerasiforme* types can also be distinguished from the cultivated types by the presence of a slightly excreted stigma in the flowers (Taylor, 1986). The main differences between the *cerasiforme* type and standard tomato cultivars is that the fruit of the *cerasiforme* types are less than half size of the cultivated forms (Rick, 1958). Fruit size of cherry tomato ranges from a thumb tip to the size of a golf ball and can range from being spherical to slightly oblong in shape. The ripe fruit have a diameter between about 1.9 to about 3.8 cm, typically between about 2.5 to 3.0 cm. Cherry tomatoes are usually prolific, tiny and some have been bred for high sugars as a salad and snacking 'fruit'.

Cherry tomato is a self pollinated crop. The commercial exploitation of hybrid vigour in cherry tomato has 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. With increasing popularity of F_1 hybrids of cherry tomato, it is necessary to develop hybrids which have excellent yield coupled with resistance to diseases and pests.

Combining ability analysis helps in understanding the nature of gene action governing the expression of the character and thus helps in deciding breeding strategy. It also helps in choosing the best combiners, which can exhibit maximum hybrid vigour in the F_1. Many biometrical procedures have been used to obtain the information on combining ability and diallel analysis is one among them, which is widely used to study combining ability of the parents to be chosen for heterosis breeding.

In India, the demand for total vegetables will be 199 MT in the year 2050 (Ghosh, 2012). It is a challenge to technological processes and resources of agricultural production to produce vegetables throughout the year to meet the need of fast increasing population. Greenhouse technology is relevant to such challenges. During the last decade, due to increase in temperature and intensity of solar radiation caused by climate change, there is more scope to grow vegetables under controlled conditions like polyhouse and shade net house. Greenhouse, the latest word in Indian agriculture is one such means, where the plant are grown under controlled or partially controlled environment resulting in higher yields than under open field conditions (Navale *et al.*, 2003). Greenhouse protects the crops from extreme high temperature, low temperature and excessive rainfall to facilitate timely harvest as per market demand with better quality of produce (More *et al.*, 1990).

The area and productivity of cherry tomato in India is very low as compared to other countries, may be due to non availability of high yielding adaptable varieties. Open field cultivation of vegetables is often damaged by unfavorable weather conditions especially during sensitive stages of growth and development. Cherry tomato is a very sensitive vegetable and even a slight variation in any of the weather parameters would lead to significant changes in growth physiology of the crop resulting with considerable yield loss.

A very scanty information available regarding greenhouse cultivation of cherry tomato and its response to different protected structures *viz.,* naturally ventilated polyhouse and shade net house. An understanding of the influence of the micro environment on growth of cherry tomato would be much helpful in tapping the potential yield under protected cultivation. Identification of high yielding small fruited F_1 hybrids, suitable for growing in greenhouse and open field conditions will help for successful commercial cultivation of cherry tomato.

Genotypes show wide fluctuations in their yielding ability when grown in different environments. Stability in productivity, therefore, is a major and important consideration for the plant breeder. Study of stability parameters is useful to identify the stable cultivars.

Considering the spectrum of aforesaid requirement in cherry tomato, the present investigation was undertaken with the following objectives.

1. To study heterosis for important quality and quantitative characters of cherry tomato.

2. To study the general and specific combining ability for important quality and quantitative characters of cherry tomato.

3. To evaluate performance of F_1 hybrids under different growing conditions.

4. To study the diseases and pests reaction against leaf curl, spotted wilt virus and thrips, whitefly and mites.

2. REVIEW OF LITERATURE

The genetic improvement of both quantitative and qualitative characters is the main interest of the plant breeder. The success of such a creative manipulation requires adequate knowledge of genetics of various characters. Hence, for the improvement of cherry tomato, detailed investigation regarding genetic architecture of fruit yield and its attributes should be the main focus.

Keeping in view the objectives of present investigation, the literature on heterosis, combining ability, evaluation of tomato under polyhouse, shade net house and open field conditions and stability analysis has been reviewed and presented in this chapter under appropriate heading and subheading.

2.1 Heterosis and combining ability

- 2.1.1 Heterosis
- 2.1.2 Combining ability

2.2 Evaluation of F_1 hybrids and stability analysis

- 2.2.1 Evaluation of F_1 hybrids under different growing conditions
- 2.2.2 Stability analysis

2.1 Heterosis and combining ability

2.1.1 Heterosis

Heterosis or hybrid vigour indicates the superiority of hybrid over its parents. It was first reported in plants by Koelreuter (1766). He noted that vigour in crosses increased with the increase in dissimilarity of parents. The term "heterosis" as is now widely used, was first coined by Shull (1908). It refers to the phenomenon in which the F_1 hybrid obtained by crossing two genetically dissimilar individuals shows the increased or decreased vigour over the better or mid-parent value. Later on, Fonesca and Patterson (1968) used the new term "heterobeltiosis" to describe improvement of heterozygotes in relation to better parent. Heterosis being a complex phenomenon, no conclusive or clear cut explanation is available to account for its manifestation.

Though, tomato is a self pollinated crop where degree of heterosis was theoretically observed that it has been attributed to the fact that tomato was basically a highly out crossing genus, which was later evolved into a self pollinated one. The literature by various scientists, on heterosis for growth, yield and quality attributes over mid parent (MP) and better parent (BP) and commercial hybrid (SH) is presented in Table 1.

Table 1. Review of literature on heterosis for different traits in tomato

Sr. No.	Characters	Range of per cent heterosis over			References
		MP	BP	SH	
1	Plant Height	-	-34.44 to 43.67	-55.32 to 26.19	Sharma and Thakur (2008)
		-22.52 to 44.19	-35.99 to 26.02	-40.99 to 4.73	Yashavantakumar (2008)
		-32.75 to 72.23	-27.37 to 74.59	-40.68 to 42.57	Dhadde *et al.* (2009)
		-28.01 to 35.70	-31.77 to 32.04	-22.76 to 77.68	Shalini (2009)
		-31.11 to 13.26	-33.88 to 8.69	-31.62 to 10.38	Virupannavar (2009)
		-16.71 to 9.58	-31.40 to 8.31	-13.77 to 26.57	Hosamani (2010)
		-39.49 to 39.65	-43.48 to 30.76	-	Sekhar *et al.* (2010)
2	Days to 50 % flowering	-13.38 to 9.89	-13.10 to 20.64	-14.28 to 3.41	Kulkarni (2003)
		-	-24.36 to 25.76	-30.56 to 3.52	Mahendrakar (2004)
		-	-7.63 to 12.71	-3.27 to 10.60	Duhan *et al.* (2005a)
		-17.70 to 12.24	-14.30 to 18.84	-19.60 to 14.79	Shalini (2009)
		-10.09 to 10.00	-16.67 to 4.76	-15.38 to 21.75	Hosamani (2010)
		-10.67 to 18.61	-17.43 to 17.56	-	Sekhar *et al.* (2010)
		-	-2.00 to 374.00	-	Ahmed *et al.* (2011b)

Table 1 (Contd...)

Sr. No.	Characters	Range of per cent heterosis over			References
		MP	BP	SH	
3	Average fruit weight	-70.83 to 53.65	-76.29 to 42.40	-73.55 to 19.21	Sajjan (2001)
		-45.73 to 57.59	-59.49 to 44.07	-59.52 to 71.23	Kulkarni (2003)
		-	-71.78 to 24.14	-64.55 to 70.95	Mahendrakar (2004)
		-42.54 to 52.92	-45.97 to 29.66	-51.80 to 55.37	Prashanth (2004)
		-	-44.05 to 73.64	-2.37 to 98.81	Duhan *et al.* (2005a)
		-61.49 to 45.01	-62.50 to 40.31	-	Premalakshmi *et al.* (2006)
4	Polar diameter	-16.32 to 18.89	-30.05 to -2.24	-11.59 to 23.62	Dhadde *et al.* (2009)
		-23.16 to 14.96	-41.75 to 3.68	-22.59 to 24.07	Shalini (2009)
		-23.97 to 25.47	-37.25 to 19.60	-30.36 to 7.73	Virupannavar (2009)
		-30.40 to 32.70	-35.70 to 15.50	-	Gul *et al.* (2010)
		-13.67 to 12.27	-23.13 to 4.53	-20.19 to 6.75	Hosamani (2010)
5	Equatorial diameter	-20.89 to 29.13	-25.34 to 12.19	-7.39 to 39.17	Dhadde *et al.* (2009)
		-19.66 to 23.34	-33.02 to 20.20	-18.46 to 21.54	Shalini (2009)
		-16.80 to 28.36	-20.35 to 27.98	-12.92 to 34.61	Virupannavar (2009)
		-49.1 to 10.60	-52.10 to 7.90	-	Gul *et al.* (2010)
		-15.82 to 10.28	-20.42 to 3.13	-10.60 to 19.28	Hosamani (2010)

Table 1 (Contd...)

Sr. No.	Characters	Range of per cent heterosis over			References
		MP	BP	SH	
6	Locules per fruit	-28.01 to 38.89	-41.18 to 29.31	-48.45 to 28.87	Yashavanthakumar (2008)
		-23.41 to 49.62	-28.73 to 30.21	-7.28 to 69.47	Dhadde *et al.* (2009)
		-27.72 to 0.95	-25.26 to 41.00	-26.39 to 47.78	Shalini (2009)
		-39.02 to 27.27	-56.14 to 8.45	-13.79 to 105.17	Virupannavar (2009)
		-11.70 to 23.28	-30.26 to 20.65	-32.44 to 30.74	Hosamani (2010)
7	Pericarp thickness	-34.95 to 68.89	-44.44 to 5.32	-27.38 to 35.71	Dhadde *et al.* (2009)
		-35.22 to 37.50	-42.51 to 22.58	-45.05 to 10.10	Shalini (2009)
		31.16 to 57.14	-39.05 to 0.43	-43.86 to 23.68	Virupannavar (2009)
		-10.61 to 20.93	-26.71 to 20.53	-24.18 to 18.95	Hosamani (2010)
		-24.64 to 55.90	-33.33 to 44.83	-	Sekhar *et al.* (2010)
8	Fruits per cluster	-43.54 to 84.54	-47.57 to 71.31	-62.89 to -7.44	Yashavantakumar (2008)
		-13.21 to 71.89	-23.70 to 53.93	-26.51 to 16.87	Shalini (2009)
		-0.80 to 38.71	-4.62 to 31.15	-25.30 to 6.02	Virupannavar (2009)
		-33.30 to 38.90	-40.50 to 32.00	-	Gul *et al.* (2010)
		-11.34 to 12.80	-26.82 to 5.98	-26.07 to 4.20	Hosamani (2010)
		-	-15.28 to 23.73	-	Ahmed *et al.* (2011)

Table 1 (Contd...)

Sr. No.	Characters	Range of per cent heterosis over			References
		MP	BP	SH	
9	Clusters per plant	-80.00 to 390.0	-81.56 to 325.88	-85.36 to 439.68	Dharmatti (1995)
		-41.37 to 37.62	-51.17 to -12.80	-50.00 to 13.70	Kulkarni (1999)
		-25.81 to 120.73	-36.41 to 92.25	-21.91 to 58.01	Sajjan (2001)
		2.50 to 253.59	-11.29 to 192.39	-2.99 to 220.83	Kulkarni (2003)
		-	-59.30 to 4.15	-29.98 to 19.41	Duhan *et al.* (2005a)
		-30.42 to 107.41	-35.99 to 105.94	-69.26 to -1.09	Yashavanthakumar (2008)
		29.91 to 105.65	36.94 to 101.85	-33.27 to 24.39	Shalini (2009)
		-22.82 to 46.52	-28.37 to 44.23	-192.72 to 4.46	Virupannavar (2009)
		-24.16 to 103.5	-33.71 to 100.00	-	Sekhar *et al.* (2010)
10	Shelf life	-40.98 to 73.59	-49.48 to 49.45	-19.21 to 91.12	Prabhushankar (1990)
		-54.63 to 63.05	-58.33 to 44.12	-16.34 to 249.02	Dundi (1991)
		-13.16 to -42.73	-42.42 to -55.15	-	Reddy and Reddy (1994)
		-	-25.46 to 46.76	-	Premalakshmi *et al.* (2002)
		-	8.50 to 81.02	-	Saidi (2007)
		-6.37 to 52.59	-20.34 to 52.59	-18.61 to 18.26	Shalini (2009)

Table 1 (Contd…)

Sr. No.	Characters	Range of per cent heterosis over			References
		MP	BP	SH	
11	Yield per plant	-30.94 to 333.45	-43.67 to 310.91	-69.58 to 42.40	Yashavantakumar (2008)
		-44.40 to108.14	-59.46 to 65.64	-31.44 to180.11	Dhadde *et al.* (2009)
		-	-49.78 to 47.20	-	Saleem *et al.* (2009)
		-12.16 to 104.99	-36.51 to 86.23	-51.38 to 20.92	Shalini (2009)
		-30.97 to 111.67	-34.70 to 94.68	-55.35 to 22.01	Virupannavar (2009)
		-18.80 to 34.90	-37.60 to 14.70	-	Gul *et al.* (2010)
		-1.23 to 40.01	-22.00 to 18.01	-12.34 to 35.66	Hosamani (2010)
		-64.50 to 56.98	-67.30 to 23.40	-	Sekhar *et al.* (2010)
		-	-30.88 to 62.31	-	Ahmed *et al.* (2011)
12	Juice	-43.78 to 23.05	-50.97 to 14.41	-14.66 to 79.16	Kulkarni (2006)
13	TSS	-24.22 to 25.52	-26.51 to 10.98	5.17 to 89.66	Yashavantakumar (2008)
		-20.92 to 36.95	-28.49 to 5.15	-4.08 to 40.87	Dhadde *et al.* (2009)
		-21.03 to 25.49	-29.25 to 12.59	-36.91 to -10.36	Shalini (2009)
		-21.63 to11.11	-22.38 to 1.17	-22.81 to 11.95	Virupannavar (2009)
		-13.34 to 8.48	-16.26 to 0.56	-24.79 to 0.93	Hosamani (2010)
		-	-41.87 to 31.89	-	Ahmed *et al.* (2011)

Table 1 (Contd...)

Sr. No.	Characters	Range of per cent heterosis over			References
		MP	BP	SH	
14	Acidity	-	-58.77 to 45.98	0 to 131.00	Duhan *et al.* (2005b)
		-34.94 to 36.46	-38.46 to 10.48	3.84 to 69.20	Kulkarni (2006)
		-55.88 to 147.50	-43.48 to 175.00	-	Kumar *et al.* (2006)
		-40.51 to 30.82	-44.21 to 5.85	-30.95 to 26.19	Dhadde *et al.* (2009)
		-32.96 to 70.26	-39.83 to 62.15	-45.24 to 42.86	Shalini (2009)
15	Ascorbic acid	-41.88 to 44.01	-52.56 to 41.68	-40.90 to 18.52	Tendulkar (1994)
		-	-50.27 to 49.21	-43.65 to 77.20	Mahendrakar (2004)
		-	-32.22 to 20.74	-22.72 to 42.24	Duhan *et al.* (2005b)
		-33.08 to 46.03	-35.84 to 58.13	14.50 to 31.70	Kulkarni (2006)
		-54.20 to 29.21	-59.67 to 48.20	-	Kumar *et al.* (2006)
		-20.79 to 192.34	-23.31 to 170.43	-64.75 to 19.04	Shalini (2009)
16	Total sugar	-9.06 to 8.72	-11.84 to 8.02	-11.2 to 9.67	Kulkarni (2006)
17	Reducing sugar	-19.80 to 28.21	-23.30 to 27.85	-13.7 to 18.95	Kulkarni (2006)
18	Lycopene	2.56 to 107.29	-0.54 to 78.09	-	Kurian and Peter (2001)
		-35.92 to 52.89	-44.13 to 41.38	-47.08 to 10.55	Virupannavar (2009)

2.1.2 Combining ability

The concept of combining ability has become very popular in the discipline of plant breeding since Davis (1927) suggested the use of inbred-variety cross (top cross) as a method of evaluating inbred lines of maize. General combining ability is the average performance of a parental line in a series of hybrid combinations with other lines and is controlled by additive genetic variance including additive x additive interaction variance. The concept of general and specific combining ability variances as a measure of gene action was proposed by Sprague and Tatum (1942). Specific combining ability is the deviation in the performance of a specific cross from the performance predicted on the basis of general combining ability. The F_1 performance between two parents may not be the true indication of the potentialities of the parents but performance of F_1 crosses involving a common parent may be good indication of the potentialities of a particular parent to transmit favourable genes to the progenies. Therefore, general and specific combining ability estimates are likely to be quite useful in self as well as cross-pollinated crops. In general combining ability, therefore, genes with additive effects are more important, while specific combining ability is more dependent on genes with dominance and epistatic effects.

The choice of parental material in a breeding programme is very important, since it puts a limitation on the possibility of isolating the genotypes outside the framework of the genetic makeup of the parents. No amount of manipulation later on would compensate for the genes not present in parental material. The knowledge of combining ability of the parents and crosses is important to achieve this goal.

Several methods have been developed to estimate the general and specific combining ability of different genetic materials *viz.,* inbred- variety cross or top cross technique (Jenkins and Brunson, 1932), poly cross (Tysdal, *et al.* 1942), diallel cross (Griffing, 1956), line x tester analysis (Kempthorne, 1957), partial diallel cross (Kempthorne and Curnow, 1961) and triallel cross (Rawling and Cockerham, 1962).

Many characters of economic importance with which the plant breeders work, exhibit continuous variation of phenotypes, as many genes with small and cumulative effect govern them. The effect of these individual genes cannot be measured separately, hence they must be considered as together and appropriate statistical procedures are used to obtain the genetic information. The inferences on magnitude and nature of gene effects are usually drawn from the estimates of different genetic variances.

The review pertaining to combining ability for various characters related to present investigation is summarized in Table 2.

Table 2. Review of literature on combining ability for different traits in tomato

SN	Characters	Combining ability	References
1	Plant height	Higher sca effects	Asati *et al.* (2007), Singh *et al.* (2008), Yashavantakumar (2008)
		Significant gca and sca effects	Bhalekar (2003), Kulkarni (2003), Mahendrakar (2004), Prashanth (2004), Singh *et al.* (2005), Premalakshmi *et al.* (2006)
2	Days to 50 % flowering	Higher sca effects	Singh *et al.* (2008)
		Significant gca and sca effects	Bhalekar (2003), Mahendrakar (2004)
3	Average fruit weight	Significant sca effects	Saleem *et al.* (2009)
		Significant gca and sca effects	Bhalekar (2003), Kavitha *et al.* (2007b), Singh *et al.* (2008), Yashavantakumar (2008)
4	Polar diameter	Significant gca and sca effects	Bhalekar (2003), Mahendrakar (2004), Singh *et al.* (2005)
5	Equatorial diameter	Significant gca and sca effects	Bhalekar (2003), Mahendrakar (2004), Singh *et al.* (2005)
6	Locules per fruit	Higher sca effects	Singh *et al.* (2008)
		Significant gca and sca effects	Joshi *et al.* (2005), Joshi and Kohli (2006), Mahendrakar (2004), Yashavantakumar (2008)
7	Pericarp thickness	Significant gca and sca effects	Kulkarni (2003), Joshi *et al.* (2005), Thakur and Kohli (2005), Mahendrakar (2004)

Table 2 (Contd...)

SN	Characters	Combining ability	References
8	Fruits per cluster	Higher sca effects	Mahendrakar (2004), Yashavantakumar (2008)
		Significant gca effects	Roopa *et al.* (2001), Joshi *et al.* (2004)
9	Clusters per plant	Higher sca effects	Dharmatti (1995), Kulkarni (2003), Yashavantakumar (2008)
		Significant gca and sca effects	Tendulkar (1994)
10	Seeds per fruit	Significant gca and sca effects	Hannan *et al.* (2007)
11	Shelf life	Significant sca effects	Saidi (2007)
		Significant gca and sca effects	Joshi *et al.* (2005), Thakur and Kohli (2005)
12	Yield per plant	Significant gca and sca effects	Asati *et al.* (2007), Kavitha *et al.* (2007), Singh *et al.* (2008), Yashavantakumar (2008)
13	Juice	Significant gca and sca effects	Kulkarni (2006)
14	TSS	Significant gca and sca effects	Bhalekar (2003), Thakur and Kohli (2005), Joshi and Kohli (2006), Mahendrakar (2004)
15	Acidity	Significant sca and gca effects	Bhatt *et al.* (2001), Bhalekar (2003), Kulkarni (2003), Mahendrakar (2004), Kulkarni (2006)
16	Ascorbic acid	Significant sca and gca effects	Joshi and Kohli (2006), Mahendrakar (2004), Kulkarni (2006)
17	Total sugar	Significant gca and sca effects	Kulkarni (2006)
18	Reducing sugar	Significant gca and sca effects	Kulkarni (2006)
19	Lycopene	Significant gca and sca effects	Mondal *et al.* (2009), Virupannavar (2009)

2.2 Evaluation of F_1 hybrids and stability analysis

2.2.1 Evaluation of F_1 hybrids under various growing conditions

2.2.1.1 Protected and open field condition

Ganesan (2002a) summarized that the highest fruit yield per plant (2310.06 g) obtained in the treatment T_3 (Four sides and triangular structured roof on both sides covered with 25% shade net and the parallelograms of the structured roof covered with UV film sheet) followed by the treatment T_2 (Entire roof covered with UV film sheet and four sides covered with 25% shade net) with a plant yield (2156.22 g) than treatment T_1 (Fully covered with UV film sheet and both sides of the door kept open for ventilation during day time) 1016.38 g. The highest average fruit weight was noted in the treatment T_3 (95.02 g) and T_2 (90.05 g) in tomato.

Ganesan (2002b) revealed that greenhouse with ventilation gaps in four side walls had significant effect on tomato cv. Vaishali (T_2), whereas greenhouse with ventilation gaps in the triangular roof and four sidewalls (T_3) was found to be more effective for 'PKM 1'. The var. Vaishali had significantly higher total sugar and reducing sugar contents in T_1 (fully covered with UV film sheet) and T_2. The lycopene content in the fruits of 'PKM 1' and 'Vaishali' were found to be significantly superior in T_3 greenhouse model, while other quality parameters *viz.,* total sugar and reducing sugar contents did not vary significantly due to greenhouse treatments.

Ganesan (2002c) discovered that UV stabilized plastic film covered greenhouse recorded higher day temperature than the open environment. The light intensity inside the greenhouse was lower than in the open. Height of the plant and average fruit weight increased under greenhouse conditions as compared to open field condition. The yield performance inside the greenhouse was highest (2145 g/plant and 2156 g/plant in the first and second season, respectively) than the open field crop. The tomato fruit yield inside the greenhouse was nearly two times more than in the open field condition.

Brandt *et al.* (2003) reported that significantly higher lycopene content was obtained in tomato harvested in greenhouse (83.0 mg kg^{-1} f.w.) than in field (59.2 mg kg^{-1} f.w.) at every harvesting time. The highest concentration of lycopene was detected in cherry tomato (77.4 mg kg^{-1} f.w.), while, Daniela F_1 with 59.2 mg lycopene per kg and Delfine F_1 with 69.6 mg lycopene per kg had significantly lower level under field conditions.

Naik (2005) recorded maximum capsicum yield 37.77 t/ha in medium cost polyhouse irrespective of treatments imposed which was followed by low cost polyhouse and net house (36.69 and 24.49 t/ha, respectively). The favourable environmental conditions prevailed in medium cost polyhouse might have helped in better growth of roots and shoots which directly helped in better vegetative growth, yield attributing parameters and highest total yield.

Mahajan and Singh (2006) recommended that greenhouse tomato fruits founded superior than fruits of open field crop in view of fruit size, TSS and ascorbic acid content. Higher yield under greenhouse may be ascribed to favorable environment at the early stages of tomatoes (especially in the month of December and January, when the day and night temperature is very low) resulted better growth and cause more pickings of tomato especially in the early stages). Further, drip irrigation in greenhouse crop caused significantly improvement in quality characteristics.

Hita *et al.* (2007) conducted a study comparing two Mediterranean greenhouse with cherry tomato in soilless culture. The first greenhouse was an improved low-cost multispan structure (A), while other was an arch shaped hi-tech multispan (B). In the first cycle, greenhouse 'B' enlarged the cropping cycle around one month and yielded 0.48 kg/m^2 more commercial tomato. Greenhouse 'A' reached higher air temperatures during the spring. The second cycle was characterized by low winter temperatures and greenhouse 'B' reached 0.90 kg/m^2 more than greenhouse 'A'.

Thangam and Thamburaj (2008) evaluated six varieties and fourteen hybrids of tomato under shade net and in open field simultaneously during consecutive summer seasons. Plants grown under shade exhibited better plant height compared to those in open field. Delayed flowering and days to first harvest was noticed under shade. The highest fruit weight recorded under shade was 59.50 g by hybrid Rashmi. The number of fruits per plant and fruit yield was more in open field than under shade. Avinash-2 recorded the highest yield in open field as well as under shade.

Zende (2008) found that fruit length (8.50 cm), fruit breadth (8.16 cm), fruit weight (147.74 g), shelf life (8.93 days) pericarp thickness (0.72 cm) and the yield parameters like number of fruits per plant (23.44), fruit yield (6.49 kg/m2) and fruit yield (64.91 t/ha) was significantly higher under polyhouse than shade house in capsicum.

Kurubetta and Patil (2009) revealed that the earliest flower initiation (33.00 days) and highest fruit set (49.81 %), fruit weight (160.00 g), rind thickness (0.91 cm) and shelf life (8.62 days) was significantly maximum under naturally ventilated polyhouse than shadowhall. The hybrid Indra recorded significantly earliest flower initiation (35.42 days) and higher fruit set (45.45 %), rind thickness (0.87 cm) and shelf life (8.60 days) as compared to other two hybrids. The hybrid Bomby recorded significantly highest weight of fruit (158.50 g) in capsicum during *summer* season.

Caliman *et al.* (2010) reported that fruits produced in the field had higher TSS/TA ratio, acidity and had more reducing sugar, ascorbic acid and TSS than those produced in protected conditions. Among the tomato genotypes, 'Carmem' and 'Santa Clara' fruits had higher TSS/TA ratio than 'BGH-320' fruit, contained higher reducing sugar. Fruits of 'BGH-320' were more acidic and higher lycopene content than the 'Carmem' and 'Santa Clara'. The ascorbic acid of 'Santa Clara' fruit was higher than the other genotypes.

Parvej *et al.* (2010) identified microclimatic environment inside polyhouse favoured the growth and development of tomato plant through increased plant height over the plants grown in open field. Flowering, fruit setting and fruit maturity in polyhouse plants were advanced by about 3, 4 and 5 days, respectively compared to the crop raised in open field condition. Polyhouse plants had higher fruit clusters per plant, fruits per cluster and fruits per plant, and fruit length, fruit diameter, individual fruit weight, fruit weight per plant and fruit yield over open field condition. The fruit yield obtained from polyhouse was 81 t/ha against 57 t/ha from the open field.

Cebolla-Cornejo *et al.* (2011) anlaysed taste and aroma related compounds of four varieties and two tomato hybrids under screen house and open field. Protected cultivation tended to show lower sugar concentration but similar acid contents indicated that protected cultivation, despite being useful to reduce the incidence of pests and viral diseases, reduces the organoleptic quality.

According to Kittas *et al.* (2012) shading increased the number of fruit per plant and total tomato yield. Shading reduced 50% losses caused by cracking and thus increased the marketable yield by approximately 50% compared to growth under non-shaded conditions.

Suchindra *et al.* (2012a) evaluated two tomato hybrids *viz.,* Athyla and Valiente under four growing environments (screen house, glass house, shade net house and open condition) for quantative characters. The results showed that among four growing environments shade net house performed good for the hybrid 'Valiente' recorded maximum plant height (2.04 m), fruits per cluster (4.28), fruit set (83.08 %), yield per plant (2.03 kg) and fruit weight (87.50 g).

Suchindra *et al.* (2012b) evaluated two tomato hybrids under four growing environments *viz.,* screen house, glass house, shade net house and open condition for quality characters. The results showed that the hybrid 'Athyla' grown under open condition recorded maximum TSS (4.12 ^{0}B), ascorbic acid (37.24 mg/100g) and acidity (0.90 %) during season II. However, the lycopene content (47.32 mg/100g) was at the highest in hybrid 'Valiente' raised under shade net house during season I.

2.2.1.2 Polyhouse

Yang *et al.* (2004) reported that light is scare in greenhouse, tomatoes were easy to grow vegetatively with reduced leaf area and low content of leaf chlorophyll, low number of flowers, low fruit setting rate and low yield, uneven fruit shape and large fruit size. This indicated preliminarily that tomato, a light crop, was not suitable for cultivation in winter greenhouse in the west of Hainan.

Singh (2005) revealed that among the cultivars, STH-1 was significantly superior to other cultivars in respect of fruit yield per plant (2.54 kg), fruit set (79.21 %), fruit weight (86.60 g), TSS (5.17 ^{0}B) and lycopene content (3.25 mg/100g) under naturally ventilated polyhouse.

Yama *et al.* (2006) evaluated four tomato varieties under plastic house condition and noted that NSITH-162 took the shortest period for flowering, highest fruit set (93.9 %) and marketable fruit yield (89.05 t/ha) and thus recommended for commercial production under plastic house condition.

Chapagain *et al.* (2011) reported that the highest marketable yield was recorded in All Rounder (86.60 t ha^{-1}) followed by Srijana (80.80 t ha^{-1}). Srijana took the shortest period for flowering and found tallest variety (268.70 cm) with more clusters per plant (36.23). However, the highest fruit weight was recorded from Manisha (61.94 g) and the largest fruit size in US-04 with a diameter of 5.78 cm. Based on yield parameter, the varieties All Rounder and Srijana were recommended for commercial cultivation under plastic house conditions.

2.2.1.3 Shade net house

Cheema *et al.* (2004) studied production of off-season tomato under net house conditions and revealed that hybrid 'Naveen' performed best in terms of fruit yield (2.87 kg/plant) as compared to hybrid Avinash and variety CLN 2026 D.

Kavitha *et al.* (2007a) noticed early flowering with the application of 100% water soluble fertilizer under open condition. While, the treatment 100% water soluble fertilizer under shade recorded highest fruits per plant and fruit weight, yield per hectare (99.80 tonnes) and also improved fruit quality parameters *viz.,* fruit firmness, ascorbic acid, lycopene and carotene in tomato.

Milenkovic *et al.* (2012) reported that the total and marketable yield increased with shading levels of 40% and decreased with increasing shading levels to 50%. Shading reduced the appearance of tomato cracking about 50% and eliminated sun scalds on tomato fruits and accordingly, increased the marketable tomato production by about 35% compared to non-shading conditions.

2.2.1.4 Open field

The six cherry tomato inbred lines *viz.,* CLN1466J, CLN1466H, CLN1466K, CLN1466P, CLN1466O and CLN1466S yielded more than 30 t/ha and two of these significantly out-yielded the heat tolerant check (CL5915-93D4-1-0-3). The entries CLN1466J, CLN1466P and CLN1466S showed high yield potential and good fruit quality (AVRDC 1999).

Dhaliwal *et al.* (2002) noted that tomato hybrid TH-1 and TH-2 recorded highest yields and out-performed Avinash-2 by 27.10 %. TH-1 was significantly better for number of locules and TSS, while TH-2 for number of locules and pericarp thickness and was at par for TSS. The hybrid TH-1 was found suitable both for fresh fruit market and processing and hybrid TH-2 for processing.

The soluble solids among the hybrid cherry tomato lines exceeded those of the fresh market types. The fresh market types CLN1462A and CLN2037B produced the highest yields and showed the largest fruit weight 133.30 and 112.50 g, respectively as compared to the hybrid cherry lines. The hybrid cherry lines CHT 54 and CHT 155 recorded the minimum yields and showed the lowest fruit weight 13.30 and 14.20 g, respectively as compared to the fresh market types. The cherry tomato lines have similar or better quality characteristics than many fresh market tomato lines. Although fruit yields may be lower, consumer preferences may make cherry tomato a valuable crop in East Africa (AVRDC, 2005a).

The hybrid cherry tomato line CHT1372 gave the highest yield at 54.50 t/ha, followed by CHT1312 and CHT1358 at 53.60 and 53.30 t/ha, respectively, significantly out-yielded the check Tainan No. 6 by 89-93 %. The incidence of ToLCV for four CHT lines was low (2.6–7.8 %), whereas 99% of check variety plants were infected. The fruit size of CHT1358 was smaller (11.8 g/fruit) but longer than other test lines, and its soluble solid at 6.18 ^{0}B. The incidence of ToLCV (2.6 %) revealed CHT1358 has stable resistance (AVRDC, 2005b).

Adalid *et al.* (2008) determined the carotenoid and vitamin C content in 11 accessions of *Lycopersicon esculentum* var.

cerasiforme and in six *L. esculentum* traditional Spanish varieties. The accession UPV20525 of *L. esculentum* var. *cersiforme* was found superior ß-carotene content and also for its vitamin C content. The *L. esculentum* var. *cersiforme* accessions UPV22353 and UPV22487 are of particular interest for their vitamin C content similar to UPV20525.

Londhe (2009) reported least days to 50% flowering (74.66) by EC-36194, lowest fruit weight (2.56 g) by EC-1445375, highest pericarp thickness (0.44 cm) by CL-4-1-2-1-2, minimum number of locules (2.00) by EC-128067, lowest polar (1.14 cm) and equatorial (1.06 cm) by EC 9159 and EC 28013, respectively. The highest fruits per cluster (10.40) by EC-136014, highest plant height (1.54 m) by EC 9159 and days for retention of fruits per cluster (12.33) by EC-129576, highest fruit yield per plant and hectare (1120 g and 376.76 q, respectively) by EC-539. Regarding the quality traits the highest TSS (8.13 ^{0}B) by EC-9159, maximum acidity and ascorbic acid (1.05 % and 108.10 mg/100g) by EC-28013 and EC-129773, respectively. The maximum total sugar and reducing sugar (8.33 % and 4.22 %) were recorded by EC- 163615 and EC-1294, respectively in cherry tomato.

Adalid *et al.* (2010) assessed fourteen accessions of the cherry type and two of the common tomato type for high and balanced nutritional properties. The accession BGV008365 and BGV012627 (cherry types with over 1.5 times the normal average ascorbic acid content) as well as BGV008166 (*Solanum pimpinellifolium* accession which presented more than nine times the normal average lycopene content) would be of interest as donor parents for breeding programmes to increase the nutrition properties of commercial varieties.

Ahmed *et al.* (2011) observed that tomato hybrid HT019 x C-41 and HT019 x C-51 took minimum days to first flower (42.5). The tallest plant was recorded from the hybrid WP7 x C-51 (146.6 cm). The hybrid WP10 x C-51 produced the heaviest fruit. The hybrid HT019 x WP10 produced the highest fruit yield per plant (1.66 kg). The hybrid WP7 x C-51 had the highest fruit breadth (5.24 cm).

Dar and Sharma (2011) recorded significantly maximum lycopene content (4.62 mg/100g) by EC-251581, β-carotene (2.55 mg/100g) by CGNT-5, ascorbic acid by CGNT-14 (37.80 mg/100g), yield (556.76 q ha^{-1}) by Improved Shalimar, while, minimum fruit weight (21.58 g) by EC-164660 in tomato.

Prema *et al.* (2011) evaluated six genotypes of cherry tomato and found minimum days to 50 % flowering (53.25) and fruit weight (5.22 g) by Stupice Harry, while, maximum plant height (146.80 cm) in Red Pear, fruit weight in Podland Pink (20.18 g), pericarp thickness in Tomy Toe (0.49 cm), number of fruits per cluster (7.13) in Stupice Harry and EC 1, titrable acidity in Podland Pink, TSS (8.10 ^{0}B) in EC 1, ascorbic acid (27.48 mg/100g) in Podland Pink, lycopene in EC 1, shelf life (14.67 days) in Tomy Toe, fruit yield per plant and hectare (4.25 kg and 75.55 t/ha, respectively) in Podland Pink.

Rahaman *et al.* (2011) found the highest number of fruit clusters $plant^{-1}$ in BINA tomato-5 (12.40) and the lowest number of fruit clusters plant-1 was recorded in BINA tomato-4 (10.10).

Genotypic variation in fruit clusters was also reported by Mondol *et al.* (2004). Highest fruit weight was noticed in BINA tomato-5 (70.20 g) and the lowest in CLN-2026 (58.10 g). Highest fruit yield was observed in BINA tomato-5 and BINA tomato-4 (2.40 kg plant^{-1}). Genotypic variation in fruit yield was also observed by Mondol *et al.* (2004) and Hossain (2003) in tomato.

Ali *et al.* (2012) assessed nine exotic tomato hybrids and revealed that maximum fruit diameter (5.19 cm), yield per plot (1.92 kg) and significantly higher yield (6939 kg) were recorded for hybrid T-7010, whereas, maximum plant height (72.00 cm), fruit length (7.80 cm) was recorded for hybrid T-7012, while maximum average fruit weight (112 g) was recorded for hybrid T-7030.

Jyothi *et al.* (2012) reported that regarding the seasons, the maximum plant height (64.08 cm) in *kharif*, fruit set (65.83 %) in *rabi,* yield per plant (2.04 kg) in *rabi*, citric acid (0.43 %) in *kharif* and lycopene in *rabi.* Among the genotypes maximum plant height (64.65 cm) by PTR-3, fruit set (73.11 %) by PTR-5, yield per plant by PTR-1, PTR-4 and PTR-6, citric acid (0.58 %) by PTR-2, TSS (5.67 ^{0}B) by PTR-4 and lowest lycopene by PTR-7 and PTR-8 in tomato.

According to Nahar and Ullah (2012) the variety BARI Tomato-4 gave higher yield and fruits per plant but lower fruit length than that of BARI Tomato-5. There were no differences in fruit yield, fruits per cluster and clusters per plant between the two varieties of tomato. The variations in the performance were due to individual characteristics of two varieties.

2.2.2 Stability analysis

Stability analysis for growth, yield and quality attributing traits are very important from the point of stable production of tomato and to avoid glut or scarcity in the market. Literature on these aspects is reviewed in this chapter and presented under different headings.

2.2.2.1 Models of stability analysis

A specified genotype does not exhibit the same phenotypic characters including yield in all environments. The failure of a genotype to give the same phenotypic performance when tested under different environments is the reflection of genotype x environment interaction. Genotype x Environment interactions is of major importance to the plant breeder in developing stable varieties (Eberhart and Russell, 1966). Vegetable breeders are mainly interested in increasing the level of production with minimum fluctuations in the crop performance as it influences prices of these perishable commodities in the market. It is here that stability has played a pivotal role. Eberhart and Russell (1966) model is efficient for deciding stability of genotypes (Luthra and Singh, 1974) and it was recommended for its simplicity and effectiveness.

2.2.2.2 Stability parameters

According to Peter and Rai (1976) tomato varieties HS-101 and Marglobe were suitable for high yielding environments (b_i>1), whereas, Pusa Early Dwarf, Roma and B-2247 were suitable for poor environments (b_i<1).

Kalloo and Pandey (1979) studied the GxE interaction for yield in tomato. Highly significant differences among genotypes, environments and GxE interactions were found. Variety HS-101 exhibited the best performance under favourable environment with regression coefficient more than one and non-significant deviation from regression.

According to Cuartero and Cubero (1982) the number of locules per fruit in tomato was very consistent due to non-significant regression slopes, but when interaction did exist, the number of locules was higher in less protected environments.

Gull *et al.* (1989) reported that Walter (bi=1.07 and S^2di=0.10) was stable variety for TSS content as indicated by unit regression coefficient and non-significant deviation from regression for TSS.

Kumarswamy and Madalageri (1989) observed highly significant difference with regard to marketable fruit yield. UC-204B and L-15 were the two genotypes with a higher mean yield and had the regression (bi) value around unity and very low deviation from regression.

Gaurish and Gotovtseva (1990) tested four tomato hybrids and the most variable in yield in different zones was F_1 Solina, while, Rusich and Strizh showed low variation in yield. Rusich gave good yields in all zones.

Patil (1994) reported that Selection-6 was least variable for TSS due to around unit regression and non-significant deviation from regression.

Kalloo *et al.* (1998) observed significant GxE interactions for average fruit weight and tomato yield. GxE (linear) interaction was significant for yield. The lines DVRT-1 and DVRT-2 were identified as stable genotypes for higher yield with regression coefficient around unity and non-significant deviation from regression and higher performance for fruit size and average fruit weight, while the genotypes NDT-96, Arka Vikas and JT-99 were stable for pericarp thickness with regression coefficient around unity and minimum non-significant deviation from regression.

Mandal *et al.* (2000) revealed that Punjab Chhuhara, Kalyani Eunish, Pusa Ruby and Sel-7 were adapted specifically to rich environments and Arka Vikas, Marglobe Supreme, KBT-1 and Anand T-1 were adapted specifically to poor environments.

Aravindakumar *et al.* (2001) revealed that mean squares of genotype x environment and genotype x environment (linear) were significant for fruit volume, number of locules and total soluble solids. NS-815, Arka Meghali, Rashmi, Shivaji and F1-124 were found stable with high mean values for fruit volume. Stability with high mean values for number of locules was observed in Arka Vikas, Pusa Ruby and Shivaji while, Arka Ashish was identified as a stable cultivar for total soluble solids in tomato.

Upadhyay *et al.* (2001) studied genotype environment interaction and stability analysis in tomato. Significant mean squares due to GxE interaction were observed for all traits except number of marketable fruits per plant and marketable fruit yield per plant. Cultivars Rupali and Pant T-3 were the only stable genotypes for marketable fruit yield per plant.

Hosamani *et al.* (2003) noticed that pooled analysis of variances indicated significant differences among tomato genotypes, environments and GxE interaction 'H-24' recorded highest mean yield of 17.69 t/ha and exhibited above average stability (bi=5.05) and with minimum unpredictable part of stability (S^2di=0.59). Megha (L-15) with second highest mean fruit yield (17.34 t/ha) was found below average stability (bi=0.27) and with least unpredictable part of stability (S^2di=0.19).

Mulge and Aravindakumar (2003) determined stability of five cultivars and six hybrids of tomato for growth characters. Significant GxE interaction was observed for plant height and Arka Meghali was stable for plant height

Dhaduk *et al.* (2004) observed significant differences among the genotypes and GxE interactions for plant height in tomato. The genotypes H-88 had maximum plant height followed by NDT-VR-60 and H-86. These three genotypes possessed higher mean values with non-significant bi values more than unity indicating their stability and responsive to favourable environments.

Kulkarni (2006) revealed that the ascorbic acid content ranged from 16.42 to 27.00 mg/100g in parents and 3.92 to 17.08 mg/100g in hybrids. While, the acidity ranged from 0.27 to 0.43 for parents and 0.27 to 0.44 mg/100g for hybrids. Juice recovery ranged from 27.92 to 39.50 % for parents and 19.37 to 40.67 % for hybrids. While, the TSS ranged from 3.47 to 6.23 and 4.00 to 6.37 ^{0}B in parents and hybrids, respectively.

Prasanna *et al.* (2007) reported significant GxE (linear) for plant height by using eight tomato genotypes. For plant height, all the genotypes had bi value non-significant from unity (bi=1) indicating average response across the environments. The genotypes VR-20 and Kashi Sharad had significant bi values greater than the unity indicating better adaptation to the favourable conditions for yield. The significant GxE linear was observed for fruit length, fruit width, number of locules and TSS. For all these traits, all the genotypes namely Kashi Viresh, Kashi Amrit, Kashi Arupam, Kashi Hemard, Kashi Sharad, Sel-7, VR-20 and VR-415 had S^2di values non-significant from zero and were thus considered stable over the environments.

Revanasiddappa (2008) evaluated BIP F_2 and BIP F_3 populations for tomato quality parameters. Total soluble solids, ascorbic acid and total titratable acidity observed were 4.40 ^{0}B, 19.09 mg/100g and 0.56 %, respectively.

Shalini (2009) revealed that the tomato genotype 'H-24' was found to be stable across the seasons as indicated by higher mean values for total yield per plant, number of fruits per plant and average fruit weight coupled with regression coefficient nearer to unity and non significant S^2di. Genotypes 'DVRT-2' and 'LE 474' considered as more stable for number of clusters per plant and number of fruits per cluster.

Thapliyal and Singh (2009) observed highly significant differences among genotypes for plant height (cm), days to 50% flowering, number of flower clusters per plant, average fruit weight (g), number of locules per fruit, fruit weight per plant (g), number of fruits per plant, TSS (%) and yield (q/ha). The differences among the environment were also highly significant for all characters except plant height where it was significant only. While this component was non-significant for number of locules per fruit. The analysis of variance revealed the presence of genotype x environment interaction for plant height, days to 50% flowering, average fruit weight, fruit weight per plant, number of fruits per plant and yield (q/ha) in tomato.

Mane *et al.* (2010) evaluated sixteen tomato genotypes along with one check across three different locations. Genotype × environment interaction was significant for most of the yield related traits. None of the genotypes was stable for all the characters and stability for one character was independent of stability for other characters. The genotypes 'TS 1', 'TS 6', 'TS 11', 'TS 14', 'TS 15' and 'TS 16' were found to possess stability for yield related traits. The analysis of quality parameters for all these genotypes revealed their superiority over check cultivar 'L 15' ('Megha').

Hosamani (2010) observed that 'HADT-294', 'PAU-2371', 'Dwd-T-1' and 'Dwd-T-6' were well adapted to all the environments on the basis of stability analysis. 'PAU-2372', 'VR-35', 'HADT-294' and 'ALT-02-39' were higher yielders per hectare. 'VR-35' had high yield per plant and single fruit weight in tomato.

3. MATERIAL AND METHODS

The present investigation entitled, "Heterosis, combining ability and evaluation of F_1 hybrids of cherry tomato under different growing conditions" was carried out at the Tomato Improvement Scheme, Department of Horticulture, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar (Maharashtra) during the year 2010 to 2012. The experimental field has an altitude of 532 m above sea level, latitude of 19°47' to 19°57' N and longitude of 74°82' to 74°91' E.

3.1 Material

The parental material consisted of seven lines of cherry tomato selected on the basis of morphological, quantitative and qualitative characters (Plate 1). Seeds of parents were obtained from Tomato Improvement Scheme, Department of Horticulture, Mahatma Phule Krishi Vidyapeeth, Rahuri. The salient features of the parents used in present investigation are presented in Table 3.

3.2 Methods

3.2.1 Heterosis and combining ability

Seven diverse parents were selected and crossed in diallel mating excluding the reciprocals as suggested by Griffing's (1956) to produce twenty one hybrids in *rabi,* 2010-11.

Table 3. Salient features of the selected seven parents of cherry tomato

SN	Genotypes	Salient features
P_1	EC 539	Indeterminate growth habit, foliage light green, fruits medium big, slightly flattened rounded with green shoulder, ripe fruits dark red
P_2	CL 15-61-6-0-5	Indeterminate growth habit, foliage dark green, fruits medium big, round with green shoulder, ripe fruits red
P_3	EC 128021	Indeterminate growth habit, foliage light green, fruits small, round without green shoulder, ripe fruits dark red
P_4	EC 128013	Indeterminate growth habit, foliage light green, fruits small, slightly flattened rounded with green shoulder, ripe fruits dark red
P_5	EC 885539	Indeterminate growth habit, foliage dark green, fruits medium big, round without green shoulder, ripe fruits orange red
P_6	EC 163615	Indeterminate growth habit, foliage light green, fruits medium, round with green shoulder, ripe fruits dark red
P_7	EC 128618	Indeterminate growth habit, foliage light green, fruits medium, round without green shoulder, ripe fruits orange red

3.2.1.1 Hybridization programme

The seeds of the parents were sown in nursery during *rabi,* 2010-11 and plants were transplanted in separate block. The crosses were made in 7x7 half diallel fashion.

Healthy flower buds in a cyme preferably of the first flush of the female parents, which were expected to open next day were emasculated before opening, between 3 to 6 pm and bagged to prevent out crossing. Pollination was done next morning using pollen grains from desired freshly opened male parent flowers. Crossed flower buds were covered with butter paper bags till fruits were set and labeled. Simultaneously, flower buds of parents were selfed and it was ensured by bagging the flower buds. Seeds were extracted from red ripe fruits by fermentation method.

3.2.1.2 Evaluation of F_1 hybrids

The evaluation of twenty one F_1 hybrids along with their parents and a commercial hybrid for various traits was done up in *kharif,* 2011.

3.2.2 Evaluation of F_1 hybrids and stability analysis

3.2.2.1 Performance of F_1 hybrids under growing conditions

Seven promising crosses (Table 4) were selected on the basis of heterosis over better parent for quantitative and qualitative characters and these promising hybrids were evaluated along with commercial hybrid under polyhouse, shade net house and open field during *summer* 2012.

Table 4. Selected promising F_1 hybrids of cherry tomato for evaluation under different growing conditions

Promising F_1s		Traits with high heterobeltiosis
1x3	EC 539 x EC 128021	Early flowering, high cluster length, cluster weight, pericarp thickness, number of clusters, fruit yield, juice, TSS, shelf life
2x6	CL 15-61-6-0-5 x EC 163615	High fruits per cluster, cluster length, cluster weight, pericarp thickness, fruit yield, juice, TSS, acidity, β-carotene, shelf life, less incidence of white fly, leaf curl, spotted wilt
3x5	EC 128021 x EC 885539	Small fruits, less seeds, high plant height, ascorbic acid, lycopene, less incidence of thrips
3x6	EC 128021 x EC 163615	Early flowering, small fruits, less seeds, high fruits per cluster, number of clusters, fruit yield, TSS, acidity, shelf life, less incidence of thrips, mites
3x7	EC 128021 x EC 128618	Early flowering, small fruits, high fruits per cluster, plant height, acidity, shelf life, less incidence of white fly
4x5	EC 128013 x EC 885539	Early flowering, high length of cluster, juice, total sugar, ascorbic acid
6x7	EC 163615 x EC 128618	Early flowering, small fruits, less seeds, high fruits per cluster, pericarp thickness, number of clusters, fruit yield, total sugar, lycopene, shelf life, less incidence of leaf curl
Check	Suncherry Extra Sweet	Commercial hybrid

3.2.2.2 Stability analysis

Seven promising hybrids and one commercial hybrid was evaluated under three environments *viz,* polyhouse, shade net house and open field during *summer*, 2012 for stability analysis to identify the most stable hybrid.

3.3 Experimental details

3.3.1 Heterosis and combining ability

The experimental material consisted of 21 F_1s, their seven parents and a commercial hybrid *viz.*, Suncherry Extra Sweet. A complete set of 29 genotypes was evaluated in randomized block design with two replications in *kharif*, 2011 (Plate 2). The plot size was 3.60 x 3.00 m and plants spaced at 90 x 30 cm apart. Recommended cultural and plant protection measures were followed to grow a healthy crop.

3.3.2 Evaluation of F_1 hybrids under various growing conditions

3.3.2.1 Open field

The experimental material consisted of seven promising hybrids and a commercial hybrid and evaluated in randomized block design with three replications in *summer*, 2012. The Cherry tomato hybrids were grown under open field condition by allowing the plants to grow naturally without removing side shoots. The plot size was 3.60 x 3.00 m and plants spaced at 90 x 30 cm apart. Recommended cultural and plant protection measures were followed to grow a healthy crop.

3.3.2.2 Protected cultivation (Naturally ventilated polyhouse)

Seven promising cherry tomato hybrids with a commercial hybrid evaluated in completely randomized design with three replications in *summer*, 2012 under naturally ventilated polyhouse. The plants spaced at 45 x 30 cm apart.

3.3.2.3 Protected cultivation (Shade net house)

Seven promising cherry tomato hybrids with a commercial hybrid evaluated in completely randomized design with three replications in *summer*, 2012 under shade net house. The plants spaced at 45 x 30 cm apart.

Cherry tomato hybrids were grown inside the polyhouse and shade net house by adopting the recommended package of practices.

3.3.2.4 Preparation of land for polyhouse and shade net house

Land area inside the naturally ventilated polyhouse and shade net house was brought to a fine tilth. Then beds of convenient size (length 25.0 m, width 1m and height 15 cm) were prepared of mixture of red soil + farmyard manure + coco peat + sand in 1:1:1:1 proportion and vermicompost (1 kg/m^2). The beds were separated 50 cm apart to enable easy cultural operations like spraying, harvesting etc. Soil fumigation was done with 2% formaldehyde for checking soil borne pathogens.

3.3.2.5 Planting and Pinching

According to spacing, marking was done on raised beds. Then one month old seedlings were transplanted in each hole under polyhouse and shade net house. Pinching operation was carried out at one month after transplanting by keeping two shoots.

3.3.2.6 Irrigation, Fertilizer application and Misting

The plants were irrigated one hour daily with drip irrigation system. Plants were watered regularly before noon or late evening.

Water soluble fertilizers were applied through fertilizer tank. Initial 1½ month N:P:K (1:2:0.5) was applied. Onwards N:P:K (2:1:3) was applied on alternate days. The micronutrients were applied through foliar spray.

Misting was carried out by overhead mister during *summer* month to bring the temperature and relative humidity at optimum level.

3.3.2.7 Plant protection measures and Harvesting

Recommended cultural and plant protection measures were followed to grow a healthy crop.

The light red coloured mature fruit clusters were harvested periodically with the help of scissor.

Photo showing cherry tomato crop in different growing conditions is presented in Plate 3.

3.4 Observations recorded

The five competitive randomly selected plants in each genotype in each replication were used for recording the observations. In all trials i.e. heterosis and combining ability, evaluation of promising F_1s under different growing conditions and stability analysis, same set of observations were recorded.

3.4.1 Morphological characters

3.4.1.1 Growing habit (Determinate/Indeterminate/Semi-determinate)

3.4.1.2 Fruit colour (Red, dark red, orange, pink, yellow)

3.4.1.3 Fruit shape (Flattened (oblate), slightly flattened, round)

3.4.2 Quantitative characters

3.4.2.1 Height of plant (cm)

The height of plant at maturity (last harvesting) was measured from the ground level to the tip of plant.

3.4.2.2 Days to 50 % flowering

Number of days was calculated from sowing of seed to the day on which the 50 per cent flowering of plants, out of total plants was observed.

3.4.2.3 Average weight of fruit (g)

The weight of 10 randomly selected fresh fruits was recorded and average weight of fruit was worked out.

3.4.2.4 Polar diameter of fruit (cm)

The polar diameter of ten randomly selected fruits was measured using vernier caliper and average polar diameter worked out.

3.4.2.5 Equatorial diameter of fruit (cm)

The equatorial diameter of ten randomly selected fruits was measured using vernier caliper and average equatorial diameter worked out.

3.4.2.6 Number of locules per fruit

Ten fruits were cut opened transversely and locule numbers were counted and the mean locule numbers was worked out.

3.4.2.7 Pericarp thickness (mm)

For the pericarp thickness, ten fruits were cut opened transversely and the pericarp thickness determined with the help of vernier caliper.

3.4.2.8 Length of cluster (cm)

The length of fruit cluster was measured from pedicel end to tip of fruit cluster by selecting ten clusters randomly from each observational plant and later on the average was worked out.

3.4.2.9 Average weight of cluster (g)

The weight of 10 randomly selected fresh fruit clusters was recorded and average weight of cluster was worked out.

3.4.2.10 Number of fruits per cluster

The number of fruits in a cluster was counted for the ten randomly selected clusters and averaged.

3.4.2.11 Number of clusters per plant

The number of fruits per cluster was recorded at each picking from the selected observational plants. The recorded clusters from all the pickings were finally summed up to obtain number of clusters per plant and average was calculated.

3.4.2.12 Number of seeds per fruit

The seeds of ten randomly selected fully matured ripe fruits was counted and averaged.

3.4.2.13 Shelf life (days)

Ten fruit clusters were selected at the time of harvesting and kept in ambient condition; number of days was calculated up to which fruits remain attached to the cluster in fresh condition.

3.4.2.13 Yield per plant (kg)

The yield data was recorded at each picking from the selected observational plants. The recorded weight from all the pickings was finally summed up to obtain total yield per plant and average was calculated.

3.4.2.14 Yield per hectare (q)

The total yield per plant was recorded and then multiplied it by hector factor.

3.4.3 Quality characters

3.4.3.1 Juice (%)

The fruits were cut and blended in a pestle and mortar and filtered through a muslin cloth to get the juice. The juice yield was measured and expressed as per cent of total weight of the fruits.

3.4.3.2 TSS (^{0}B)

Total soluble solids were recorded by using digital refractometer and expressed in degree Brix (A.O.A.C., 1960).

3.4.3.3 Acidity (%)

A clear filtered juice sample from each genotype was titrated against 0.1N NaOH using phenolphthalein indicator and total titratable acidity as the percentage of anhydrous citric acid was calculated as per the procedure recommended by A.O.A.C. (1960).

3.4.3.4 Ascorbic acid (mg/100g)

Ascorbic acid content in fruits was analyzed using the method suggested by Ranganna (1977).

3.4.3.5 Total sugar (%)

Total sugar was determined by general volumetric method standardized by A.O.A.C. (1960).

3.4.3.6 Reducing sugar (%)

Reducing sugar was determined by general volumetric method standardized by A.O.A.C. (1960).

3.4.3.7 Lycopene (μg/g)

The lycopene content from fruit samples was estimated on NIR spectrometer (ZEUTEC Make) using the procedure described by Deshmukh (2011).

3.4.3.8 β-carotene (μg/g fresh wt.)

The β-carotene content from fruit samples was estimated on NIR spectrometer (ZEUTEC Make) using the procedure described by Deshmukh (2011).

3.4.4 Pest incidence

1. Thrips per leaf

The observations were recorded on randomly selected five plants after 30 days from transplanting. The thrips count was taken from three terminal leaves of a plant and average was worked out as thrips incidence per leaf.

2. White fly per leaf

The white fly count was taken as like thrips from lower, middle and upper leaf of a plant and average was worked out as white fly incidence per leaf.

3. Mites per leaf

The mites count was taken from randomly selected three leaves from five selected plant and average was worked out as mites incidence per leaf.

3.4.5 Disease incidence *viz.*, Leaf curl virus and Spotted wilt virus (%)

The number of infected and healthy plants was counted under field condition and disease incidence of leaf curl virus was calculated on percentage basis by using following formula.

$$\text{Disease incidence (\%)} = \frac{\text{Number of diseased plants}}{\text{Total number of plants}} \times 100$$

3.5 Statistical analysis

3.5.1 Heterosis and combining ability

3.5.1.1 Analysis of variance

The mean values recorded for various characters from observational plants were used for statistical analysis. The first step in the statistical analysis is to test the null hypothesis that there is no significant difference among the genotypes. This test involves the analysis of variance of RBD for metric traits. The analysis of variance was carried out as per Panse and Sukhatme, 1985. The metric traits which are significant were subjected for further statistical analysis.

3.5.1.2 Heterosis

The values of F_1 averaged over replications were used for estimating heterosis. The magnitude of heterosis was calculated as percentage increase or decrease of F_1 mean (F_1) over the mean of better parent (BP) (Turner, 1953 and Hays *et al.*, 1955). Similarly per cent superiority over the top (TP) parent and commercial hybrid (SH) was calculated.

1. Percent heterosis over better parent (BP)

$$\text{Percent heterosis over BP} = \frac{\overline{F_1} - \overline{BP}}{\overline{BP}} \times 100$$

2. Percent superiority over top parent (TP)

$$\text{Percent heterosis over TP} = \frac{\overline{F_1} - \overline{TP}}{\overline{TP}} \times 100$$

3. Percent superiority over commercial hybrid (SH)

$$\text{Percent heterosis over SH} = \frac{\overline{F_1} - \overline{SH}}{\overline{SH}} \times 100$$

Where,

$\overline{F_1}$ = Mean of the F_1 hybrid

$\overline{BP}$ = Mean of the better parent of that particular F_1 cross

$\overline{TP}$ = Mean of the top parent of that particular character

$\overline{SH}$ = Mean of commercial hybrid of that particular character

3.5.1.3 Analysis of variance for combining ability

The combining ability analysis was carried out according to following Method II and Model I suggested by Griffing (1956). The mathematical model for combining ability analysis assumed as followed

$Y_{ij} = \mu + g_i + g_j + s_{ij} + r_k + \in_{ijk}$

ij = 1,................, p

k = 1,................,r

Where,

μ = General mean

r = Number of replications

p = Number of parents

$g_i(g_j)$ = gca effect of i(j)th parent

S_{ij} = sca cross between ith and jth parents

$\in_{ijk}$ = Mean error effect associated with I, j and kth observation

The restriction imposed to the model is:

$\sum_i g_i = 0$ and

$\sum_i S_{ij} \# S_{ij} = 0$ (for each i)

On the basis of this model, the analysis of variance and exploitation of mean sum of squares was set up as under.

ANOVA for combining ability

Sources	d.f.	S.S	Mean squares	
			Observed	Expected
gca	(p-1)	Sg	Mg	$\sigma^2 e + \frac{n+2}{n-1} \sum_i \sigma^2 g_i$
sca	p(p-1)/2	Ss	Ms	$\sigma^2 e + \frac{2}{n(n-1)} \sum_{i<j} \sigma^2 s_{ij}$
Error	M	SE	Me	$\sigma^2 e$

Where,

P = Number of parents

M = (r-1) (g-1)

Me = Error mean squares

The sum of squares was calculated as:

$$S_g = \frac{1}{P + 2} \left[\sum (X_{i.}+X_{ii})^2 - 4/p \times X^2..\right]$$

$$S_s = \sum_{i \leq j}\sum X_{ij}^2 - \frac{1}{P + 2} \sum (X_{i.}+X_{ij})^2 + \frac{2}{(P+1)(P+2)} \times X^2....$$

Where,

S_g	=	S. S. due to gca
S_s	=	S. S. due to sca
P	=	Number of parents
X_i	=	Total of assay involving i^{th} parent
X_{ij}	=	Mean value of ij^{th} cross
X	=	Total number of combination
n	=	Difference for error mean square

The mean sum of square for gca and sca were computed by dividing sum of squares with respective degree of freedom.

The following 'F' ratios were used for testing the significance of gca and sca effects.

1. To test the significance of gca

$$F\left[(P-1), m\right] = Mg/Me$$

2. To test the significance of sca

$$F\left[\frac{P (P-1)}{2}, m\right] = Ms/Me$$

3.5.1.3.1 Estimates of general and specific combining ability effects

The individual effects were estimated as follows.

1. Population mean $\hat{\mu} = \frac{2}{P(P-1)} \times X....$

2. General Combining ability effect

$$\hat{g}_i = \frac{1}{P+2} [\sum (X_{i.}+X_{ii})\ 2/P \times X..]$$

3. Special combining ability effect

$$\hat{S}_{ij} = X_{ij} \frac{1}{P+2} [X_{i.}+X_{ii} + X_{j.}+X_{ij.}) + \frac{2}{(P+1)(P+2)} \times X...$$

3.5.1.3.2 Standard error for estimates

Standard error of effect was calculated as a square root of the variance of the effect. The variance of various effects was calculated as follows.

$$\text{SE for gca effects } (\hat{gi}) = \left(\frac{(P-1)}{P(P+2)} \times \hat{\sigma}^2 \right)^{1/2}$$

$$\text{SE for sca effects } (\hat{Sij}) = \left(\frac{P2+P+2}{(P+1)(P+2)} \times \hat{\sigma}^2 \right)^{1/2} \quad (i\#1)$$

Where,

P = Number of parents, $\sigma^2 = M'_e$

3.5.1.3.3 Standard error of difference between two effects

Standard error of difference between two effects was taken as a square root of the variance of the two estimates. The variance for difference between two estimates was computed as:

$$\text{SE for } (\hat{g}_i - \hat{g}_j) = \left(\frac{2}{(P + 2)} \times \hat{\sigma}^2 \right)^{1/2} \qquad (i \# 1)$$

$$\text{SE for } (\hat{S}_{ij} - \hat{S}_{jk}) = \left(\frac{2\,(P + 1)}{(P + 2)} \times \hat{\sigma}^2 \right)^{1/2} \qquad (i \# j,\ k;\ j \# \ k)$$

$$\text{SE for } (\hat{S}_{ij} - \hat{S}_{kl}) = \left(\frac{2P}{(P + 2)} \times \hat{\sigma}^2 \right)^{1/2} \qquad (i \# j,\ k,\ i;\ j \ \# \ k,\ l;\ k \# \ l)$$

3.5.2 Evaluation of F_1 hybrids and stability analysis

3.5.2.1 Performance of F_1 hybrids under growing conditions

The open field experiment was carried out in randomized block design (RBD), while, the polyhouse and shade net house experiments were carried out in completely randomized design (CRD) with three replications and eight treatments (hybrids), respectively.

The results obtained during the course of present investigation were tabulated and the statistical analysis was done as per the method suggested by Panse and Sukhatme (1985).

3.5.2.2 Stability analysis

Stability analysis was performed as per Eberhart and Russell (1966), who proposed three stability parameters to describe the performance of genotypes over different environments. According to them the regression of each variety on an environmental index and a function of square deviation from this regression provide estimates of stability parameters.

For each genotype stability was described by three parameters *viz.*, mean performance ($\bar{X}$), regression coefficient (bi) and the squared deviation from the regression (S^2 di).

These parameters are defined by using the following model.

Yij = $\mu + \beta i Ij + \delta ij$ (I= 1, 2 ……, t and j = 1, 2 …… S)

Where,

Yij = Mean of i^{th} genotype in j^{th} environment

μ = Mean of all genotypes over all environments

βi = Regression coefficient of i^{th} genotype on environmental index, which measures response of genotype to varying environments

Ij = Environmental index is defined as deviation of the mean of all the genotypes at a given environment from the overall mean

$$\frac{\sum_j Yij}{t} - \frac{\sum_j \sum_j Yij}{ts} \text{ with } \sum Ij = 0$$

∑ij = Deviation from regression of the i^{th} genotype of j^{th} environment

3.5.2.2.1 The stability parameters

a. The regression coefficient (bi) is described as under

$$bi = \sum_j Yij \; Ij \;/\; \sum_j I^2j$$

Where,

$\sum_j Yij \; Ij$ is the sum of products

$\sum_j I^2j$ is the sum of squares of environmental index

b. Mean square deviation (S^2di) from linear regression is calculated as

$$S^2di = \frac{\sum_j \delta^2 ij}{(S-2)} - \frac{S^2e}{r}$$

Where,

$$\sum_j \delta^2 ij = \left(\sum_j Y^2ij - \frac{Y^2i}{t} \right) - \frac{(\sum_j Yij \,.\, Ij)^2}{\sum_j I^2j}$$

and

S^2e = Estimate of pooled error

t = Number of genotypes

S = Number of environments

1. Computation of environmental index (Ij)

I_j is defined as

$$Ij = \frac{\sum_j Yij}{t} - \frac{\sum_i \sum_j Yij}{ts}$$

$$= \frac{\text{Total of genotypes at } j^{th} \text{ location}}{\text{Number of genotypes}} - \frac{\text{Grand total}}{\text{Total no. of observations}}$$

2. Computation of regression coefficient (bi) for each genotype

$$bi = \frac{\sum_j Yij.Ij}{\sum_j I^2j}$$

i. For each value of regression coefficient $\sum I^2j$ is common, equal to sum of squares of environmental indices.

$\sum_j I^2 j = (I^2_1 + I^2_2 + \ldots + I^2j)$

ii. The $\sum_j$ Yij.Ij for each genotype of environmental index (Ij) with the corresponding mean $(\overline{X})$ of that genotype at each environment.

These values were obtained in the following manner

$(\overline{X})\ (I_j) = (\sum_j Yij.Ij) = (S)$

$(\overline{X})$ = Matrix of means

(I_j) = Vector of environmental index

(S) = Vector for sum of products i.e. $\sum_j Yij.Ij$

iii. The bi value for each genotype was thus calculated by dividing $\sum_j$ Yij.Ij [as calculated above in (ii)] by $\sum_j I^2$ obtained above under

$bi = \sum_j Yij\ \ Ij \ / \sum_j I^2 j$

3. Computation of S^2di

In regression analysis it is possible to partition the variance of the dependent variable (Y) into two parts, the one which explains the linearity between dependent and independent variables (variance due to regression) and the other which explains the variance due to deviations from linearity.

Symbolically

$\sigma^2 y = \sigma^2$ regression + σ^2 deviation from regression

By subtracting the variance due to regression from $\sigma^2 y$ one can get the variance due to deviation from regression which in turn can be used for estimating $S^2 di$ values. The variance of means over different environments was obtained as follows.

$$\sigma^2 V_i = \sum_j Yij^2 - (Yi^2/s)$$

Where,

$\sum_j Yij^2$	=	Sum of squares of mean of i^{th} genotype over j^{th} environment.
Yi	=	Sum of means of i^{th} genotype over environments.
S	=	Number of environments

The variance due to deviations from regression $\sum_j \sigma^2 ij$ for a genotype being

$$\sum_j \sigma^2 ij = \left[\sum_j Yij^2 - \frac{Yi^2}{S} \right] - \frac{(\sum_j Yij \cdot Ij)^2}{\sum_j I^2 j}$$

Where,

$(\sum_j Yij - Yi^2/S)$ = The variance due to dependent variable and

$(\sum_j Yij. Ij)^2 / \sum I^2 j$ = The variance due to regression

Because,

$$\frac{(\sum_j Yij. Ij)^2}{\sum_j I^2 j} = \frac{(\sum_j Yij \cdot Ij)(\sum_j Yij \cdot Ij)}{\sum_j I^2 j} = bi \sum_j Yij. Ij$$

Where,

bi values have been calculated in (2) and

$\sum_j$ Yij . Ij value in 2 (ii)

The $\sum_j \sigma^2 ij$ values may be computed as

$\sum_j \sigma^2 ij = \sigma^2 Vi - bi \sum_j Yij \cdot Ij$

From $\sum_j \sigma^2 ij$, the stability parameter S^2di for each genotype was computed as follows:

$S^2di = [\sum_j \sigma^2 ij / (S-2)] - (S^2e/r)$

3.5.2.2.2 Analysis of variance

The analysis of variance partitioned into three main parts.

a. Sum of squares due to genotypes.
b. Sum of squares due to environment + (genotype x environment)
c. Pooled error

The sum of squares due to genotype x environment is further partitioned into two parts.

i. S.S. due to genotype x environment (linear) which is infact S.S. due to regression.
ii. S.S. due to deviation from linearity of response (i.e. S.S. due to pooled deviation).

The latter can be further partitioned into as many components as the number of genotypes with (s-2) degrees of freedom (s-represents number of environments).

The analysis of variance table for stability parameter was constructed in tabulated form as,

Source	D.F.	S.S.	M.S.S.
Genotypes	(t-1)	$1/s\sum_i Y_i^2$ - C.F.	MS_1
Environments	(s-1)	$1/t\sum_i Y_i^2$ - C.F.	MS_2
Genotype x Environments	(t-1)(s-1)	$\sum_i\sum_j Y_i^2$ - C.F.-G.S.S.-E.S.S.	MS_3
Environment + Genotype x Environment)	t(s-1)	$\sum_i\sum_j Y_{ij}^2 - Y_i^2 -/S$	MS_4
Environment (linear)	1	$1/t[(\sum_i Yij\ I_j)^2/\sum_j I^2{}_i]$	
Genotype x Environment (linear)	(t-1)	$\sum_i(\sum_i Yij\ I_j)^2/\sum_j I^2{}_i$ - E(1)S.S.	MS_5
Pooled deviation	t(s-1)	$\sum_i\sum_i \sigma^2 ij$	MS_6
Pooled error	s(r-1)(t-1)		MS_7

Where,

t = Number of genotype

s = Number of environment

r = Number of replication

G.S.S. = S.S. due to genotypes

E.S.S. = S.S. due to environment

S.S. due to genotypes, environment and genotype x environment were calculated as per the method of pooled analysis.

The M.S. pooled error was calculated as

$$\frac{(n_1 - 1)\ (\text{M.S. error } L_1) + \ldots (n_s - 1)\ (\text{M.S. errors})}{(n_1 - 1) + (n_2 - 1) + \ldots . + (n_s - 1)}$$

Where,

M.S. error Ls = Mean sum of squares due to error for s^{th} environment.

n_1 - 1 = Error d.f. in environment 1

n_2 - 1 = Error d.f. in environment 2

The S.S. due to remaining sources was calculated as follows:

S.S. due to environment (Gen. x Env.) = $\sum_{ij} \sum Yij - \sum_{i} Y^2 i/t$

in fact,

S.S. (E + G x E) = S.S.E. + S.S.G. x E

Where,

S.S.E. = $1/t\ (\sum_j Y_j\ .\ Ij)^2\ /\ Ej.\ I^2 j$

The Yj and Ij values are already computed and by putting appropriate values we can get S.S. environment (linear) which can also be checked as,

S.S. Environment (linear)

$= t \times \sum_j I^2 j$

In fact,

S.S.G. x E (linear)

$= \sum_j [\sum_j (Yij\ Ij)^2\ /\ (\sum_j .\ I_j)^2] -$ S.S.E. (linear)

$=$ bi $\sum_j Yij\ Ij$ for each genotype

Thus by taking simply the sum of these values over all the genotypes, the first part of S.S., G x E (linear) can be obtained.

S.S. due to pooled deviation is simply the sum of S.S. due to deviation for individual genotype for (s-2) degrees of freedom each.

3.5.2.2.3 Test of significance

a. The significance of difference among genotypes was tested against the M.S.S. due to G x E interaction (MS_3). The genotypic differences were also tested against pooled deviation (MS_6).

b. The G x E interaction (MS_3) was tested against effective pooled error.

c. The components, environment (linear), G x E (linear) was tested against pooled deviation (MS_6).

d. Pooled deviation was tested against effective pooled error (PE/r). Individual deviation from linear regression was tested as follows.

$$F = \frac{[(\sum_j \sigma^2 ij) / (S - 2)]}{\text{Pooled error}}$$

e. Stable genotype i.e. test of significance for regression coefficient.

A genotype with unit regression coefficient (bi $\simeq$ 1 or not significantly deviating from unity) and deviation not significantly deviating from zero ($S^2di = 0$) is said to be stable one.

$$\text{T test bi} = \frac{|bi-1|}{\text{S.E. (bi)}}$$

Where,

$$\text{SE bi} = \sqrt{\frac{\text{MSS due to pooled deviation}}{\sum_j I^2 j}}$$

The significance of bi values were tested by 't' test as against unity.

$$\text{'t' test bi} = \frac{|\text{bi-1}|}{\text{S.E. (bi)}}$$

Mean of bi = $\sum_i$ bi/t

Population mean and standard error are calculated as,

$$\text{Population mean } (\mu) = \frac{\text{Grand total}}{\text{No. of observations}}$$

$$\text{S.E. (Mean)} = \frac{\text{M.S. due to pooled deviation}}{\text{Number of environments -1}}$$

4. EXPERIMENTAL RESULTS

The present investigation entitled, “Heterosis and combining ability and evaluation of F_1 hybrids of cherry tomato under different growing conditions” were conducted during 2010 to 2012 and the results obtained for various characters are presented in this chapter under appropriate headings, heterosis, combining ability and evaluation of promising F_1 hybrids under different growing conditions and stability analysis. Twenty one hybrids derived from crossing seven parents in diallel fashion without reciprocals were evaluated in *kharif*, 2011. From this, the promising hybrids were selected on the basis of better parent heterosis of quantitative and qualitative characters for evaluation under polyhouse, shade net house and open field during *summer*, 2012.

4.1 Heterosis and combining ability

4.1.1 Analysis of variance

The analysis of variance revealed that, all characters studied exhibited significant differences among the genotypes at 5 % and 1 % level of significance (Table 5).

4.1.2 Mean performance

Mean performance of parents and their F_1 hybrids for all the characters under investigation were averaged over replications and presented in Table 6. The differences in the mean values of the parents and hybrids for all the characters studied were highly significant.

Table 5. Analysis of variance for different characters of cherry tomato

Sources	D.F.	Plant height (cm)	Days to 50% flowering	Av. weight of fruit (g)	Polar diameter (cm)	Equatorial diameter (cm)	Number of locules	Pericarp thickness (mm)	Length of cluster (cm)
Replications	1	45.3600	42.8750	0.1116	0.00022	0.0117	0.0088	0.00018	0.2212
Treatments	27	271.2907 **	22.7956 **	13.3865 **	0.2960 **	0.2611 **	0.0567 **	9.5374 **	1.0153 **
Error	27	74.2148	8.2453	0.1557	0.02403	0.0224	0.0139	1.7324	0.3604

Sources	D.F.	Av. weight of cluster (g)	Number of fruits/ cluster	Number of clusters/ plant	Number of seeds/ fruit	Shelf life (days)	Yield/plant (kg)	Yield/ha (q)
Replications	1	0.5402	0.00018	0.8257	78.2589	0.3779	0.00378	536.5482
Treatments	27	177.668 **	0.9553 **	60.6640 **	885.094 **	4.8539 **	0.0983 **	13450.756 **
Error	27	28.7802	0.3157	5.4598	37.9513	0.7053	0.0159	2185.2586

Sources	D.F.	Juice (%)	TSS (°B)	Acidity (%)	Ascorbic acid (mg/100g)	Total sugar (%)	Reducing sugar (%)	Lycopene (µg/g)	ß-carotene (µg/g)
Replications	1	2.9901	0.1450	0.00022	0.5782	0.0435	0.0407	0.0467	0.04980
Treatments	27	29.3228 **	0.9133**	0.0057 **	30.8107**	0.2578 **	0.2121 **	1.3884 **	12.0964 **
Error	27	2.8595	0.0549	0.00057	3.5083	0.0136	0.0197	0.0157	1.0026

*, ** significant at 5% and 1% level, respectively

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4.1.2.1 Height of plant (cm)

The parent EC 128618 (120.60) recorded significantly maximum height of plant (cm) and at par with parents EC 128021 (113.50), EC 163615 (108.60) and EC 539 (104.10).

Among the twenty one crosses, the cross combination 3x6 (137.80) recorded significantly maximum height of plant and which was at par with almost all the crosses except 2x5, 4x5 and 5x7.

4.1.2.2 Days to 50 % flowering

Among the parents, EC 539 and EC 163615 was significantly earliest to produce flower with mean values of 60.00 days and at par with EC 128021 and EC 163615 (61.00 days).

Among the hybrids, the cross combinations 2x5, 3x6 and 4x7 (52.00 days) displayed significant earliness in flowering and was at par with most of the cross combinations except the crosses 1x5 and 5x7.

4.1.2.3 Average weight of fruit (g)

Among the parents, EC 128021 (7.10) recorded significantly lowest average weight of fruit (g); however, it was at par with the parent EC 128013 (7.45).

Among the crosses, the cross combination 4x7 (7.00) recorded significantly minimum average weight of fruit (g). However, it was at par with the cross combinations 3x6 (7.45) and 3x7 (7.60).

4.1.2.4 Polar diameter of fruit (cm)

The parent EC 128021 (2.13) recorded significantly lowest polar diameter of fruit and was at par with the parents EC 128013 (2.21) and EC 163615 (2.39).

Among the crosses, the cross combination 3x6 (2.19) recorded minimum polar diameter of fruit and at par with cross combinations *viz.,* 3x7 (2.21), 4x7 (2.21), 4x5 (2.29), 6x7 (2.31) and 3x5 (2.33).

4.1.2.5 Equatorial diameter of fruit (cm)

The parent EC 128021 (2.31) recorded significantly lowest polar diameter of fruit and was at par with the parent EC 128013 (2.42).

Among the crosses, the cross combination 3x6 (2.42) recorded minimum polar diameter of fruit and was at par with cross combinations *viz.,* 4x7 (2.44), 6x7 (2.44), 3x7 (2.46), 3x5 (2.47), Suncherry Extra Sweet (2.51), 4x5 (2.60) and 3x4 (2.65).

4.1.2.6 Number of locules per fruit

The parent EC 163615 (2.10) produced significantly lowest number of locules per fruit and was at par with parents EC 128021 (2.15), CL 15-61-6-0-5 (2.30) and EC 539 (2.35). While, among the crosses, the cross combination 2x7 (2.05) recorded lowest number of locules per fruit and which was at par with crosses 2x5 (2.15), 3x6 (2.15), 2x4 (2.20), 2x6 (2.20), 6x7 (2.20) 4x6 (2.30) and Suncherry Extra Sweet (2.30).

4.1.2.7 Pericarp thickness (mm)

The parent EC 128618 recorded significantly maximum pericarp thickness of fruit (23.45) and at par with parent CL 15-61-6-0-5, EC 163615 and EC 539. The cross combination 2x7 significantly produced maximum pericarp thickness of fruit (27.95) and was at par with Suncherry Extra Sweet (27.65), 2x5 (25.80) and 2x6 (25.25).

4.1.2.8 Length of cluster (cm)

Among the parents, EC 539 produced significantly highest length of cluster (8.08) and was at par with almost all parents.

The standard check Suncherry Extra Sweet (SES) recorded highest length of cluster (13.47).

4.1.2.9 Average weight of cluster (g)

The parent CL 15-61-6-0-5 recorded significantly highest average weight of cluster (49.40) and was at par with EC 885539 (45.60) and EC 539 (43.50).

Among the hybrids, check variety Suncherry Extra Sweet (74.70) recorded highest weight of cluster and was at par with the cross 2x5 (65.50).

4.1.2.10 Number of fruits per cluster

The parent EC 128021 (5.60) recorded maximum number of fruits per cluster; however, it was at par with rest of the parents.

Among the hybrids, Suncherry Extra Sweet (9.25) recorded more number of fruits per cluster followed by the cross 3x6 (7.00).

4.1.2.11 Number of clusters per plant

The parent EC 128618 recorded significantly maximum number of clusters per plant (29.80) and was at par with the parents EC 128021 (29.30) and EC 163615 (25.40).

Among the hybrids, cross combinations 3x6 exhibited significant maximum number of clusters per plant (36.60) and was at par with the crosses 3x4 (36.10) and 6x7 (33.10).

4.1.2.12 Number of seeds per fruit

Among the parents, EC 885539 showed minimum number of seeds per fruit (50.10) and was at par with EC 128021 (56.90) and EC 163615 (54.30).

Among the hybrids, check Suncherry Extra Sweet (23.30) recorded lowest number of seeds per fruit and at par with the cross 5x6 (34.60).

4.1.2.13 Shelf life (days)

Among the parents, CL 15-61-6-0-5 recorded maximum shelf life (10.10) and at par with EC 128618 (10.00), EC 163615 (8.90) and EC 539(8.70).

Among hybrids, check Suncherry Extra Sweet (12.00) recorded maximum shelf life and at par with the crosses 1x2 (11.90), 2x5 (11.90), 2x7 (11.10), 1x6 (11.00), 1x7 (11.00) and 2x6 (10.70).

4.1.2.14 Yield per plant (kg) and per hectare (q)

The parent EC 128618 recorded highest yield per plant and per hectare (1.26 and 464.81), respectively and was at par with almost all the parents except EC 128021 and EC 128013.

The hybrid 1x3 recorded maximum yield (1.74 and 642.59) per plant and per hectare, respectively and was at par with 2x6 (1.69 and 624.44), 1x4 (1.59 and 590.00), 1x7 (1.56 and 577.04), Suncherry Extra Sweet (1.55 and 572.22), 6x7 (1.53 and 567.04), 1x6 (1.50 and 554.44), 1x2 (1.49 and 551.48) and 3x6 (1.48 and 547.41).

4.1.2.15 Juice (%)

Among the parents, EC 885539 (67.74) recorded highest juice percentage and was at par with the parents CL 15-61-6-0-5 (67.11) EC 128618 (66.42) and EC 539 (64.83).

Among the hybrids, 2x5 recorded significantly maximum juice per cent (73.48) and at par with 5x7 (72.18), 1x2 (71.92) and 2x6 (71.84).

4.1.2.16 TSS (^{0}B)

The parent CL 15-61-6-0-5 (5.46) recorded significantly maximum TSS and was at par with parent EC 163615 (5.39).

The check variety Suncherry Extra Sweet (6.96) recorded maximum TSS followed by the cross 3x6 (5.96).

Table 6. Mean performance of parents and their F_1s for different characters in cherry tomato

Parents/ Hybrids		Plant height (cm)	Days to 50% flowering	Av. weight of fruit (g)	Polar diameter (cm)	Equatorial diameter (cm)	Number of locules/ fruit
P_1	EC 539	104.10	60.00	11.30	2.71	2.84	2.35
P_2	CL 15-61-6-0-5	98.50	61.50	12.50	2.82	2.91	2.30
P_3	EC 128021	113.50	61.00	7.10	2.13	2.31	2.15
P_4	EC 128013	93.90	61.50	7.45	2.21	2.42	2.45
P_5	EC 885539	95.00	62.50	11.50	2.70	2.88	2.75
P_6	EC 163615	108.60	60.00	8.00	2.39	2.49	2.10
P_7	EC 128618	120.60	61.50	8.70	2.46	2.60	2.40
1x2	EC 539 x CL 15-61-6-0-5	122.40	54.00	12.85	2.95	3.13	2.35
1x3	EC 539 x EC 128021	131.00	54.00	9.75	2.55	2.74	2.45
1x4	EC 539 x EC 128013	124.00	54.00	11.00	2.65	2.84	2.50
1x5	EC 539 x EC 885539	123.90	59.00	14.05	3.17	3.38	2.50
1x6	EC 539 x EC 163615	131.50	54.00	11.05	2.64	2.87	2.35
1x7	EC 539 x EC 128618	131.10	57.00	12.60	3.05	3.16	2.35
2x3	CL 15-61-6-0-5 x EC 28021	122.00	54.00	12.00	2.75	2.91	2.40
2x4	CL 15-61-6-0-5 x EC 128013	122.70	55.00	13.15	2.91	3.05	2.20
2x5	CL 15-61-6-0-5 x EC 885539	115.50	55.50	15.65	3.57	3.62	2.15
2x6	CL 15-61-6-0-5 x EC 163615	124.50	52.00	10.90	2.71	2.75	2.20
2x7	CL 15-61-6-0-5 x EC 128618	130.70	55.00	14.50	3.36	3.40	2.05
3x4	EC 128021 x EC 128013	127.00	55.00	8.35	2.53	2.65	2.40
3x5	EC 128021 x EC 885539	130.00	53.00	8.15	2.33	2.47	2.40
3x6	EC 128021 x EC 163615	137.80	52.00	7.45	2.19	2.42	2.15
3x7	EC 128021 x EC 128618	135.70	54.00	7.60	2.21	2.46	2.40
4x5	EC 128013 x EC 885539	118.50	55.50	8.80	2.29	2.60	2.50
4x6	EC 128013 x EC 163615	122.40	56.00	9.20	2.68	2.95	2.30
4x7	EC 128013 x EC 128618	126.40	52.00	7.00	2.21	2.44	2.45
5x6	EC 885539 x EC 163615	124.90	54.00	11.40	2.74	2.94	2.60
5x7	EC 885539 x EC 128618	117.20	59.50	14.70	3.32	3.55	2.65
6x7	EC 163615 x EC 128618	130.80	53.00	8.05	2.31	2.44	2.20
SC	Suncherry Extra Sweet (SES)	128.80	53.50	9.55	2.73	2.51	2.30
S.E.±		6.14	2.00	0.28	0.11	0.11	0.08
C.D. 5%		17.79	5.79	0.81	0.32	0.31	0.25

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Table 6 (Contd...)

Parents/ Hybrids	Pericarp thickness (mm)	Length of cluster (cm)	Av. weight of cluster (g)	Number of fruits/cluster	Number of clusters/ plant	Number of seeds/ fruit	Shelf life (days)
P_1	21.80	8.08	43.50	5.20	20.50	84.50	8.70
P_2	23.40	7.61	49.40	4.60	17.10	93.90	10.10
P_3	20.55	6.92	28.90	5.60	29.30	56.90	7.00
P_4	19.05	7.03	31.00	5.40	19.00	95.50	6.80
P_5	19.05	7.10	45.60	4.40	19.30	50.10	6.50
P_6	22.60	6.80	33.50	5.40	25.40	54.30	8.90
P_7	23.45	7.12	38.10	5.20	29.80	70.60	10.00
1x2	25.85	9.12	57.90	6.50	25.20	101.90	11.90
1x3	23.65	8.39	51.30	6.10	30.20	81.90	10.30
1x4	21.25	8.87	43.80	6.15	24.50	98.50	9.20
1x5	23.05	7.88	54.20	5.50	23.70	65.90	9.80
1x6	23.10	8.61	48.50	6.35	28.20	79.30	11.00
1x7	23.40	9.34	49.10	5.75	26.50	91.60	11.00
2x3	24.65	8.37	58.00	5.30	17.20	95.20	9.80
2x4	24.05	8.67	60.20	6.15	19.00	109.20	9.60
2x5	25.80	8.41	65.50	5.00	17.50	79.80	11.90
2x6	25.25	9.37	54.90	6.40	28.40	75.70	10.70
2x7	27.95	8.47	56.90	6.15	17.40	107.30	11.10
3x4	22.30	7.83	36.40	6.90	36.10	52.50	8.80
3x5	21.85	8.21	39.10	6.25	26.20	49.80	8.90
3x6	22.60	7.56	37.00	7.00	36.60	62.50	9.60
3x7	21.65	7.59	38.50	6.90	29.50	66.00	8.70
4x5	20.05	8.20	40.75	6.30	24.00	91.30	7.90
4x6	21.65	7.18	43.90	5.65	25.00	110.90	8.80
4x7	22.80	7.85	39.00	6.40	27.00	72.80	7.80
5x6	18.95	7.98	43.40	5.35	23.40	34.60	6.30
5x7	20.75	8.14	54.80	5.35	21.90	54.10	7.30
6x7	24.85	8.19	41.40	6.70	33.10	55.10	9.80
SC	27.65	13.47	74.70	9.25	21.20	23.30	12.00
S.E.±	0.93	0.47	3.88	0.42	1.63	4.37	0.60
C.D. 5%	2.70	1.36	11.23	1.22	4.72	12.67	1.73

Table 6 (Contd...)

Parents/ Hybrids	Yield/plant (kg)	Yield/ha (q)	Juice (%)	TSS (°B)	Acidity (%)	Ascorbic acid (mg/100g)	Total sugar (%)	Reducing sugar (%)
P_1	1.23	454.81	64.83	4.71	0.45	41.89	3.19	2.59
P_2	1.15	427.41	67.11	5.46	0.47	34.05	2.78	2.16
P_3	0.97	359.63	60.73	4.71	0.43	42.04	3.44	2.93
P_4	0.91	337.04	63.09	3.49	0.45	42.49	2.54	2.05
P_5	1.07	397.41	67.74	3.54	0.40	41.50	2.74	2.19
P_6	1.07	395.93	62.14	5.39	0.49	42.11	3.30	2.82
P_7	1.26	464.81	66.42	4.58	0.36	40.95	3.10	2.46
1x2	1.49	551.48	71.92	5.28	0.44	40.96	3.61	2.93
1x3	1.74	642.59	67.89	5.07	0.50	44.34	3.48	2.70
1x4	1.59	590.00	67.57	4.87	0.53	47.34	2.78	2.05
1x5	1.27	468.52	67.98	4.57	0.41	40.33	3.00	2.45
1x6	1.50	554.44	59.83	5.64	0.46	39.02	3.42	2.77
1x7	1.56	577.04	69.24	5.45	0.36	44.24	3.41	2.83
2x3	1.25	462.96	66.77	5.24	0.50	44.08	2.84	2.21
2x4	1.04	384.81	66.51	5.17	0.44	47.18	2.91	2.24
2x5	1.07	395.56	73.48	5.24	0.51	36.85	2.74	2.28
2x6	1.69	624.44	71.84	5.19	0.52	43.67	3.13	2.59
2x7	1.25	461.11	68.11	5.63	0.54	40.57	3.36	2.60
3x4	1.15	425.93	57.04	4.97	0.38	45.84	2.84	2.35
3x5	1.27	471.11	64.98	4.85	0.49	50.16	3.56	3.05
3x6	1.48	547.41	63.03	5.96	0.56	43.89	3.16	2.51
3x7	1.28	475.56	64.19	4.87	0.45	41.11	3.55	2.81
4x5	1.11	409.26	66.87	4.16	0.50	47.67	3.02	2.37
4x6	1.13	419.26	62.00	4.55	0.49	37.32	2.58	2.13
4x7	1.21	449.63	66.60	3.94	0.53	44.29	2.48	2.06
5x6	0.96	355.93	64.95	4.04	0.51	49.01	2.71	2.16
5x7	1.30	481.48	72.18	3.72	0.42	39.99	2.68	2.25
6x7	1.53	567.04	65.30	5.84	0.49	35.34	3.65	3.13
SC	1.55	572.22	69.62	6.96	0.49	45.03	3.76	3.06
S.E.±	0.09	31.89	1.23	0.18	0.02	1.34	0.08	0.07
C.D. 5%	0.25	92.37	3.56	0.51	0.05	3.88	0.24	0.20

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Table 6 (Contd...)

Parents/ Hybrids	Lycopene (µg/g)	ß-carotene (µg/g)	Thrips/leaf	Whitefly/leaf	Mites/leaf	Leaf curl (%)	Spotted wilt (%)
P_1	3.58	20.19	2.25 (1.65)	1.65 (1.47)	1.28 (1.33)	10.23 (18.62)	6.82 (15.14)
P_2	2.68	23.68	1.09 (1.26)	0.80 (1.14)	0.87 (1.16)	7.96 (16.34)	5.68 (13.72)
P_3	4.77	16.87	1.77 (1.50)	1.13 (1.27)	1.06 (1.24)	7.96 (16.34)	7.95 (16.34)
P_4	4.04	21.31	1.90 (1.55)	1.33 (1.35)	1.29 (1.33)	10.23 (18.62)	4.55 (12.31)
P_5	2.32	26.44	1.20 (1.30)	0.70 (1.09)	0.37 (0.91)	9.09 (17.42)	7.95 (16.34)
P_6	4.41	20.44	1.06 (1.25)	1.36 (1.36)	1.07 (1.25)	6.82 (14.93)	5.68 (13.72)
P_7	3.19	23.30	1.38 (1.37)	1.23 (1.31)	0.95 (1.20)	9.09 (17.55)	4.55 (12.31)
1x2	3.82	20.83	2.35 (1.69)	1.41 (1.38)	1.53 (1.42)	10.23 (18.62)	3.41 (10.49)
1x3	3.99	21.39	2.13 (1.62)	1.51 (1.42)	0.80 (1.13)	9.09 (17.55)	3.41 (10.49)
1x4	3.81	20.63	1.50 (1.41)	0.94 (1.19)	2.42 (1.71)	14.78 (22.59)	4.55 (11.90)
1x5	3.91	22.32	1.91 (1.55)	1.11 (1.27)	1.81 (1.52)	7.96 (16.34)	5.68 (13.72)
1x6	4.14	19.35	1.50 (1.41)	1.26 (1.33)	0.46 (0.98)	5.69 (13.73)	2.27 (8.67)
1x7	3.71	21.95	1.28 (1.33)	0.78 (1.13)	2.54 (1.74)	6.82 (14.93)	7.95 (16.34)
2x3	3.16	22.29	1.46 (1.40)	1.14 (1.28)	0.00 (0.71)	9.09 (17.42)	3.41 (10.49)
2x4	3.52	22.34	1.36 (1.36)	1.07 (1.25)	1.68 (1.47)	7.96 (16.34)	6.82 (15.14)
2x5	2.79	23.88	1.37 (1.36)	0.63 (1.06)	1.56 (1.43)	6.82 (15.14)	5.68 (13.72)
2x6	3.62	22.47	1.38 (1.37)	0.23 (0.85)	0.14 (0.80)	5.69 (13.73)	2.27 (8.67)
2x7	2.56	23.91	1.34 (1.35)	0.39 (0.94)	1.63 (1.45)	12.50 (20.69)	2.27 (8.67)
3x4	5.27	18.24	1.56 (1.43)	1.47 (1.40)	1.11 (1.26)	17.05 (24.37)	7.95 (16.34)
3x5	4.59	18.97	1.27 (1.33)	0.82 (1.15)	1.39 (1.37)	6.82 (14.93)	2.27 (8.67)
3x6	5.33	16.74	0.95 (1.20)	0.95 (1.20)	0.28 (0.88)	7.96 (16.34)	4.55 (12.31)
3x7	4.47	19.72	1.49 (1.41)	0.72 (1.10)	1.58 (1.44)	7.96 (16.34)	5.68 (13.72)
4x5	3.71	20.39	1.59 (1.44)	1.05 (1.24)	1.24 (1.31)	10.23 (18.62)	4.55 (12.31)
4x6	4.42	19.65	1.27 (1.33)	1.15 (1.28)	1.57 (1.44)	9.09 (17.42)	4.55 (11.90)
4x7	4.63	20.49	1.32 (1.68)	1.49 (1.41)	1.86 (1.53)	11.37 (19.61)	5.68 (13.72)
5x6	2.63	25.32	1.59 (1.44)	0.75 (1.12)	1.24 (1.31)	12.50 (20.53)	7.95 (16.34)
5x7	2.52	26.29	0.76 (1.11)	0.95 (1.20)	0.88 (1.17)	7.96 (16.34)	4.55 (12.31)
6x7	4.57	21.08	1.48 (1.40)	1.05 (1.24)	0.90 (1.16)	7.96 (16.34)	4.55 (12.31)
SC	3.87	24.37	1.73 (1.49)	0.24 (0.86)	1.33 (1.35)	2.28 (6.16)	2.27 (8.67)
S.E.±	0.09	0.72	0.08	0.06	0.10	1.88	1.31
C.D. 5%	0.26	2.09	0.24	0.17	0.29	5.45	3.80

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4.1.2.17 Acidity (%)

Among the parents, EC 163615 (0.49) produced significantly highest acidity and was at par with CL 15-61-6-0-5 (0.47), EC 539 (0.45) and EC 128013 (0.45).

The hybrid 3x6 (0.56) recorded significantly highest acidity and was at par with the cross combinations 2x7 (0.54), 1x4 (0.53), 4x7 (0.53), 2x6 (0.52), 2x5 (0.51) and 5x6 (0.51).

4.1.2.18 Ascorbic acid (mg/100g)

The parent EC 128013 (42.49) recorded significantly highest ascorbic acid content and was at par with all the parents except CL 15-61-6-0-5.

Among the hybrids, 3x5 (50.16) recorded significantly highest ascorbic acid and was at par with 5x6 (49.01), 4x5 (47.67), 1x4 (47.34) and 2x4 (47.18).

4.1.2.19 Total sugar (%)

The parent EC 128021 (3.44) recorded maximum total sugar content; however, it was at par with EC 163615 (3.30).

Among the hybrids, check variety Suncherry Extra Sweet (3.76) recorded significantly highest total sugar content and was at par with the crosses 6x7 (3.65), 1x2 (3.61), 3x5 (3.56) and 3x7 (3.55).

4.1.2.20 Reducing sugar (%)

The parent EC 128021 (2.93) recorded significantly maximum reducing sugar and at par with EC 163615 (2.82).

Among the hybrids, cross combinations 6x7 (3.13) exhibited significant maximum reducing sugar and was at par with Suncherry Extra Sweet (3.06), 3x5 (3.05) and 1x2 (2.93).

4.1.2.21 Lycopene (µg/g)

The parent EC 128021 (4.77) recorded significantly highest lycopene content among all the parents.

Among the hybrids, 3x6 (5.33) recorded significantly highest lycopene content and was at par with the cross 3x4 (5.27).

4.1.2.22 ß-carotene (µg/g)

The parent EC 885539 recorded maximum ß-carotene (26.44) content among all the parents.

Among the hybrids, the 5x7 (26.29) recorded significantly more ß-carotene content and was at par with the check variety Suncherry Extra Sweet (24.37).

4.1.2.23 Thrips per leaf

Among the parents, the parent EC 163615 recorded significantly lowest incidence of thrips per leaf (1.06) under field condition and was at par with the parents CL 15-61-6-0-5 (1.09), EC 885539 (1.20) and EC 128618 (1.38).

Among the hybrids, cross combination 5x7 exhibited significant minimum incidence of thrips per leaf (0.76) and was at par with the crosses 3x6 (0.95), 3x5 (1.27), 4x6 (1.27), 1x7 (1.28) and 2x7 (1.34).

4.1.2.24 Whitefly per leaf

Among the parents, EC 885539 recorded significantly least incidence of whitefly per leaf (0.70) followed by the cross CL 15-61-6-0-5 (0.80).

Among the hybrids, the cross combination 2x6 displayed significant lowest incidence of whitefly per leaf (0.23) under field condition and was at par with the cross combination 2x7 (0.39).

4.1.2.25 Mites per leaf

Among the parents, EC 885539 recorded significantly lowest incidence of mites per leaf (0.37); however, it was at par with CL 15-61-6-0-5 (0.87) and EC 128618 (0.95).

There was no incidence of mites recorded on the cross between 2x3 at harvest under field condition. However, it was at par with the cross combinations 2x6 (0.14), 3x6 (0.28) and 1x6 (0.46).

4.1.2.26 Leaf curl (%)

The parent EC 163615 recorded lowest incidence of leaf curl (6.82) disease.

Among the crosses, the check Suncherry Extra Sweet recorded the minimum incidence of leaf curl (2.28) under field condition. Moreover, the cross combinations 1x6 and 2x6 (5.69) recorded less incidence of leaf curl disease.

4.1.2.27 Spotted wilt (%)

The parent EC 128013 and EC 128618 (4.55) recorded significantly lowest spotted wilt disease incidence and was at par with all the parents except EC 128021.

Among the crosses, the cross combinations 1x6, 2x6, 2x7, 3x5 and Suncherry Extra Sweet (2.27) recorded minimum incidence of spotted wilt disease under field condition and was at par with almost all cross combinations except 1x5, 2x4, 2x5, 3x4, 3x7, 4x5 and 5x6.

4.1.3 Heterosis

The range of heterosis over better parent (BP), top parent (TP) and commercial hybrid (SH) for different characters in cherry tomato are presented in Table 7. The heterosis in favourable direction is only considered for the characters studied.

4.1.3.1 Height of plant (cm)

Among the 21 hybrids, only seven hybrids exhibited significant heterosis in favourable direction over better parent. The cross combination 4x6 (24.74 %) exhibited highest percentage of positive heterosis and was at par with the cross combinations 2x5 (24.57 %), 3x7 (21.41 %), 1x7 (21.09 %), 1x5 (19.12 %), 1x6 (19.02 %) and 1x3 (17.58 %). While, none of the hybrids showed significant positive heterosis over top parent and commercial hybrid.

4.1.3.2 Days to 50 % flowering

It is always desirable to develop hybrids which flowers earlier. Negative heterosis for days to 50 % flowering is desirable. Out of 21 hybrids, 17 and 12 hybrids expressed significant negative heterosis over better and top parent, respectively. The cross 4x7 (-15.45 % and -13.33 %) recorded significant maximum negative heterosis followed by the crosses 2x6 (-13.33 %), 3x6 (-13.33 %) and 3x5 (-13.11 % and -11.67 %) over better and top parent, respectively. None of the cross showed significant negative heterosis over commercial hybrid.

4.1.3.3 Average weight of fruit (g)

The small juicy fruits in cherry tomato are always desirable and negative heterosis for average weight fruit weight is also desirable. The cross 4x7 (-31.71 %) has recorded highest significant negative heterosis followed by the hybrids 3x6 (-27.32 %), 3x7 (-25.85 %), 6x7 (-21.46 %), 3x5 (-20.49 %), 3x4 (-18.54 %), 4x5 (-14.15 %) and 4x6 (-10.24 %) over commercial hybrid.

4.1.3.4 Polar diameter of fruit (cm)

It is always desirable to develop the cherry tomato hybrid having small fruit size. Six hybrids recorded significant negative heterosis over commercial hybrid. The cross 3x6 (-19.96 %) expressed highest negative heterosis over commercial hybrid and was at par with the hybrids 3x7 (-19.23 %), 4x7 (-19.23 %), 4x5 (-16.12 %), 6x7 (-15.38 %) and 3x5 (-14.84 %).

4.1.3.5 Equatorial diameter fruit (cm)

Regarding the equatorial diameter, none of the hybrids showed significant negative heterosis over better, top parent and commercial hybrid.

4.1.3.6 Number of locules per fruit

Since minimum number of locules is desirable, the F_{1S} showing negative heterosis is of immense value in breeding programme. Therefore, the cross combinations exhibiting negative heterosis are consider as superior. The cross 2x7 (-10.87 %) has displayed significant negative heterosis over better parent and commercial hybrid, respectively number of locules per fruit. None of the hybrids showed significant negative heterosis over top parent.

4.1.3.7 Pericarp thickness (mm)

The cross 2x7 (19.19 %) has recorded significant positive heterosis over better and top parent for pericarp thickness, however, none of the hybrids showed significant negative heterosis over commercial hybrid.

4.1.3.8 Length of cluster (cm)

For length of cluster, two cross combinations each was displayed positive and significant heterosis over better and top parent, respectively. The cross 2x6 (23.13 %, 15.97 %) has recorded significant heterosis and was at par with the cross 1x7 (15.59 %) over better and top parent, respectively. None of the cross recorded significant positive heterosis over commercial hybrid.

Table 7. Heterosis (%) over better, top parent and commercial hybrid for different characters of cherry tomato hybrids

Hybrids		Plant height (cm)			Days to 50 % flowering		
		BP	TP	SH	BP	TP	SH
1x2	EC 539 x CL 15-61-6-0-5	0.00	0.00	0.00	-10.00 *	-10.00 *	0.93
1x3	EC 539 x EC 128021	17.58 *	1.49	-4.97	-10.00 *	-10.00 *	0.93
1x4	EC 539 x EC 128013	15.42	8.62	1.71	-10.00 *	-10.00 *	0.93
1x5	EC 539 x EC 885539	19.12 *	2.82	-3.73	-1.67	-1.67	10.28
1x6	EC 539 x EC 163615	19.02 *	2.74	-3.80	-10.00 *	-10.00 *	0.93
1x7	EC 539 x EC 128618	21.09 *	9.04	2.10	-5.00	-5.00	6.54
2x3	CL 15-61-6-0-5 x EC 28021	8.71	8.71	1.79	-11.48 *	-10.00 *	0.93
2x4	CL 15-61-6-0-5 x EC 128013	7.49	1.16	-5.28	-10.57 *	-8.33	2.80
2x5	CL 15-61-6-0-5 x EC 885539	24.57 **	1.74	-4.74	-9.76 *	-7.50	3.74
2x6	CL 15-61-6-0-5 x EC 163615	17.26	-4.23	-10.33	-13.33 **	-13.33 **	-2.80
2x7	CL 15-61-6-0-5 x EC 128618	14.64	3.23	-3.34	-10.57 *	-8.33	2.80
3x4	EC 128021 x EC 128013	8.37	8.37	1.48	-9.84 *	-8.33	2.80
3x5	EC 128021 x EC 885539	11.89	5.31	-1.40	-13.11 **	-11.67 *	-0.93
3x6	EC 128021 x EC 163615	14.54	7.79	0.93	-13.33 **	-13.33 **	-2.80
3x7	EC 128021 x EC 128618	21.41 **	14.26	6.99	-11.48 *	-10.00 *	0.93
4x5	EC 128013 x EC 885539	12.52	12.52	5.36	-9.76 *	-7.50	3.74
4x6	EC 128013 x EC 163615	24.74 *	-1.74	-8.00	-6.67	-6.67	4.67
4x7	EC 128013 x EC 128618	12.71	1.49	-4.97	-15.45 **	-13.33 **	-2.80
5x6	EC 885539 x EC 163615	4.81	4.81	-1.86	-10.00 *	-10.00 *	0.93
5x7	EC 885539 x EC 128618	15.01	3.57	-3.03	-3.25	-0.83	11.21 *
6x7	EC 163615 x EC 128618	-2.82	-2.82	-9.01	-11.67 *	-11.67 *	-0.93
	S.E.±	8.61	8.61	8.61	2.87	2.87	2.87
	C.D. 5%	17.68	17.68	17.68	5.89	5.89	5.89
	C.D. 1%	23.87	23.87	23.87	7.96	7.96	7.96

*, ** significant at 5% and 1% level, respectively

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Table 7 (Contd...)

Hybrids	Av. weight of fruit (g)			Polar diameter (cm)			Equatorial diameter (cm)		
	BP	TP	SH	BP	TP	SH	BP	TP	SH
1x2	13.72 **	80.99 **	25.37 **	8.86	38.82 **	8.06	10.41	35.79 **	24.95 **
1x3	37.32 **	37.32 **	-4.88	19.76 *	19.76 *	-6.78	18.66 **	18.66 **	9.18
1x4	47.65 **	54.93 **	7.32	19.91 **	24.71 **	-2.93	17.39 **	22.99 **	13.17 *
1x5	24.34 **	97.89 **	37.07 **	17.41 **	49.18 **	16.12 **	19.05 **	46.42 **	34.73 **
1x6	38.12 **	55.63 **	7.80	10.69	24.24 **	-3.30	15.49 *	24.51 **	14.57 *
1x7	44.83 **	77.46 **	22.93 **	23.98 **	43.53 **	11.72 *	21.77 **	37.09 **	26.15 **
2x3	69.01 **	69.01 **	17.07 **	29.18 **	29.18 **	0.55	26.25 **	26.25 **	16.17 *
2x4	76.51 **	85.21 **	28.29 **	31.67 **	36.94 **	6.59	26.29 **	32.32 **	21.76 **
2x5	36.09 **	120.42 **	52.68 **	32.22 **	68.00 **	30.77 **	25.91 **	57.05 **	44.51 **
2x6	36.25 **	53.52 **	6.34	13.63 *	27.53 **	-0.73	10.46	19.09 **	9.58
2x7	66.67 **	104.23 **	41.46 **	36.59 **	58.12 **	23.08 **	30.83 **	47.29 **	35.53 **
3x4	17.61 **	17.61 **	-18.54 **	19.06 *	19.06 *	-7.33	14.97 *	14.97 *	5.79
3x5	14.79 *	14.79 *	-20.49 **	9.41	9.41	-14.84 *	6.94	6.94	-1.60
3x6	4.93	4.93	-27.32 **	2.82	2.82	-19.96 **	4.77	4.77	-3.59
3x7	7.04	7.04	-25.85 **	3.76	3.76	-19.23 **	6.51	6.51	-2.00
4x5	18.12 **	23.94 **	-14.15 **	3.62	7.76	-16.12 **	7.66	12.80	3.79
4x6	23.49 **	29.58 **	-10.24 *	21.27 **	26.12 **	-1.83	21.95 **	27.77 **	17.56 **
4x7	-6.04	-1.41	-31.71 **	-0.23	3.76	-19.23 **	1.04	5.86	-2.59
5x6	42.50 **	60.56 **	11.22 **	14.68 *	28.71 **	0.18	18.11 **	27.33 **	17.17 **
5x7	68.97 **	107.04 **	43.41 **	34.76 **	56.00 **	21.43 **	36.80 **	54.01 **	41.72 **
6x7	0.63	13.38 *	-21.46 **	-3.14	8.71	-15.38 *	-2.01	5.64	-2.79
S.E.±	0.39	0.39	0.39	0.16	0.16	0.16	0.15	0.15	0.15
C.D. 5%	0.81	0.81	0.81	0.32	0.32	0.32	0.31	0.31	0.31
C.D. 1%	1.09	1.09	1.09	0.43	0.43	0.43	0.41	0.41	0.41

*, ** significant at 5% and 1% level, respectively

Table 7 (Contd...)

Hybrids	Number of locules/fruit			Pericarp thickness (mm)			Length of cluster (cm)		
	BP	TP	SH	BP	TP	SH	BP	TP	SH
1x2	2.17	11.90 *	2.17	10.47	10.23	-6.51	12.81	12.81	-32.31 **
1x3	13.95 *	16.67 **	6.52	8.49	0.85	-14.47 **	3.84	3.84	-37.69 **
1x4	6.38	19.05 **	8.70	-2.52	-9.38	-23.15 **	9.72	9.72	-34.16 **
1x5	6.38	19.05 **	8.70	5.73	-1.71	-16.64 **	-2.54	-2.54	-41.52 **
1x6	11.90 *	11.90 *	2.17	2.21	-1.49	-16.46 **	6.50	6.50	-36.09 **
1x7	0	11.90 *	2.17	-0.21	-0.21	-15.37 **	15.59 *	15.59 *	-30.63 **
2x3	11.63 *	14.29 *	4.35	5.34	5.12	-10.85 *	9.99	3.59	-37.84 **
2x4	-4.35	4.76	-4.35	2.78	2.56	-13.02 *	13.93	7.30	-35.61 **
2x5	-6.52	2.38	-6.52	10.26	10.02	-6.69	10.51	4.08	-37.54 **
2x6	4.76	4.76	-4.35	7.91	7.68	-8.68	23.13 **	15.97 *	-30.41 **
2x7	-10.87 *	-2.38	-10.87 *	19.19 **	19.19 **	1.08	11.24	4.76	-37.13 **
3x4	11.63 *	14.29 *	4.35	8.52	-4.90	-19.35 **	11.39	-3.16	-41.89 **
3x5	11.63 *	14.29 *	4.35	6.33	-6.82	-20.98 **	15.72	1.61	-39.03 **
3x6	2.38	2.38	-6.52	0	-3.62	-18.26 **	9.25	-6.44	-43.85 **
3x7	11.63 *	14.29 *	4.35	-7.68	-7.68	-21.70 **	6.68	-6.06	-43.63 **
4x5	2.04	19.05 **	8.70	5.25	-14.50 *	-27.49 **	15.57	1.49	-39.10 **
4x6	9.52	9.52	0	-4.20	-7.68	-21.70 **	2.14	-11.20	-46.71 **
4x7	2.08	16.67 **	6.52	-2.77	-2.77	-17.54 **	10.33	-2.85	-41.70 **
5x6	23.81 **	23.81 **	13.04 *	-16.15 **	-19.19 **	-31.46 **	12.40	-1.30	-40.77 **
5x7	10.42 *	26.19 **	15.22 **	-11.51	-11.51	-24.95 **	14.34	0.68	-39.58 **
6x7	4.76	4.76	-4.35	5.97	5.97	-10.13 *	15.04	1.30	-39.21 **
S.E.±	0.12	0.12	0.12	1.32	1.32	1.32	0.60	0.60	0.60
C.D. 5%	0.24	0.24	0.24	2.70	2.70	2.70	1.23	1.23	1.23
C.D. 1%	0.33	0.33	0.33	3.65	3.65	3.65	1.66	1.66	1.66

*, ** significant at 5% and 1% level, respectively

Table 7 (Contd...)

Hybrids	Av. weight of cluster (g)			Number of fruits/cluster			Number of clusters/plant		
	BP	TP	SH	BP	TP	SH	BP	TP	SH
1x2	17.21	17.21	-31.64 **	25.00 *	16.07	-36.59 **	22.93	-15.44	38.46 **
1x3	17.93	3.85	-39.43 **	8.93	8.93	-40.49 **	3.07	1.34	65.93 **
1x4	0.69	-11.34	-48.29 **	13.89	9.82	-40.00 **	19.51	-17.79 *	34.62 *
1x5	18.86	9.72	-36.01 **	5.77	-1.79	-46.34 **	15.61	-20.47 *	30.22 *
1x6	11.49	-1.82	-42.74 **	17.59	13.39	-38.05 **	11.02	-5.37	54.95 **
1x7	12.87	-0.61	-42.03 **	10.58	2.68	-43.90 **	-11.07	-11.07	45.60 **
2x3	17.41	17.41	-31.52 **	-5.36	-5.36	-48.29 **	-41.30 **	-42.28 **	-5.49
2x4	21.86	21.86	-28.93 **	13.89	9.82	-40.00 **	0.00	-36.24 **	4.40
2x5	32.59 **	32.59 **	-22.67 **	8.70	-10.71	-51.22 **	-9.33	-41.28 **	-3.85
2x6	11.13	11.13	-35.18 **	18.52	14.29	-37.56 **	11.81	-4.70	56.04 **
2x7	15.18	15.18	-32.82 **	18.27	9.82	-40.00 **	-41.61 **	-41.61 **	-4.40
3x4	17.42	-26.32 *	-57.02 **	23.21 *	23.21 *	-32.68 **	23.21 **	21.14 *	98.35 **
3x5	-14.25	-20.85	-53.84 **	11.61	11.61	-39.02 **	-10.58	-12.08	43.96 **
3x6	10.45	-25.10 *	-56.32 **	25.00 *	25.00 *	-31.71 **	24.91 **	22.82 **	101.10 **
3x7	1.05	-22.06	-54.55 **	23.21 *	23.21 *	-32.68 **	-1.01	-1.01	62.09 **
4x5	-10.64	-17.51	-51.89 **	16.67	12.5	-38.54 **	24.35	-19.46 *	31.87 *
4x6	31.04	-11.13	-48.17 **	4.63	0.89	-44.88 **	-1.57	-16.11 *	37.36 **
4x7	2.36	-21.05	-53.96 **	18.52	14.29	-37.56 **	-9.40	-9.40	48.35 **
5x6	-4.82	-12.15	-48.76 **	-0.93	-4.46	-47.80 **	-7.87	-21.48 *	28.57 *
5x7	20.18	10.93	-35.30 **	2.88	-4.46	-47.80 **	-26.51 **	-26.51 **	20.33
6x7	8.66	-16.19	-51.12 **	24.07 *	19.64	-34.63 **	11.07	11.07	81.87 **
S.E.±	5.36	5.36	5.36	0.56	0.56	0.56	2.34	2.34	2.34
C.D. 5%	11.01	11.01	11.01	1.15	1.15	1.15	4.79	4.79	4.79
C.D. 1%	14.86	14.86	14.86	1.56	1.56	1.56	6.47	6.47	6.47

*, ** significant at 5% and 1% level, respectively

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Table 7 (Contd...)

Hybrids	Number of seeds/fruit			Shelf life (days)			Yield/plant (kg)		
	BP	**TP**	**SH**	**BP**	**TP**	**SH**	**BP**	**TP**	**SH**
1x2	20.59 **	103.39 **	337.34 **	17.82 *	17.82 *	-0.83	21.14 *	18.73	-3.56
1x3	43.94 **	63.47 **	251.50 **	18.39	1.98	-14.17	41.06 **	38.25 **	12.30
1x4	16.57 *	96.61 **	322.75 **	5.75	-8.91	-23.33 **	29.27 **	26.69 *	2.91
1x5	31.54 *	31.54 *	182.83 **	12.64	-2.97	-18.33 *	2.85	0.80	-18.12 *
1x6	46.04 **	58.28 **	240.34 **	23.60 *	8.91	-8.33	21.95 *	19.52	-2.91
1x7	29.75 **	82.83 **	293.13 **	10.00	8.91	-8.33	24.30 *	24.30 *	0.97
2x3	67.31 **	90.02 **	308.58 **	-2.97	-2.97	-18.33 *	8.70	-0.40	-19.09 *
2x4	16.29 *	117.96 **	368.67 **	-4.95	-4.95	-20.00 **	-9.57	-17.13	-32.69 **
2x5	59.28 **	59.28 **	242.49 **	17.82 *	17.82 *	-0.83	-7.39	-15.14	-31.07 **
2x6	39.41 **	51.10 **	224.89 **	5.94	5.94	-10.83	46.52 **	34.26 **	9.06
2x7	51.98 **	114.17 **	360.52 **	9.90	9.90	-7.50	-0.80	-0.80	-19.42 *
3x4	-7.73	4.79	125.32 **	25.71 *	-12.87	-26.67 **	18.56	-8.37	-25.57 **
3x5	-0.60	-0.60	113.73 **	27.14 *	-11.88	-25.83 **	18.14	1.20	-17.80 *
3x6	15.1	24.75	168.24 **	7.87	-4.95	-20.00 **	38.32 **	17.93	-4.21
3x7	15.99	31.74 *	183.26 **	-13.00	-13.86	-27.50 **	1.99	1.99	-17.15 *
4x5	82.24 **	82.24 **	291.85 **	16.18	-21.78 *	-34.17 **	2.79	-11.95	-28.48 **
4x6	104.24 **	121.36 **	375.97 **	-1.12	-12.87	-26.67 **	5.61	-9.96	-26.86 **
4x7	3.12	45.31 **	212.45 **	-22.00 *	-22.77 *	-35.00 **	-3.59	-3.59	-21.68 *
5x6	-30.94 *	-30.94 *	48.50	-29.21 **	-37.62 **	-47.50 **	-10.70	-23.51 *	-37.86 **
5x7	7.98	7.98	132.19 **	-27.00 **	-27.72 **	-39.17 **	3.59	3.59	-15.86
6x7	1.47	9.98	136.48 **	-2.00	-2.97	-18.33 *	21.91 *	21.91 *	-5.50
S.E.±	6.16	6.16	6.16	0.84	0.84	0.84	0.12	0.12	0.12
C.D. 5%	12.64	12.64	12.64	1.72	1.72	1.72	0.25	0.25	0.25
C.D. 1%	17.07	17.07	17.07	2.33	2.33	2.33	0.34	0.34	0.34

*, ** significant at 5% and 1% level, respectively

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Table 7 (Contd...)

Hybrids	Yield/ha (q)			Juice (%)			TSS (°B)		
	BP	TP	SH	BP	TP	SH	BP	TP	SH
1x2	21.25 *	18.65	-3.62	7.18 **	6.17 *	3.30	-3.21	-3.21	-24.14 **
1x3	41.29 **	38.25 **	12.30	4.72	0.22	-2.48	7.76	-7.06	-27.16 **
1x4	29.72 **	26.93 *	3.11	4.23	-0.25	-2.94	3.51	-10.72 *	-30.03 **
1x5	3.01	0.80	-18.12 *	0.35	0.35	-2.36	-2.87	-16.22 **	-34.34 **
1x6	21.91 *	19.28	-3.11	-7.71 **	-11.68 **	-14.06 **	4.74	3.39	-18.97 **
1x7	24.14 *	24.14 *	0.84	4.24	2.21	-0.55	15.83 **	-0.09	-21.70 **
2x3	8.32	-0.40	-19.09 *	-0.50	-1.43	-4.09	-3.94	-3.94	-24.71 **
2x4	-9.96	-17.21	-32.75 **	-0.89	-1.82	-4.47	-5.22	-5.22	-25.72 **
2x5	-7.45	-14.90	-30.87 **	8.47 **	8.47 **	5.54 *	-3.94	-3.94	-24.71 **
2x6	46.10 **	34.34 **	9.13	7.05 **	6.05 *	3.18	-4.86	-4.86	-25.43 **
2x7	-0.80	-0.80	-19.42 *	1.50	0.55	-2.17	3.21	3.21	-19.11 **
3x4	18.44	-8.37	-25.57 **	-9.59 **	-15.80 **	-18.07 **	5.63	-8.89 *	-28.59 **
3x5	18.55	1.35	-17.67 *	-4.07	-4.07	-6.66 *	3.08	-11.09 *	-30.32 **
3x6	38.26 **	17.77	-4.34	1.43	-6.96 **	-9.47 **	10.68 *	9.26 *	-14.37 **
3x7	2.31	2.31	-16.89 *	-3.36	-5.24 *	-7.80 **	3.51	-10.72 *	-30.03 **
4x5	2.98	-11.95	-28.48 **	-1.28	-1.28	-3.95	17.68 *	-23.74 **	-40.23 **
4x6	5.89	-9.80	-26.73 **	-1.74	-8.48 **	-10.95 **	-15.60 **	-16.68 **	-34.70 **
4x7	-3.27	-3.27	-21.42 *	0.26	-1.69	-4.35	-13.88 *	-27.77 **	-43.39 **
5x6	-10.44	-23.43 *	-37.80 **	-4.12	-4.12	-6.71 *	-24.98 **	-25.94 **	-41.95 **
5x7	3.59	3.59	-15.86	6.55 *	6.55 *	3.67	-18.69 **	-31.81 **	-46.55 **
6x7	21.99 *	21.99 *	-5.57	-1.69	-3.61	-6.21 *	8.45	7.06	-16.09 **
S.E.±	46.75	46.75	46.75	1.69	1.69	1.69	0.23	0.23	0.23
C.D. 5%	95.92	95.92	95.92	3.47	3.47	3.47	0.48	0.48	0.48
C.D. 1%	129.52	129.52	129.52	4.69	4.69	4.69	0.65	0.65	0.65

*, ** significant at 5% and 1% level, respectively

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Table 7 (Contd...)

Hybrids	Acidity (%)			Ascorbic acid (mg/100g)			Total sugar (%)		
	BP	TP	SH	BP	TP	SH	BP	TP	SH
1x2	-6.45	-10.31 *	-11.22 *	-2.21	-3.60	-9.04 *	13.19**	4.80	-3.99
1x3	11.24 *	2.06	1.02	5.46	4.34	-1.54	1.16	1.16	-7.32
1x4	16.67 **	8.25	7.14	11.40 *	11.40 *	5.12	-12.87**	-19.33**	-26.10**
1x5	-7.87	-15.46 **	-16.33 **	-3.72	-5.10	-10.45 *	-5.97	-12.94**	-20.24**
1x6	-5.15	-5.15	-6.12	-7.35	-8.18	-13.36 **	3.64	-0.73	-9.05**
1x7	-20.22 **	-26.80 **	-27.55 **	5.61	4.11	-1.77	6.91	-1.02	-9.32**
2x3	7.53	3.09	2.04	4.84	3.73	-2.12	-17.44**	-17.44**	-24.37**
2x4	-6.45	-10.31 *	-11.22 *	11.03 *	11.03 *	4.76	4.50	-15.55**	-22.64**
2x5	8.60	4.12	3.06	-11.20 *	-13.27 **	-18.17 **	-1.44	-20.35**	-27.03**
2x6	7.22	7.22	6.12	3.70	2.78	-3.02	-5.01	-9.01*	-16.64**
2x7	15.05 **	10.31 *	9.18	-0.92	-4.52	-9.90 *	8.39*	-2.33	-10.52**
3x4	-16.67 **	-22.68 **	-23.47 **	7.87	7.87	1.79	-17.59**	-17.59**	-24.50**
3x5	15.29 *	1.03	0.00	19.30 **	18.04 **	11.38 *	3.34	3.34	-5.33
3x6	14.43 **	14.43 **	13.27 *	4.22	3.28	-2.54	-8.28*	-8.28*	-15.98**
3x7	4.71	-8.25	-9.18	-2.21	-3.25	-8.71 *	3.05	3.05	-5.59
4x5	10.00	2.06	1.02	12.18 *	12.18 *	5.85	10.42*	-12.21**	-19.57**
4x6	0.00	0.00	-1.02	-12.17 *	-12.17 *	-17.12 **	-21.85**	-25.15**	-31.42**
4x7	16.67 **	8.25	7.14	4.22	4.22	-1.65	-20.16**	-28.05**	-34.09**
5x6	5.15	5.15	4.08	16.37 **	15.33 **	8.83 *	-17.75**	-21.22**	-27.83**
5x7	5.00	-13.40 *	-14.29 **	-3.64	-5.88	-11.19 *	-13.71**	-22.24**	-28.76**
6x7	1.03	1.03	0.00	-16.08 **	-16.83 **	-21.52 **	10.62**	5.96	-2.93
S.E.±	0.02	0.02	0.02	1.87	1.87	1.87	0.12	0.12	0.12
C.D. 5%	0.05	0.05	0.05	3.84	3.84	3.84	0.24	0.24	0.24
C.D. 1%	0.07	0.07	0.07	5.19	5.19	5.19	0.32	0.32	0.32

*, ** significant at 5% and 1% level, respectively

Table 7 (Contd...)

Hybrids	Reducing sugar (%)			Lycopene (µg/g)			ß-carotene (µg/g)		
	BP	TP	SH	BP	TP	SH	BP	TP	SH
1x2	12.93**	0.00	-4.41	6.56	-20.02**	-1.29	-12.04 **	-21.22 **	-14.53 **
1x3	-7.86*	-7.86*	-11.93**	-16.35**	-16.35**	3.23	5.92	-19.12 **	-12.25 **
1x4	-21.04**	-30.09**	-33.17**	-5.70	-20.23**	-1.55	-3.19	-21.99 **	-15.37 **
1x5	-5.60	-16.41**	-20.10**	9.08*	-18.13**	1.03	-15.60 **	-15.60 **	-8.43 *
1x6	-1.78	-5.47	-9.64**	-6.02*	-13.21**	7.12*	-5.36	-26.83 **	-20.62 **
1x7	9.07*	-3.42	-7.68*	3.63	-22.22**	-4.01	-5.79	-16.98 **	-9.93 *
2x3	-24.44**	-24.44**	-27.78**	-33.75**	-33.75**	-18.24**	-5.89	-15.71 **	-8.56 *
2x4	3.70	-23.42**	-26.80**	-12.89**	-26.31**	-9.06**	-5.68	-15.53 **	-8.35
2x5	3.88	-22.22**	-25.65**	4.30	-41.51**	-27.81**	-9.68 *	-9.68 *	-2.01
2x6	-7.99*	-11.45**	-15.36**	-17.93**	-24.21**	-6.47	-5.11	-15.02 **	-7.80
2x7	5.49	-11.28**	-15.20**	-19.75**	-46.33**	-33.76**	0.95	-9.59 *	-1.91
3x4	-19.66**	-19.66**	-23.20**	10.38**	10.38**	36.22**	-14.39 **	-31.01 **	-25.15 **
3x5	4.10	4.10	-0.49	-3.88	-3.88	18.63**	-28.27 **	-28.27 **	-22.18 **
3x6	-14.36**	-14.36**	-18.14**	11.74**	11.74**	37.90**	-18.10 **	-36.69 **	-31.31 **
3x7	-4.10	-4.10	-8.33*	-6.29*	-6.29*	15.65**	-15.36 **	-25.42 **	-19.08 **
4x5	8.22	-18.97**	-22.55**	-8.18*	-22.33**	-4.14	-22.90 **	-22.90 **	-16.35 **
4x6	-24.33**	-27.18**	-30.39**	0.34	-7.34**	14.36**	-7.77	-25.68 **	-19.37 **
4x7	-16.46**	-29.74**	-32.84**	14.75**	-2.94	19.79**	-12.06 **	-22.50 **	-15.92 **
5x6	-23.27**	-26.15**	-29.41**	-40.30**	-44.86**	-31.95**	-4.25	-4.25	3.88
5x7	-8.74*	-23.25**	-26.63**	-21.16**	-47.27**	-34.93**	-0.59	-0.59	7.86
6x7	11.19**	7.01*	2.29	3.63	-4.30	18.11**	-9.53 *	-20.27 **	-13.50 **
S.E.±	0.10	0.10	0.10	0.13	0.13	0.13	1.00	1.00	1.00
C.D. 5%	0.20	0.20	0.20	0.26	0.26	0.26	2.05	2.05	2.05
C.D. 1%	0.28	0.28	0.28	0.35	0.35	0.35	2.77	2.77	2.77

*, ** significant at 5% and 1% level, respectively

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4.1.3.9 Average weight of cluster (g)

As regards the average weight of cluster, the hybrid 2x5 (32.59 %) displayed significant heterosis over better parent and top parent. None of the cross combinations has recorded significant positive heterosis over commercial hybrid.

4.1.3.10 Number of fruits per cluster

Among the hybrids, five and three hybrids exhibited significant positive heterosis over better and top parent, respectively for number of fruits per cluster. The cross combinations 3x6 (25.00 %) expressed significant positive heterosis followed by 3x4 (23.21 %) and 3x7 (23.21 %) over better and top parent, respectively. None of the cross combinations has recorded significant heterosis over commercial hybrid.

4.1.3.11 Number of clusters per plant

Out of 21 hybrids, two, two and sixteen hybrids recorded significant positive heterosis over better parent, top parent and commercial hybrid, respectively for number of clusters per plant. The hybrid 3x6 (24.91 %, 22.82 %, 101.10 %) showed significantly highest positive heterosis followed by cross 3x4 (23.21 %, 21.14 %, 98.35 %) over better, top parent and commercial hybrid, respectively.

4.1.3.12 Number of seeds per fruit

Minimum seed is considered as desirable character. Out of 21 hybrids, one hybrid recorded significantly negative heterosis over better parent and top parent for the number of seeds per fruit. The cross combination 5x6 (-30.94 %) has displayed significant negative heterosis over better and top parent. None of the cross combinations has recorded significant negative heterosis over commercial hybrid.

4.1.3.13 Shelf life (days)

Among the 21 hybrids, five and two hybrids showed significant positive heterosis over better and top parent, respectively for shelf life. The hybrid 3x5 (27.14 %) expressed significant highest positive heterosis over better parent, while the hybrids 1x2 and 2x5 (17.82 %) exhibited significantly highest positive heterosis over top parent. None of the cross combinations has recorded significant positive heterosis over commercial hybrid.

4.1.3.14 Yield per plant (kg)

Eight and five hybrids recorded significant positive heterosis over better and top parent, respectively for yield per plant. The hybrid 2x6 (46.52 %) recorded significantly maximum positive heterosis followed by the hybrids 1x3 (41.06 %), 3x6 (38.32 %), 1x4 (29.27 %), 1x7 (24.30 %) and 6x7 (21.91 %) over better parent. While, the hybrid 1x3 (38.25 %) recorded significantly highest positive heterosis followed by the crosses 2x6 (34.26 %), 1x4 (26.69 %), 1x7 (24.30 %) and 6x7 (21.91 %) over top parent. None of the cross recorded significant positive heterosis over commercial hybrid.

4.1.3.15 Yield per hectare (q)

As regarding yield per hectare, eight and four hybrids recorded significant positive heterosis over better and top parent, respectively. The hybrid 2x6 (46.10 %) recorded significantly maximum positive heterosis followed by the crosses 1x3 (41.29 %), 3x6 (38.26 %), 1x4 (29.72 %), 1x7 (24.14 %) and 6x7 (21.99 %) over better parent. While, the hybrid 1x3 (38.25 %) recorded significantly highest positive heterosis followed by the cross combinations 2x6 (34.34 %), 1x4 (26.93 %), 1x7 (24.14 %) and 6x7 (21.99 %) over top parent. None of the cross exhibited significant positive heterosis over commercial hybrid.

4.1.3.16 Juice (%)

Four, four and one hybrids recorded significant positive heterosis over better, top parent and commercial hybrid, respectively for per cent juice content. The cross 2x5 (8.47 %, 8.47 %, 5.54 %) recorded significantly highest positive heterosis over better parent, top parent and commercial hybrid, respectively.

4.1.3.17 TSS (^{0}B)

Three and one hybrids proved significant positive heterosis over better and top parent, respectively for TSS. The cross combination 4x5 (17.68 %) expressed significant positive heterosis followed by 1x7 (15.83 %) and 3x6 (10.68 %) over better parent, while, the cross 3x6 (9.26 %) expressed significantly highest positive heterosis over top parent. None of the cross combinations has proved significant positive heterosis over commercial hybrid.

4.1.3.18 Acidity (%)

Five, one and one hybrids out of 21 hybrids exhibited significant positive heterosis over better parent, top parent and commercial hybrid, respectively for acidity. The hybrids 1x4 (16.67 %)

and 4x7 (16.67 %) showed significantly highest positive heterosis over better parent, while, the cross combinations 3x6 (14.43 %, 13.27 %) confirmed significant positive heterosis over top parent and commercial hybrid, respectively.

4.1.3.19 Ascorbic acid (mg/100g)

Five, five and two hybrids recorded significant positive heterosis over better, top parent and commercial hybrid, respectively for ascorbic acid content. The cross 3x5 (19.30 %, 18.04 %, 11.38 %) recorded significantly highest positive heterosis followed by the cross 5x6 (16.37 %, 15.33 %, 8.83 %) over better, top parent and commercial hybrid, respectively.

4.1.3.20 Total sugar (%)

Regarding the total sugar, four hybrids showed significant positive heterosis over better. The cross 1x2 (13.19 %) exhibited significantly maximum heterosis followed by 6x7 (10.62 %), 4x5 (10.42 %) and 2x7 (8.39 %) over better parent. None of the cross combinations expressed significant positive heterosis over top parent and commercial hybrid.

4.1.3.21 Reducing sugar (%)

Three and one hybrids recorded significant positive heterosis over better and top parent, respectively for reducing sugar. The hybrids 1x2 (12.93 %) and 6x7 (7.01 %) recorded significantly maximum heterosis over better and top parent, respectively. None of the cross combinations has expressed significant positive heterosis over commercial hybrid.

4.1.3.22 Lycopene (µg/g)

Among the hybrids, four, two and eight hybrids recorded significant positive heterosis over better, top parent and commercial hybrid, respectively for lycopene content. The cross 4x7 (14.75 %) exhibited significantly maximum positive heterosis over better parent, while, the cross 3x6 (11.74 %, 37.90 %) recorded significantly highest positive heterosis over top parent and commercial hybrid, respectively.

4.1.3.23 ß-carotene (µg/g)

None of hybrids expressed the significant positive heterosis over better, top parent and commercial hybrid for ß-carotene.

The best heterotic F_1 hybrids are presented in plates 4, 5, 6 and 7.

4.1.4 Combining ability

4.1.4.1 Analysis of variance for combining ability

The analysis of variance for general and specific combining ability is presented in Table 8. The variance due to general combining ability was highly significant for all the characters except days to 50 % flowering; whereas the variance due to specific combining ability was highly significant for all the characters under investigation.

4.1.4.2 General combining ability

The estimates of general combining ability effects for parents are described under favourable direction and presented in Table 9.

4.1.4.2.1 Height of plant (cm)

Among the parents, two parents *viz.*, EC 128618 (5.13) and EC 128021 (4.84) exhibited significant positive gca effects and were found good general combiners for height of plant.

4.1.4.2.2 Days for 50 % flowering

Non significant differences were recorded in respect of days to 50 % flowering, which indicate that there was no variability among the studied parent for this character.

4.1.4.2.3 Average weight of fruit (g)

The parents exhibiting significantly negative gca effects were considered superior. Among the parents, four parents *viz.,* EC 128021 (-1.86), EC 128013 (-1.31), EC 163615 (-1.13) and EC 128618 (-0.26) exhibited significant negative gca effects and found good general combiners for this trait.

4.1.4.2.4 Polar diameter of fruit (cm)

Parents which having negative gca effects were considered as superior. Out of eight parents, three parents EC 128021 (-0.28), EC 128013 (-0.18) and EC 163615 (-0.14) exhibited significant negative gca effects for polar diameter and were found good general combiners for this trait.

4.1.4.2.5 Equatorial diameter of fruit (cm)

For equatorial diameter, negative gca effects is an important attribute. Parents having negative gca effects considered as superior. For equatorial diameter of fruit, three parents EC 128021 (-0.26), EC 128013 (-0.14) and EC 163615 (-0.14) exhibited significant negative gca effects and were found good general combiners for this trait.

4.1.4.2.6 Number of locules per fruit

Among the parents, CL 15-61-6-0-5 (-0.10) and EC 163615 (-0.10) displayed negative significant gca effects and were found good general combiners for this trait.

4.1.4.2.7 Pericarp thickness (mm)

The parents CL 15-61-6-0-5 (2.09) and EC 128618 (0.75) exhibited positive significant gca effects for pericarp thickness.

4.1.4.2.8 Length of cluster (cm)

Among the parents, EC 539 (0.46) and CL 15-61-6-0-5 (0.38) displayed significant positive gca effects and also found good general combiners for length of cluster.

Table 8. Analysis of variance for combining ability for different characters of cherry tomato

Sources	D.F.	Plant height (cm)	Days to 50% flowering	Av. weight of fruit (g)	Polar diameter (cm)	Equatorial diameter (cm)	Number of locules	Pericarp thickness (mm)	Length of cluster (cm)
Gca	6	171.054 **	4.9603	21.2627 **	0.3835 **	0.3208 **	0.0748 **	13.2668 **	0.7747 **
Sca	21	125.529 **	13.2371 **	2.5305 **	0.0807 **	0.0762 **	0.0150 *	2.3407 **	0.4313 *
Error	27	37.1074	4.1227	0.0778	0.0120	0.0112	0.0070	0.8662	0.1802

Sources	D.F.	Av. weight of cluster (g)	Number of fruits/ cluster	Number of clusters/ plant	Number of seeds/ fruit	Shelf life (days)	Yield/plant (kg)	Yield/ha (q)
Gca	6	250.0373 **	0.6632 **	81.459 **	1377.924 **	6.2006 **	0.085 **	11611.900 **
Sca	21	42.7759 **	0.4247 **	15.724 **	175.2964 **	1.3487 **	0.039 **	5329.229 **
Error	27	14.3901	0.1578	2.7299	18.9757	0.3526	0.0079	1092.6293

Sources	D.F.	Juice (%)	TSS (°B)	Acidity (%)	Ascorbic acid (mg/100g)	Total sugar (%)	Reducing sugar (%)	Lycopene (µg/g)	ß-carotene (µg/g)
gca	6	39.0242 **	1.3628 **	0.0033 **	18.5676 **	0.3102 **	0.2444 **	2.214 **	19.938 **
sca	21	7.7006 **	0.1978 **	0.0027 **	14.5018 **	0.0771 **	0.0666 **	0.260 **	2.080 **
Error	27	1.4298	0.0274	0.00029	1.7542	0.0068	0.0049	0.0079	0.5013

*, ** significant at 5% and 1% level, respectively

4.1.4.2.9 Average weight of cluster (g)

Out of seven parents, CL 15-61-6-0-5 (9.47), EC 539 (2.75) and EC 885539 (2.44) exhibited positive significant gca effects and were found good general combiners for this trait.

4.1.4.2.10 Number of fruits per cluster

Only one parent EC 128021 (0.31) displayed positive significant gca effects and found good general combiner for number of fruits per cluster.

4.1.4.2.11 Number of clusters per plant

The parents, EC 128021 (3.79), EC 163615 (2.80) and EC 128618 (1.64) exhibited positive significant gca effects and were found good general combiners for this trait.

4.1.4.2.12 Number of seeds per fruit

The lowest number of seeds and negative gca effects is an important attribute. For number of seeds per fruit, the parents EC 885539 (-15.14), EC 128021 (-10.02) and EC 163615 (-9.47) exhibited significant negative gca effects and found good general combiners.

4.1.4.2.13 Shelf life (days)

Out of eight parents, significant positive gca effects were expressed by two parents *viz.*, CL 15-61-6-0-5 (1.27) and EC 539 (0.76) for this trait.

4.1.4.2.14 Yield per plant (kg) and per hectare (q)

Among the parents, EC 539 (0.16 and 60.38) and EC 128618 (0.06 and 20.40) displayed positive significant gca effects and found good general combiners for this trait, respectively.

4.1.4.2.15 Juice (%)

The parents, EC 539 (2.69), EC 885539 (1.92) and EC 128618 (1.09) exhibited positive significant gca effects and were found good general combiners for this trait.

4.1.4.2.16 TSS (^{0}B)

Four parents *viz*., CL 15-61-6-0-5 (0.42), EC 163615 (0.35), EC 128021(0.17) and EC 539 (0.16) emerged as good general combiners for TSS.

4.1.4.2.17 Acidity (%)

Among the parents, EC 163615 (0.03) and CL 15-61-6-0-5 (0.02) displayed significant positive gca effects.

4.1.4.2.18 Ascorbic acid (mg/100g)

Out of seven parents, EC 885539 (0.84), EC 128013 (1.68) and EC 128021 (1.56) exhibited positive significant gca effects and were found good general combiners for this trait.

4.1.4.2.19 Total sugar (%)

Among the parents, four parents EC 128021 (0.19), EC 539 (0.17), EC 163615 (0.08) and EC 128618 (0.08) displayed positive significant gca effects and were found good general combiners for this trait.

Table 9. Estimates of general combining ability effects (gca) of parents for different characters of cherry tomato

Parents		Plant height (cm)	Days to 50% flowering	Av. weight of fruit (g)	Polar diameter (cm)	Equatorial diameter (cm)	Number of locules
P_1	EC 539	0.58	0.21	1.08 **	0.13 **	0.13 **	0.04
P_2	CL 15-61-6-0-5	-3.57	-0.18	2.20 **	0.29 **	0.23 **	-0.10 **
P_3	EC 128021	4.84 *	-0.68	-1.86 **	-0.28 **	-0.26 **	-0.04
P_4	EC 128013	-4.24 *	0.04	-1.31 **	-0.18 **	-0.14 **	0.04
P_5	EC 885539	-5.21 **	1.26	1.28 **	0.17 **	0.19 **	0.16 **
P_6	EC 163615	2.47	-1.02	-1.13 **	-0.14 **	-0.14 **	-0.10 **
P_7	EC 128618	5.13 *	0.37	-0.26 **	0.01	0.002	0.003
S.E. (gi)±		1.88	0.63	0.09	0.03	0.03	0.03
C.D. 5%		3.86	NS	0.18	0.07	0.07	0.05
C.D. 1%		5.21	NS	0.25	0.09	0.09	0.07

Parents	Pericarp thickness (mm)	Length of cluster (cm)	Av. weight of cluster (g)	Number of fruits/ cluster	Number of clusters/ plant	Number of seeds/ fruit
P_1	0.26	0.46 **	2.75 *	-0.01	-0.11	8.47 **
P_2	2.09 **	0.38 **	9.47 **	-0.24	-4.60 **	16.11 **
P_3	-0.41	-0.27 *	-5.44 **	0.31 *	3.79 **	-10.02 **
P_4	-1.26 **	-0.18	-4.55 **	0.17	-0.74	12.70 **
P_5	-1.44 **	-0.14	2.44 *	-0.48 **	-2.78 **	-15.14 **
P_6	0.01	-0.20	-3.44 **	0.16	2.80 **	-9.47 **
P_7	0.75 *	-0.05	-1.24	0.09	1.64 **	-2.65
S.E. (gi)±	0.29	0.13	1.17	0.12	0.51	1.34
C.D. 5%	0.59	0.27	2.40	0.25	1.05	2.76
C.D. 1%	0.80	0.36	3.24	0.34	1.41	3.72

*, ** significant at 5% and 1% level, respectively

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Table 9 (Contd…)

Parents	Shelf life (days)	Yield/plant (kg)	Yield/ha (q)	Juice (%)	TSS (°B)	Acidity (%)
P_1	0.76 **	0.16 **	60.38 **	0.60	0.16 **	-0.02 **
P_2	1.27 **	-0.01	-1.68	2.69 **	0.42 **	0.02 **
P_3	-0.41 *	0.00	-0.61	-2.59 **	0.17 **	0.00
P_4	-0.90 **	-0.12 **	-44.14 **	-1.77 **	-0.47 **	0.00
P_5	-0.96 **	-0.11 **	-41.51 **	1.92 **	-0.58 **	-0.01*
P_6	0.03	0.03	9.27	-1.94 **	0.35 **	0.03 **
P_7	0.21	0.06 *	20.40 *	1.09 **	-0.03	-0.03 **
S.E. (gi)±	0.18	0.03	9.82	0.37	0.05	0.01
C.D. 5%	0.38	0.05	20.15	0.76	0.10	0.01
C.D. 1%	0.51	0.07	27.20	1.02	0.14	0.01

Parents	Ascorbic acid (mg/100g)	Total sugar (%)	Reducing sugar (%)	Lycopene (µg/g)	ß-carotene (µg/g)
P_1	0.06	0.17 **	0.11 **	0.02	-0.52 *
P_2	-2.01 **	-0.05*	-0.08 **	-0.61 **	1.28 **
P_3	1.56 **	0.19 **	0.18 **	0.67 **	-2.28 **
P_4	1.68 **	-0.32 **	-0.29 **	0.34 **	-0.80 **
P_5	0.84*	-0.15 **	-0.11 **	-0.62 **	2.05 **
P_6	-0.78	0.08 **	0.11 **	0.36 **	-0.67 **
P_7	-1.34 **	0.08 **	0.08 **	-0.17 **	0.94 **
S.E. (gi)±	0.41	0.03	0.02	0.03	0.22
C.D. 5%	0.84	0.05	0.04	0.06	0.44
C.D. 1%	1.13	0.07	0.06	0.08	0.61

*, ** significant at 5% and 1% level, respectively

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4.1.4.2.20 Reducing sugar (%)

Among the parents, four parents EC 128021 (0.18), EC 539 (0.11), EC 163615 (0.11) and EC 128618 (0.08) displayed positive significant gca effects and were found good general combiners for reducing sugar content.

4.1.4.2.21 Lycopene (µg/g)

Among the parents, three parents EC 128021 (0.67), EC 163615 (0.36) and EC 128013 (0.34) displayed positive significant gca effects and were found good general combiners for this trait.

4.1.4.2.22 ß-carotene (µg/g)

The parents, EC 885539 (2.05), CL 15-61-6-0-5 (1.28) and EC 128618 (0.94) exhibited positive significant gca effects and were found good general combiners for ß-carotene content.

4.1.4.3 Specific combining ability

The data on specific combining ability of crosses for different characters in cherry tomato is depicted in Table 10.

4.1.4.3.1 Height of plant (cm)

Among 21 hybrids, none of the hybrid showed significant positive sca effects for height of plant.

4.1.4.3.2 Days to 50 % flowering

The crosses exhibiting significantly negative sca effects were considered as superior. Among the cross combinations studied, two crosses *viz.*, 4x7 (-4.68) and 3x5 (-3.85) showed negative significant sca effects for days to 50 % flowering.

4.1.4.3.3 Average weight of fruit (g)

Lower fruit weight and negative sca effect is an important attribute. Crosses having negative gca effects considered as superior. Among 21 crosses, seven crosses *viz.*, 4x7 (-1.95) and 3x5 (-1.80) showed significant negative sca effects.

4.1.4.3.4 Polar diameter of fruit (cm)

The crosses exhibiting significantly negative sca effects were considered as superior. For polar diameter, four cross combinations exhibited significantly negative sca effects. The cross 6x7 (-0.22) had recorded significant negative sca effects.

4.1.4.3.5 Equatorial diameter of fruit (cm)

Hybrids which having negative sca effects were consider as superior. Among the cross combinations studied, four crosses *viz.*, 3x5 (-0.29), 4x5 (-0.27), 4x7 (-0.25) and 6x7 (-0.25) showed negative significant sca effects.

4.1.4.3.6 Number of locules per fruit

Minimum number of locules and negative sca effects is desirable character. The data presented in Table 10 revealed that out 21 cross combinations, two cross combinations *viz.,* 2x5 (-0.27) and 2x7 (-0.21) showed significant highest negative sca effects for this trait.

Table 10. Estimates of specific combining ability effects (sca) of hybrids for different characters of cherry tomato

Hybrids		Plant height (cm)	Days to 50% flowering	Av. weight of fruit (g)	Polar diameter (cm)	Equatorial diameter (cm)
1x2	EC 539 x CL 15-61-6-0-5	4.53	-2.29	-0.96**	-0.13	-0.06
1x3	EC 539 x EC 128021	4.72	-1.79	0.00	0.04	0.04
1x4	EC 539 x EC 128013	6.79	-2.51	0.71**	0.04	0.02
1x5	EC 539 x EC 885539	7.67	1.26	1.17**	0.21*	0.23*
1x6	EC 539 x EC 163615	7.59	-1.46	0.58*	-0.01	0.06
1x7	EC 539 x EC 128618	4.53	0.15	1.26**	0.25*	0.20*
2x3	CL 15-61-6-0-5 x EC 28021	-0.14	-1.40	1.13**	0.07	0.12
2x4	CL 15-61-6-0-5 x EC 128013	9.64	-1.13	1.73**	0.14	0.14
2x5	CL 15-61-6-0-5 x EC 885539	3.42	-1.85	1.64**	0.45**	0.38**
2x6	CL 15-61-6-0-5 x EC 163615	4.74	-3.07	-0.70**	-0.10	-0.17
2x7	CL 15-61-6-0-5 x EC 128618	8.27	-1.46	2.03**	0.40**	0.34**
3x4	EC 128021 x EC 128013	5.53	-0.63	0.99**	0.33**	0.23*
3x5	EC 128021 x EC 885539	9.51	-3.85*	-1.80**	-0.23*	-0.29**
3x6	EC 128021 x EC 163615	9.63	-2.57	-0.09	-0.06	0.00
3x7	EC 128021 x EC 128618	4.86	-1.96	-0.81**	-0.19	-0.11
4x5	EC 128013 x EC 885539	7.08	-2.07	-1.70**	-0.36**	-0.27**
4x6	EC 128013 x EC 163615	3.31	0.71	1.12**	0.34**	0.40**
4x7	EC 128013 x EC 128618	4.64	-4.68*	-1.95**	-0.29**	-0.25*
5x6	EC 885539 x EC 163615	6.78	-2.51	0.72**	0.05	0.07
5x7	EC 885539 x EC 128618	-3.58	1.60	3.15**	0.48**	0.54**
6x7	EC 163615 x EC 128618	2.34	-2.63	-1.09**	-0.22*	-0.25*
S.E. (Sij)±		5.47	1.82	0.25	0.10	0.10
C.D. 5%		11.22	3.74	0.51	0.20	0.20
C.D. 1%		15.14	5.04	0.69	0.27	0.26

*, ** significant at 5% and 1% level, respectively

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Table 10 (Contd...)

Hybrids	Number of locules	Pericarp thickness (mm)	Length of cluster (cm)	Av. weight of cluster (g)	Number of fruits/ cluster	Number of clusters/ plant
1x2	0.06	0.80	0.25	-0.20	0.89*	4.87**
1x3	0.10	1.11	0.18	8.10*	-0.06	1.48
1x4	0.06	-0.45	0.56	-0.28	0.14	0.32
1x5	-0.05	1.54	-0.47	3.13	0.13	1.55
1x6	0.05	0.14	0.32	3.30	0.35	0.47
1x7	-0.05	-0.31	0.90*	1.70	-0.19	-0.06
2x3	0.19*	0.28	0.24	8.09*	-0.63	-7.03**
2x4	-0.10	0.53	0.44	9.41*	0.37	-0.69
2x5	-0.27**	2.46**	0.14	7.72*	-0.14	-0.16
2x6	0.04	0.46	1.16**	2.99	0.63	5.16**
2x7	-0.21**	2.42**	0.11	2.79	0.44	-4.67**
3x4	0.04	1.28	0.25	0.51	0.57	8.02**
3x5	-0.08	1.02	0.59	-3.78	0.56	0.15
3x6	-0.07	0.32	0.00	-0.01	0.68	4.97**
3x7	0.08	-1.38	-0.12	-0.71	0.64	-0.96
4x5	-0.06	0.06	0.49	-3.01	0.75*	2.48
4x6	0.00	0.21	-0.48	6.01	-0.53	-2.09
4x7	0.05	0.62	0.05	-1.09	0.29	1.07
5x6	0.18*	-2.31**	0.28	-1.48	-0.19	-1.66
5x7	0.13	-1.25	0.29	7.72*	-0.12	-1.99
6x7	-0.07	1.40	0.40	0.19	0.60	3.63*
S.E. (Sij)±	0.07	0.84	0.38	3.40	0.36	1.48
C.D. 5%	0.15	1.71	0.78	6.99	0.73	3.04
C.D. 1%	0.21	2.31	1.06	9.43	0.99	4.10

*, ** significant at 5% and 1% level, respectively

Table 10 (Contd...)

Hybrids	Number of seeds/fruit	Shelf life (days)	Yield/plant (kg)	Yield/ha (q)	Juice (%)	TSS (°B)
1x2	0.84	0.65	0.07	23.99	2.55*	-0.16
1x3	6.97	0.73	0.31**	114.04**	3.79**	-0.11
1x4	0.85	0.12	0.28**	104.98**	2.65*	0.33*
1x5	-3.92	0.78	-0.05	-19.14	-0.63	0.14
1x6	3.81	0.99	0.05	16.01	-4.92**	0.28
1x7	9.29*	0.81	0.08	29.59	1.46	0.47**
2x3	12.63**	-0.28	-0.01	-3.54	0.59	-0.21
2x4	3.90	0.01	-0.10	-38.15	-0.50	0.36*
2x5	2.34	2.37**	-0.08	-30.04	2.79*	0.54**
2x6	-7.43	0.18	0.40**	148.06**	5.01**	-0.44**
2x7	17.35**	0.39	-0.06	-24.28	-1.75	0.38*
3x4	-26.66**	0.88	0.01	1.90	-4.69**	0.42**
3x5	-1.53	1.05	0.12	44.44	-0.43	0.41**
3x6	5.50	0.76	0.19*	69.96*	1.47	0.59**
3x7	2.18	-0.33	-0.03	-10.91	-0.39	-0.12
4x5	17.25**	0.54	0.07	26.13	0.64	0.35*
4x6	31.18**	0.45	-0.04	-14.65	-0.38	-0.19
4x7	-13.74**	-0.74	0.02	6.71	1.19	-0.42**
5x6	-17.29**	-1.98**	-0.22**	-80.62**	-1.11	-0.58**
5x7	-4.61	-1.17*	0.10	35.92	3.09**	-0.53**
6x7	-9.28*	0.34	0.18 *	65.52 *	0.07	0.67**
S.E. (Sij)±	3.91	0.53	0.08	28.55	1.07	0.15
C.D. 5%	8.02	1.09	0.16	58.59	2.20	0.30
C.D. 1%	10.83	1.48	0.21	79.10	2.97	0.41

*, ** significant at 5% and 1% level, respectively

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Table 10 (Contd...)

Hybrids	**Acidity (%)**	**Ascorbic acid (mg/100g)**	**Total sugar (%)**	**Reducing sugar (%)**	**Lycopene (µg/g)**	**ß-carotene (µg/g)**
1x2	-0.03*	0.48	0.42**	0.41**	0.61**	-1.37*
1x3	0.05**	0.29	0.05	-0.08	-0.49**	2.74**
1x4	0.07**	3.17*	-0.14	-0.26**	-0.35**	0.51
1x5	-0.03*	-3.00*	-0.09	-0.04	0.71**	-0.66
1x6	-0.02	-2.70*	0.11	0.06	-0.03	-0.90
1x7	-0.07**	3.08*	0.09	0.15*	0.06	0.09
2x3	0.02	2.09	-0.38**	-0.37**	-0.69**	1.84**
2x4	-0.05**	5.07**	0.20**	0.12	-0.01	0.41
2x5	0.03*	-4.41**	-0.13	-0.02	0.23**	-0.90
2x6	0.01	4.02**	0.03	0.07	0.08	0.42
2x7	0.08**	1.48	0.25**	0.11	-0.45**	0.24
3x4	-0.09**	0.17	-0.11	-0.02	0.46**	-0.13
3x5	0.04*	5.33**	0.45**	0.49**	0.74**	-2.26**
3x6	0.06**	0.68	-0.18**	-0.27**	0.52**	-1.75*
3x7	0.01	-1.54	0.20**	0.07	0.18*	-0.39
4x5	0.04**	2.72*	0.43**	0.28**	0.19*	-2.31**
4x6	-0.01	-6.02**	-0.25**	-0.18**	-0.07	-0.32
4x7	0.08**	1.51	-0.36**	-0.22**	0.66**	-1.10
5x6	0.02	6.52**	-0.28**	-0.33**	-0.90**	2.49**
5x7	-0.01	-1.94	-0.32**	-0.21**	-0.49**	1.85**
6x7	0.02	-4.98**	0.42**	0.45**	0.59**	-0.63
S.E. (Sij)±	0.02	1.19	0.07	0.06	0.08	0.64
C.D. 5%	0.03	2.44	0.15	0.13	0.16	1.30
C.D. 1%	0.04	3.29	0.21	0.17	0.22	1.76

*, ** significant at 5% and 1% level, respectively

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4.1.4.3.7 Pericarp thickness (mm)

Out of 21 hybrids, two cross combinations *viz.*, 2x5 (2.46) and 2x7 (2.42) exhibited significant positive sca effects for pericarp thickness.

4.1.4.3.8 Length of cluster (cm)

For length of cluster, two cross combinations *viz.*, 2x6 (1.16) and 1x7 (0.90) exhibited positive and significant sca effects.

4.1.4.3.9 Average weight of cluster (g)

Among the cross combination, five crosses *viz.*, 2x4 (9.41), 1x3 (8.10), 2x3 (8.09), 5x7 (7.72) exhibited significant positive sca effects for average weight of cluster.

4.1.4.3.10 Number of fruits per cluster

Significant and positive sca effects were recorded by the two crosses *viz.*, 1x2 (0.89) and 4x5 (0.75) for number of fruits per cluster.

4.1.4.3.11 Number of clusters per plant

The cross combinations *viz.*, 3x4 (8.02), 2x6 (5.16), 3x6 (4.97), 1x2 (4.87) and 6x7 (3.63) displayed the magnitude of significant positive sca effects for number of clusters per plant.

4.1.4.3.12 Number of seeds per fruit

Minimum number of seeds and negative sca effects is desirable. Four hybrids expressed significant negative sca effects *viz.*, 3x4 (-26.66), 5x6 (-17.29), 4x7 (-13.74) and 6x7 (-9.28) for this trait.

4.1.4.3.13 Shelf life (days)

Among the 21 cross combinations studied, the cross 2x5 (2.37) displayed highest magnitude of positive significant sca effects for shelf life.

4.1.4.3.14 Yield per plant (kg) and per hectare (q)

Five hybrids *viz.*, 2x6 (0.40 and 148.06), 1x3 (0.31 and 114.04), 1x4 (0.28 and 104.98), 3x6 (0.19 and 69.96) and 6x7 (0.18 and 65.52) expressed significant positive sca effects for fruit yield per plot and per hectare, respectively.

4.1.4.3.15 Juice (%)

Significant positive sca effects were noted in six hybrids for juice per cent. The highest significant sca effects were exhibited by cross 2x6 (5.01) and 1x3 (3.79).

4.1.4.3.16 TSS (^{0}B)

From the data on total soluble solids presented in Table 10, it was revealed that the significant positive sca effects were recorded in ten crosses. The highest magnitude of positive sca effects was exhibited by 6x7 (0.67).

4.1.4.3.17 Acidity (%)

Significant and positive sca effects were recorded by eight cross combinations for acidity. The highest magnitude of positive sca effects was displayed by the crosses 2x7 and 4x7 (0.08), 1x4 (0.07) and 3x6 (0.06).

4.1.4.3.18 Ascorbic acid (mg/100g)

Out of 21 hybrids, seven hybrids showed significant positive sca effects for ascorbic acid content. The highest magnitude of significant sca effects were exhibited by cross 5x6 (6.52), 3x5 (5.33) and 2x4 (5.07).

4.1.4.3.19 Total sugar (%)

Out of 21 cross combinations studied, seven crosses expressed significant positive sca effects for this trait. The cross 3x5 (0.45), 4x5 (0.43), 1x2 (0.42) and 6x7 (0.42) expressed significantly highest positive sca effects.

4.1.4.3.20 Reducing sugar (%)

Significant positive sca effects were recorded by five cross combinations *viz.*, 3x5 (0.49), 6x7 (0.45), 1x2 (0.41), 4x5 (0.28) and 1x7 (0.15) for reducing sugar.

4.1.4.3.21 Lycopene (µg/g)

Out of 21 crosses, ten crosses were recorded positive significant sca effects for the lycopene content. The highest positive sca effects were exhibited by the cross 3x5 (0.74) and 1x5 (0.71).

4.1.4.3.22 ß-carotene (µg/g)

Among the 21 cross combinations, four crosses *viz.*, 1x3 (2.74), 5x6 (2.49), 5x7 (1.85) and 2x3 (1.84) exhibited positive significant sca effects for this trait.

4.2 Evaluation of F_1 hybrids and stability analysis

4.2.1 Performance of F_1 hybrids under growing conditions

Mean performance of selected promising F_1 hybrids evaluated under different growing conditions (Plate 8) are presented in Table 11.

4.2.1.1 Height of plant (cm)

Under polyhouse condition, the hybrid 3x5 (401.33) displayed significantly maximum height of plant and was at par with the hybrids 3x7 (384.00), 3x6 (376.00), 4x5 (366.67) and check Suncherry Extra Sweet (SES) (360.67).

Under shade net house, the hybrid 3x5 (346.00) recorded significantly highest height of plant and was at par with the hybrids 3x6 (341.33), 3x7 (330.67) and 1x3 (310.67).

The hybrid 3x7 (113.40) recorded significantly highest height of plant and was at par with the hybrid 3x6 (104.33) under open field condition.

4.2.1.2 Days to 50 % flowering

The hybrid 3x5 (49.00) recorded significantly lowest days to 50 % flowering and at par with all the hybrids except 1x3 and 6x7 studied under polyhouse condition.

Under shade net house, the hybrid 3x6 (49.33) displayed significantly least days to 50 % flowering and was at par with the hybrids Suncherry Extra Sweet (50.67), 2x6 (51.00), 3x7 (52.33) and 3x5 (52.67).

The hybrid 3x6 (50.67) recorded significantly minimum days to 50 % flowering and was at par with the hybrids 3x5 (53.00), 3x7 (53.33) and 6x7 (55.33) under open field condition.

4.2.1.3 Average fruit weight (g)

The hybrid 3x6 (7.30) recorded significantly lowest average weight of fruit and at par with the hybrids 3x7 (7.63) and 3x5 (7.83) studied under polyhouse condition.

The hybrid 3x6 (7.57) displayed significantly minimum average weight of fruit and was at par with the hybrids 3x7 (7.97), 3x5 (8.17) and 6x7 (8.27) under shade net house.

Under open field condition, the hybrids 3x6 and 3x7 (7.57) recorded significantly minimum average weight of fruit and was at par with the hybrids 3x5 (7.63) and 6x7 (7.67).

4.2.1.4 Polar diameter of fruit (cm)

The hybrids 3x6 and 3x7 (2.21) displayed significantly lowest polar diameter of fruit and at par with the hybrids 3x5 (2.23), 4x5 (2.27) and 6x7 (2.32) under polyhouse condition.

Under shade net house, the hybrid 3x6 (2.37) recorded significantly least polar diameter and was at par with the hybrids 3x7 (2.40), 3x5 (2.41), 6x7 (2.43) and 4x5 (2.50).

The hybrid 3x7 (2.07) recorded significantly minimum polar diameter and was at par with the hybrids 3x6 (2.21), 6x7 (2.21) and 3x5 (2.27) under open field condition.

4.2.1.5 Equatorial diameter of fruit (cm)

The hybrid 3x6 (2.30) recorded significantly lowest equatorial diameter and at par with all hybrids except 1x3 and 2x6 under polyhouse condition.

The hybrid 3x7 (2.54) displayed significantly minimum equatorial diameter and was at par with all hybrids except 1x3 and

2x6 under shade net house.

Under open field condition, the hybrid 3x7 (2.31) recorded significantly minimum equatorial diameter and was at par with the hybrids 3x6 (2.35), 6x7 (2.35), Suncherry Extra Sweet (2.37) and 3x5 (2.39).

4.2.1.6 Number of locules per fruit

The hybrid 6x7 (2.00) recorded significantly lowest number of locules and at par with the hybrids 3x6 (2.07) and 3x5 (2.20) studied under polyhouse condition.

Under shade net house, the hybrid 6x7 (2.07) recorded significantly least number of locules and was at par with the hybrids 3x6 (2.20), 3x7 (2.20), 3x5 (2.27) and 4x5 (2.27).

The hybrid 6x7 (2.00) displayed significantly minimum number of locules and was at par with the hybrid 3x6 (2.20) under open field condition.

4.2.1.7 Pericarp thickness (mm)

Under polyhouse condition, the check variety Suncherry Extra Sweet (26.73) recorded maximum pericarp thickness and was at par with the hybrid 2x6 (25.20).

Under shade net house, the check variety Suncherry Extra Sweet (26.27) recorded highest pericarp thickness and was at par with the hybrid 1x3 (24.67).

The check variety Suncherry Extra Sweet (25.53) recorded highest pericarp thickness under open field condition also.

Table 11. Mean performance of cherry tomato hybrids under different growing conditions

Hybrids		Plant height (cm)			Days to 50 % flowering		
		Poly house	Shade net	Open field	Poly house	Shade net	Open field
1x3	EC 539 x EC 128021	332.00	310.67	89.07	55.67	57.33	55.67
2x6	CL 15-61-6-0-5 x EC 163615	349.33	299.33	92.13	50.00	51.00	55.67
3x5	EC 128021 x EC 885539	401.33	346.00	94.53	49.00	52.67	53.00
3x6	EC 128021 x EC 163615	376.00	341.33	104.33	49.67	49.33	50.67
3x7	EC 128021 x EC 128618	384.00	330.67	113.40	50.33	52.33	53.33
4x5	EC 128013 x EC 885539	366.67	277.33	80.40	49.33	57.00	58.67
6x7	EC 163615 x EC 128618	326.00	296.67	86.20	52.00	54.67	55.33
SES	Suncherry Extra Sweet	360.67	283.33	90.80	49.67	50.67	53.67
S.E.±		14.36	13.78	4.27	0.81	1.50	1.02
C.D. 5%		43.06	41.31	12.95	2.42	4.50	3.08

Hybrids	Av. weight of fruit (g)			Polar diameter (cm)		
	Poly house	Shade net	Open field	Poly house	Shade net	Open field
1x3	9.47	9.60	9.40	2.41	2.64	2.44
2x6	11.00	10.00	11.07	2.69	2.87	2.69
3x5	7.83	8.17	7.63	2.23	2.41	2.27
3x6	7.30	7.57	7.57	2.21	2.37	2.21
3x7	7.63	7.97	7.57	2.21	2.40	2.07
4x5	8.70	9.20	8.87	2.27	2.50	2.31
6x7	8.60	8.27	7.67	2.32	2.43	2.21
SES	9.43	11.17	9.10	2.64	2.97	2.68
S.E.±	0.25	0.43	0.23	0.06	0.08	0.07
C.D. 5%	0.75	1.29	0.69	0.19	0.23	0.21

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Table 11 (Contd...)

Hybrids	Equatorial diameter (cm)			Number of locules/fruit			Pericarp thickness (mm)		
	Poly house	Shade net	Open field	Poly house	Shade net	Open field	Poly house	Shade net	Open field
1x3	2.62	2.85	2.69	2.33	2.40	2.33	24.80	24.67	21.87
2x6	2.74	2.96	2.75	2.33	2.40	2.33	25.20	23.60	23.53
3x5	2.46	2.59	2.39	2.20	2.27	2.27	23.93	22.53	21.00
3x6	2.30	2.55	2.35	2.07	2.20	2.20	22.60	22.87	20.33
3x7	2.38	2.54	2.31	2.40	2.20	2.27	21.27	22.40	21.07
4x5	2.45	2.72	2.55	2.33	2.27	2.27	22.53	19.40	19.13
6x7	2.37	2.59	2.35	2.00	2.07	2.00	24.00	23.33	22.80
SES	2.47	2.66	2.37	2.40	2.33	2.27	26.73	26.27	25.53
S.E.±	0.06	0.07	0.06	0.08	0.07	0.07	0.63	0.64	0.59
C.D. 5%	0.17	0.21	0.19	0.25	0.22	0.22	1.88	1.93	1.79

Hybrids	Length of cluster (cm)			Av. weight of cluster (g)			Number of fruits/cluster		
	Poly house	Shade net	Open field	Poly house	Shade net	Open field	Poly house	Shade net	Open field
1x3	9.51	8.47	7.98	39.00	49.87	46.53	4.53	6.53	6.47
2x6	10.15	9.95	8.75	46.80	53.07	49.40	5.20	7.00	6.73
3x5	9.51	8.04	7.97	26.93	36.27	35.13	4.33	5.27	5.07
3x6	9.33	8.21	7.83	30.80	39.87	38.53	4.20	6.47	5.93
3x7	9.97	8.55	8.08	33.13	39.27	35.53	5.47	6.87	6.73
4x5	10.00	8.16	7.75	34.00	48.00	43.47	4.80	5.67	4.80
6x7	9.82	8.48	7.22	35.87	42.93	42.93	4.73	6.07	5.87
SES	15.10	14.69	12.64	71.80	71.87	70.20	8.47	9.87	8.93
S.E.±	0.44	0.38	0.36	1.46	1.59	1.72	0.14	0.32	0.22
C.D. 5%	1.33	1.14	1.09	4.37	4.78	5.21	0.41	0.90	0.66

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Table 11 (Contd...)

Hybrids	Number of clusters/plant			Number of seeds/fruit			Shelf life (days)		
	Poly house	Shade net	Open field	Poly house	Shade net	Open field	Poly house	Shade net	Open field
1x3	21.73	20.93	24.40	73.80	86.00	74.07	10.33	10.00	9.33
2x6	19.33	21.20	25.67	81.07	73.60	70.80	11.33	11.83	10.17
3x5	19.87	20.80	20.87	42.07	49.87	43.87	10.83	9.67	7.83
3x6	23.93	24.07	23.27	65.20	80.93	63.27	10.50	10.17	7.50
3x7	22.80	21.60	22.80	59.07	65.00	55.33	7.83	9.33	7.67
4x5	14.53	17.67	18.73	71.07	69.20	76.73	8.83	8.17	7.67
6x7	20.67	21.27	27.00	52.60	63.20	43.80	9.00	10.67	9.33
SES	16.87	18.73	18.47	18.53	23.67	18.67	12.50	12.17	11.00
S.E.±	0.90	1.03	1.15	2.51	2.75	2.95	0.50	0.47	0.43
C.D. 5%	2.69	3.08	3.47	7.52	8.23	8.93	1.49	1.41	1.30

Hybrids	Yield/plant (kg)			Yield/ha (q)			Juice (%)		
	Poly house	Shade net	Open field	Poly house	Shade net	Open field	Poly house	Shade net	Open field
1x3	0.96	1.19	1.30	428.14	527.40	482.72	69.62	69.75	64.91
2x6	1.04	1.33	1.52	460.74	591.11	564.20	71.40	68.85	65.82
3x5	0.76	0.91	0.89	339.26	402.96	330.86	62.42	63.30	61.91
3x6	0.87	1.11	1.23	385.18	494.81	454.32	63.70	62.21	61.59
3x7	0.76	0.98	1.02	337.77	437.03	377.78	63.89	63.17	62.36
4x5	0.58	0.93	0.93	257.78	414.81	343.21	70.77	70.59	67.80
6x7	0.96	1.12	1.33	426.66	499.25	493.83	61.18	65.29	61.53
SES	1.10	1.24	1.44	487.40	549.62	533.33	68.70	68.82	65.37
S.E.±	0.03	0.04	0.07	15.25	15.90	24.71	1.21	1.26	1.18
C.D. 5%	0.10	0.11	0.20	45.73	47.68	74.48	3.61	3.77	3.58

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Table 11 (Contd...)

Hybrids	TSS (°B)			Acidity (%)			Ascorbic acid (mg/100g)		
	Poly house	Shade net	Open field	Poly house	Shade net	Open field	Poly house	Shade net	Open field
1x3	6.20	5.53	5.96	0.34	0.24	0.45	33.89	30.23	36.20
2x6	4.66	4.89	5.76	0.34	0.39	0.44	29.96	33.44	35.17
3x5	5.25	5.46	6.13	0.35	0.36	0.52	38.11	35.19	42.05
3x6	5.77	6.10	6.89	0.41	0.33	0.47	36.78	33.36	42.60
3x7	5.36	5.39	6.04	0.27	0.27	0.42	39.31	33.55	41.66
4x5	4.52	4.98	5.27	0.44	0.42	0.47	35.27	38.73	43.67
6x7	5.98	6.04	6.80	0.31	0.28	0.39	32.49	27.37	40.19
SES	7.30	7.41	8.04	0.28	0.30	0.38	33.17	29.82	42.61
S.E.±	0.20	0.12	0.14	0.01	0.01	0.01	0.75	1.20	1.48
C.D. 5%	0.61	0.37	0.43	0.03	0.03	0.04	2.26	3.60	4.49

Hybrids	Total sugar (%)			Reducing sugar (%)			Lycopene (µg/g)		
	Poly house	Shade net	Open field	Poly house	Shade net	Open field	Poly house	Shade net	Open field
1x3	3.52	4.17	4.03	2.78	3.33	3.03	4.24	4.17	3.75
2x6	3.78	3.60	3.91	3.03	2.88	3.04	4.11	5.03	4.33
3x5	4.22	3.48	5.04	3.68	3.08	3.77	4.71	5.10	4.72
3x6	3.44	3.50	4.45	2.78	3.03	3.19	5.04	5.31	4.51
3x7	3.27	4.13	4.11	2.49	3.38	2.77	5.09	4.73	5.50
4x5	3.69	3.89	4.54	2.97	3.08	3.31	3.96	4.54	3.71
6x7	3.28	3.69	4.34	2.81	3.06	3.32	5.66	5.90	4.41
SES	3.41	3.58	4.51	2.81	2.85	3.50	5.03	4.20	4.92
S.E.±	0.10	0.10	0.12	0.08	0.09	0.10	0.12	0.14	0.14
C.D. 5%	0.30	0.29	0.37	0.23	0.28	0.29	0.37	0.42	0.44

Table 11 (Contd...)

Hybrids	ß-carotene (µg/g)			Thrips/leaf			Whitefly/leaf		
	Poly house	Shade net	Open field	Polyhouse	Shade net	Open field	Poly house	Shade net	Open field
1x3	15.29	20.26	22.14	1.89 (1.54)	1.84 (1.53)	3.23 (1.93)	1.66 (1.47)	2.22 (1.64)	2.30 (1.67)
2x6	20.01	20.35	21.05	1.11 (1.27)	1.62 (1.44)	2.59 (1.76)	0.73 (1.10)	1.10 (1.26)	1.31 (1.34)
3x5	16.90	19.09	20.17	2.12 (1.62)	2.19 (1.64)	3.46 (1.99)	2.06 (1.60)	1.89 (1.55)	2.47 (1.72)
3x6	18.08	17.85	19.76	1.68 (1.47)	1.96 (1.57)	2.93 (1.85)	1.04 (1.24)	1.38 (1.37)	1.48 (1.41)
3x7	20.74	18.16	15.77	1.47 (1.40)	1.48 (1.40)	2.22 (1.65)	0.95 (1.20)	1.17 (1.28)	1.94 (1.56)
4x5	20.84	17.44	19.71	1.80 (1.52)	1.27 (1.33)	2.69 (1.79)	1.52 (1.41)	2.28 (1.67)	2.12 (1.62)
6x7	18.87	17.72	20.55	2.14 (1.62)	2.11 (1.61)	2.69 (1.78)	1.52 (1.42)	2.00 (1.58)	2.04 (1.59)
SES	22.17	20.83	20.51	0.90 (1.17)	1.52 (1.42)	2.46 (1.72)	0.63 (1.02)	1.15 (1.28)	1.47 (1.40)
S.E.±	0.45	0.50	0.62	0.07	0.07	0.05	0.10	0.08	0.05
C.D. 5%	1.35	1.50	1.88	0.20	N.S.	0.14	0.31	0.23	0.14

Hybrids	Mites/leaf			Leaf curl (%)		
	Polyhouse	Shade net	Open field	Poly house	Shade net	Open field
1x3	1.84 (1.52)	2.16 (1.63)	4.99 (2.34)	11.36 (19.45)	13.64 (21.63)	19.70 (26.32)
2x6	1.94 (1.56)	2.50 (1.73)	2.37 (1.69)	8.33 (16.52)	9.85 (18.18)	14.39 (22.28)
3x5	1.55 (1.42)	3.89 (2.09)	3.76 (2.06)	13.64 (21.55)	17.42 (24.60)	24.24 (29.43)
3x6	2.78 (1.80)	1.78 (1.51)	3.76 (2.06)	12.88 (20.97)	12.12 (20.25)	18.18 (25.16)
3x7	1.30 (1.31)	2.25 (1.65)	3.06 (1.88)	9.09 (17.46)	12.12 (20.36)	16.67 (24.05)
4x5	3.95 (2.11)	2.80 (1.81)	2.06 (1.60)	17.42 (24.55)	15.91 (23.39)	23.48 (28.95)
6x7	1.97 (1.57)	1.99 (1.57)	2.91 (1.84)	11.36 (19.64)	15.15 (22.86)	17.42 (24.60)
SES	2.05 (1.59)	1.43 (1.37)	1.98 (1.57)	4.55 (12.04)	6.06 (14.06)	9.09 (17.46)
S.E.±	0.12	0.10	0.06	1.82	1.47	1.36
C.D. 5%	0.37	0.30	0.20	5.45	4.40	4.14

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4.2.1.8 Length of cluster (cm)

The check variety Suncherry Extra Sweet (15.10, 14.69 and 12.64) recorded maximum length of cluster under polyhouse, shade net and open field conditions, respectively.

4.2.1.9 Average weight of cluster (g)

The check variety Suncherry Extra Sweet (71.80, 71.87 and 70.20) recorded maximum weight of cluster under polyhouse, shade net and open field conditions, respectively followed by the cross 2x6 and 1x3, respectively.

4.2.1.10 Number of fruits per cluster

The check variety Suncherry Extra Sweet (8.47, 9.87 and 8.93) displayed maximum number of fruits per cluster under polyhouse, shade net and open field, respectively.

4.2.1.11 Number of clusters per plant

The hybrid 3x6 (23.93) recorded significantly highest number of clusters per plant and at par with the hybrids 3x7 (22.80) and 1x3 (21.73) under polyhouse condition.

The hybrid 3x6 (24.07) noted significantly maximum number of clusters per plant and was at par with the hybrids 3x7 (21.60), 6x7 (21.27) and 2x6 (21.20) under shade net house.

Under open field condition, the hybrid 6x7 (27.00) recorded significantly maximum number of clusters per plant and was at par with the hybrids 2x6 (25.67) and 1x3 (24.40).

4.2.1.12 Number of seeds per fruit

The check variety Suncherry Extra Sweet (18.53, 23.67 and 18.67) displayed lowest number of seeds per fruit under polyhouse, shade net and open field conditions, respectively.

4.2.1.13 Shelf life (days)

The check variety Suncherry Extra Sweet (12.50) showed maximum shelf life and was at par with the hybrid 2x6 (11.33) under polyhouse condition.

Under shade net house, the check variety Suncherry Extra Sweet (12.17) displayed highest shelf life and was at par with the hybrid 2x6 (11.83).

The check variety Suncherry Extra Sweet (11.00) recorded highest shelf life and was at par with the hybrid 2x6 (10.17) under open field condition.

4.2.1.14 Yield per plant (kg) and per hectare (q)

Under polyhouse condition, the check variety Suncherry Extra Sweet (1.10 kg and 487.40 q/ha) recorded maximum yield per plant and per hectare, respectively and was c with the hybrid 2x6 (1.04 kg and 460.74 q/ha).

Under shade net house, the hybrid 2x6 (1.33 kg and 591.11 q/ha) recorded significantly highest yield per plant and per hectare, respectively and was at par with the check variety Suncherry Extra Sweet (1.24 kg and 549.62 q/ha).

The hybrid 2x6 (1.52 kg and 564.20 q/ha) recorded significantly highest yield per plant and per hectare, respectively and was at par with the hybrids Suncherry Extra Sweet (1.44 kg and 533.33 q/ha) and 6x7 (1.33 kg and 493.83 q/ha) under open field condition.

4.2.1.15 Juice (%)

The hybrid 2x6 (71.40) recorded significantly highest juice per cent than standard check variety Suncherry Extra Sweet and at par with the hybrids 4x5 (70.77) and 1x3 (69.62) under polyhouse condition.

The hybrid 4x5 (70.59) noted significantly maximum juice content and was at par with the hybrids 1x3 (69.75), 2x6 (68.85) and Suncherry Extra Sweet (68.82) under shade net house.

Under open field condition, the hybrid 4x5 (67.80) recorded significantly maximum juice percentage and was at par with the hybrids 1x3 (64.91) and 2x6 (65.82).

4.2.1.16 TSS (^{0}B)

The check variety Suncherry Extra Sweet (7.30, 7.41, 8.04) recorded maximum TSS under polyhouse, shade net and open field conditions.

4.2.1.17 Acidity (%)

The hybrid 4x5 (0.44) showed significantly maximum per cent acidity and was at par with the hybrid 3x6 (0.41) under polyhouse condition.

Under shade net house, the hybrid 4x5 (0.42) recorded significantly highest acidity and was at par with the hybrid 2x6 (0.39). The hybrid 3x5 (0.52) recorded significantly highest acidity percentage under open field condition.

4.2.1.18 Ascorbic acid (mg/100g)

The hybrid 3x7 (39.31 mg/100g) recorded significantly highest ascorbic acid content and at par with the hybrid 3x5 (38.11) under polyhouse condition.

The hybrid 4x5 (38.73) noted significantly maximum ascorbic acid content and was at par with the hybrid 3x5 (35.19) under shade net house.

Under open field condition, the hybrid 4x5 (43.67) recorded significantly maximum ascorbic acid content and was at par with the hybrids Suncherry Extra Sweet (42.61), 3x6 (42.60), 3x5 (42.05) and 6x7 (40.19).

4.2.1.19 Total sugar (%)

The hybrid 3x5 (4.22) showed significantly maximum total sugar content under polyhouse condition.

Under shade net house, the hybrid 1x3 (4.17) recorded significantly highest total sugar content and at par with the hybrid 3x7 (4.13) and 4x5 (3.89). The hybrid 3x5 (5.04) recorded significantly highest total sugar content under open field condition.

4.2.1.20 Reducing sugar (%)

The hybrid 3x5 (3.68) showed significantly maximum reducing sugar content under polyhouse condition.

Under shade net house, the hybrid 3x7 (3.38) recorded significantly highest reducing sugar and at par with the hybrid 1x3 (3.33). The hybrid 3x5 (3.77) recorded significantly highest reducing sugar and at par with the check variety Suncherry Extra Sweet (3.50) under open field condition.

4.2.1.21 Lycopene (µg/g)

The hybrid 6x7 (5.66) recorded significantly the higher lycopene under polyhouse condition.

The hybrid 6x7 (5.90) noted significantly highest lycopene under shade net house.

Under open field condition, the hybrid 3x7 (5.50) recorded significantly maximum lycopene content over rest of the hybrids.

4.2.1.22 ß-carotene (µg/g)

The check variety Suncherry Extra Sweet (22.17) recorded highest ß-carotene content and at par with the hybrid 4x5 (20.84) under polyhouse condition. The check variety Suncherry Extra Sweet (20.83) noted maximum ß-carotene content and was at par with the hybrids 2x6 (20.35) and 1x3 (20.26) under shade net house.

Under open field condition, the hybrid 1x3 (22.14) recorded significantly maximum ß-carotene content and was at par with the hybrids 2x6 (21.05), 6x7 (20.55) and check Suncherry Extra Sweet (20.51).

4.2.1.23 Thrips per leaf

The check variety Suncherry Extra Sweet (0.90) showed least incidence of thrips per leaf and it was at par with the hybrid 2x6 (1.11) under polyhouse condition. Under shade net house, the hybrid 4x5 (1.27) recorded significantly least incidence of thrips per leaf.

Significantly least incidence of thrips per leaf was recorded in the hybrid 3x7 (2.22) and at par with all the hybrids except 1x3, 3x5 and 3x6 under open field condition.

4.2.1.24 Whitefly per leaf

The check variety Suncherry Extra Sweet (0.63) recorded minimum incidence of white fly per leaf and at par with the hybrids 2x6 (0.73), 3x7 (0.95) and 3x6 (1.04) under polyhouse condition.

Significantly minimum incidence of white fly per leaf was noted in the hybrid 2x6 (1.10) and it was at par with the hybrids Suncherry Extra Sweet (1.15), 3x7 (1.17) and 3x6 (1.38) under shade net house.

Under open field condition, the hybrid 2x6 (1.31) recorded significantly minimum incidence of white fly per leaf and it was at par with the check Suncherry Extra Sweet (1.47) and 3x6 (1.48).

4.2.1.25 Mites per leaf

Significantly lower incidence of mites per leaf was recorded by hybrid 3x7 (1.30) and at par with all hybrids except 3x6 and 4x5 under polyhouse condition.

Under shade net house, the check variety Suncherry Extra Sweet (1.43) recorded lower incidence of mites per leaf and it was at par with all hybrids except 2x6, 3x5 and 4x5.

The check variety Suncherry Extra Sweet (1.98) recorded lower incidence of mites per leaf and at par with the hybrids 4x5 (2.06) and 2x6 (2.37) under open field condition.

4.2.1.26 Leaf curl (%)

The check variety Suncherry Extra Sweet (4.55) showed lowest incidence of leaf curl disease and at par with the hybrids 2x6 (8.33) and 3x7 (9.09) under polyhouse condition.

Under shade net house, the check variety Suncherry Extra Sweet (6.06) recorded lowest incidence of leaf curl disease and at par with the hybrid 2x6 (9.85).

The check variety Suncherry Extra Sweet (9.09) recorded lowest incidence of leaf curl disease under open field condition.

4.2.1.27 Spotted wilt (%)

There was no incidence of spotted wilt virus disease recorded on the hybrids grown under polyhouse, shade net house and open field conditions.

4.2.2 Stability Analysis

The analysis of variance indicated significantly higher amount of variability among the genotypes over all three growing conditions for all the characters studied. GxE interaction is important in the expression of quantitative characters which are controlled by polygenic system and are largely influenced by the environmental fluctuations (Patil, 1984). Since GxE interaction was detected significant for days to 50 % flowering, average weight of fruit, weight of cluster, number of fruits/cluster, number of clusters/plant, number of seeds/fruit, shelf life, yield/plant, TSS, acidity, ascorbic acid, total sugar, reducing sugar, lycopene and ß-carotene, the stability parameters in respect of these traits were estimated only and are presented in Table 12. The range of variation for mean performance over three environments (Xi), linear regression coefficient (bi) and deviation from regression (S^2di) for the studied characters are described below in detail. The genotypes with at least mean performance statistically greater than population mean (also with in population mean $\pm$ S.E.) and S^2di low or non-significant and (1) 'bi' approaching to unity or not significantly deviating from unity are regarded with general adaptability or average stability. (2) 'bi' significantly greater than unity is considered as better adaptable to rich or favourable environment (below average stability). (3) 'bi' significantly less than unity and or having lower magnitude than unity are considered as better adaptable to poor or unfavourable environment (above average stability).

The genotypes with significant S^2di components are considered as highly unpredictable. In some cases relative 'bi' values were also considered to decide specific adaptability. Eberhart and Russell (1966) method was preferred because of its explicit nature.

4.2.3 Estimates of environmental indices

Estimates of environmental indices (Ij) are presented in Table 12, which revealed that environment E_1 (Polyhouse) was favourable for plant height, days to 50 % flowering, pericarp thickness, length of cluster and average weight of cluster (g).

Environment E_2 (Shade net house) was favourable for characters viz., fruits per cluster, shelf life, yield per hectare, juice and lycopene content.

Environment E_3 (Open field) was favourable for characters *viz.*, average fruit weight, polar and equatorial diameter, number of locules, clusters/plant, seeds/fruit, yield/plant, TSS, acidity, ascorbic acid, total and reducing sugar and β-carotene.

In general environment E_2 was most favourable for yield, while, environment E_3 was most favourable for quality characters.

Table 12. Estimation of environment index under different environments

SN	Characters	Environmental index (Ij)		
		E_1	E_2	E_3
1	Height of plant (cm)	106.492	55.158	-161.650
2	Days to 50% flowering	-2.069	0.347	1.722
3	Average weight of fruit (g)	0.036	0.210	-0.174
4	Polar diameter of fruit (cm)	-0.063	0.139	-0.076
5	Equatorial diameter of fruit (cm)	-0.068	0.140	-0.072
6	Number of locules per fruit	0.003	0.011	-0.014
7	Pericarp thickness (mm)	0.908	0.158	-1.067
8	Length of cluster (cm)	0.999	-0.105	-0.894
9	Average weight of cluster (g)	-4.425	3.425	1.000
10	Number of fruits per cluster	-0.867	0.633	0.233
11	Number of clusters per plant	-1.167	-0.350	1.517
12	Number of seeds per fruit	-1.300	4.708	-3.408
13	Shelf life (days)	0.410	0.514	-0.924
14	Yield per plant (kg)	-0.184	0.039	0.146
15	Yield per hectare (q)	-52.141	47.117	5.023
16	Juice (%)	0.836	0.875	-1.711
17	TSS (^{0}B)	-0.275	-0.181	0.456
18	Acidity (%)	-0.028	-0.046	0.074
19	Ascorbic acid (mg/100g)	-1.161	-3.323	4.484
20	Total sugar (%)	-0.323	-0.144	0.467
21	Reducing sugar (%)	-0.162	0.003	0.159
22	Lycopene (µg/g)	0.036	0.177	-0.213
23	β-carotene (µg/g fresh wt.)	-0.232	-0.381	0.613

4.2.4 Stability parameters for yield and quality characters

Since GxE interaction was detected for all the characters, the stability parameters in respect of these traits were estimated and were presented in Table 14. The non-significant bi values were considered as around unity irrespective of their high or low numerical values.

4.2.4.1 Days to 50 % flowering

Five hybrids showed least days for 50 % flowering (earliness) than that of population mean which is desirable for earliness. The hybrid 3x5 and Suncherry Extra Sweet recorded lower mean performance (51.56, 51.33 days, respectively), non-significant S^2di (-0.494, 0.256, respectively) and non-significant regression coefficient close to unity (1.11, 0.98, respectively) indicating their general adaptability for this trait i.e. these genotypes perform better under all environments.

None of the hybrids had significant estimate of regression coefficient and deviation variance from regression.

4.2.4.2 Average weight of fruit (g)

Four hybrids showed lowest weight of fruit than that of population mean, which is desirable for cherry fruits. The hybrids 3x7 and 6x7 recorded lower mean performance (7.72, 8.18, respectively), non significant regression coefficient (bi = 1.08, 1.22, respectively) and non-significant deviation from regression (S^2di = -0.095, 0.236, respectively) indicating their average stability for i.e. suitable for all environment.

The hybrid 3x5 recorded lower mean performance (7.88), regression coefficient (bi = 1.39) significantly greater than unity and non-significant deviation from regression (S^2di = -0.098) indicating its stability for favourable environment i.e. below average stability.

4.2.4.3 Average weight of cluster (g)

Two hybrids showed maximum weight of cluster than that of population mean. The hybrid 2x6 recorded higher mean performance (49.76), regression coefficient (bi = 0.75) significantly lower than unity and non-significant deviation from regression (S^2di = -0.538) indicating their stability for poor environment i.e. above average stability.

4.2.4.4 Number of fruits per cluster

Three hybrids showed maximum number of fruits per cluster than that of population mean. The hybrids 2x6, 3x7 and Suncherry Extra Sweet exhibited higher mean (6.31, 6.36, 10.09, respectively), non-significant regression coefficient (bi = 1.24, 0.98, 0.83, respectively) close to unity and non-significant deviation from regression (S^2di = -0.028, -0.020, 0.139, respectively) values indicating their average stability for this trait.

None of the hybrids recorded significant regression coefficient (bi) for this trait. The hybrid 4x5 exhibited significant deviation from regression (S^2di = 0.195) values indicating its unpredictability for this character.

Table 13. Analysis of variance for stability in cherry tomato

Sources	D.F.	Plant height (cm)	Days to 50% flowering	Av. weight of fruit (g)	Polar diameter (cm)
Varieties	7	975.336 +@**	13.344 ++@@**	4.744 ++@@**	0.138 ++@@**
Environments	2	162054.4 ++@@**	29.476 ++@@**	0.302	0.117 ++@@**
Var.x Env.	14	237.048	2.937 *	0.247 *	0.002
Environments (Lin.)	1	324108.9 @@**	58.953 @@ **	0.603 @*	0.233 @@**
Var.x Env.(Lin.)	7	214.179	4.25 **	0.406 @**	0.002
Pooled Deviation	8	227.428	1.418	0.076	0.002
Pooled Error	42	129.629	1.368	0.104	0.005
Total	23	14532.82	8.412	1.62	0.054

Sources	D.F.	Equatorial diameter (cm)	Number of locules	Pericarp thickness (mm)	Length of cluster (cm)
Varieties	7	0.07 ++@@**	0.04 ++@@**	9.639 ++@@**	11.344 ++@@**
Environments	2	0.118 ++@@**	0.001	7.952 ++@@**	7.239 ++@@**
Var.x Env.	14	0.002	0.004	0.656	0.161
Environments (Lin.)	1	0.235 @@**	0.003	15.904 @@**	14.478 @@**
Var.x Env.(Lin.)	7	0	0.001	0.551	0.11
Pooled Deviation	8	0.002	0.006	0.666	0.186
Pooled Error	42	0.004	0.006	0.367	0.155
Total	23	0.033	0.015	4.024	4.18

+, ++ = Significant at 5% and 1% level respectively against the GxE interaction
@, @@ = Significant at 5% and 1% level respectively against the pooled deviation
*, ** = Significant at 5% and 1% level respectively against the pooled error

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Table 13 (Contd...)

Sources	D.F.	Av. weight of cluster (g)	Number of fruits/cluster	Number of clusters/plant	Number of seeds/fruit
Varieties	7	698.357 ++@@**	8.185 ++@@**	27.289 ++@@**	1129.613 ++@@**
Environments	2	129.244 ++@@**	4.827 ++@@**	15.135 +@@**	141.903 +@@**
Var.x Env.	14	5.669 *	0.132 *	2.534 *	26.782 **
Environments (Lin.)	1	258.488 @@**	9.653 @@**	30.271 @@**	283.805 @@**
Var.x Env.(Lin.)	7	9.601 @@**	0.170 **	4.011 @**	40.112 **
Pooled Deviation	8	1.519	0.083	0.924	11.770
Pooled Error	42	2.438	0.055	1.113	7.237
Total	23	227.233	2.991	11.164	372.436

Sources	D.F.	Shelf life (days)	Yield/plant (kg)	Yield/ha (q)
Varieties	7	4.790 ++@@**	0.099 ++@@**	16930.780 ++@@**
Environments	2	5.140 ++@@**	0.227 ++@@**	19855.670 ++@@**
Var.x Env.	14	0.489 *	0.004 *	475.898
Environments (Lin.)	1	10.28 @@**	0.454 @@**	39711.330 @@**
Var.x Env.(Lin.)	7	0.420	0.005 *	578.828
Pooled Deviation	8	0.489 *	0.003	326.347
Pooled Error	42	0.223	0.002	305.991
Total	23	2.203	0.052	7169.103

+, ++ = Significant at 5% and 1% level respectively against the GxE interaction
@, @@ = Significant at 5% and 1% level respectively against the pooled deviation
*, ** = Significant at 5% and 1% level respectively against the pooled error

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Table 13 (Contd...)

Sources	D.F.	Juice (%)	TSS (°B)	Acidity (%)	Ascorbic acid (mg/100g)
Varieties	7	30.232 ++@@**	2.081 ++@@**	0.007 ++@@**	20.451 +@**
Environments	2	17.568 ++@@**	1.264 ++@@**	0.033 ++@@**	129.991 ++@@**
Var.x Env.	14	1.696	0.056 *	0.001 **	5.801 **
Environments (Lin.)	1	35.137 @@**	2.527 @@**	0.067 @@**	259.983 @@**
Var.x Env.(Lin.)	7	1.457	0.063 *	0.002 **	6.276 **
Pooled Deviation	8	1.694	0.042	0.001 **	4.660 **
Pooled Error	42	1.555	0.022	0	1.425
Total	23	11.761	0.777	0.006	21.059

Sources	D.F.	Total sugar (%)	Reducing sugar (%)	Lycopene (µg/g)	ß-carotene (µg/g)
Varieties	7	0.084 **	0.105 **	0.641 +@@**	2.987 **
Environments	2	1.375 ++@@**	0.205 **	0.313 **	2.297 **
Var.x Env.	14	0.111 **	0.073 **	0.196 **	3.759 **
Environments (Lin.)	1	2.750 @@**	0.411 **	0.627 @**	4.593 **
Var.x Env.(Lin.)	7	0.074 **	0.024 **	0.294 **	3.121 **
Pooled Deviation	8	0.129 **	0.107 **	0.086 **	3.848 **
Pooled Error	42	0.012	0.008	0.017	0.263
Total	23	0.213	0.094	0.342	3.397

+, ++ = Significant at 5% and 1% level respectively against the GxE interaction
@, @@ = Significant at 5% and 1% level respectively against the pooled deviation
*, ** = Significant at 5% and 1% level respectively against the pooled error

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4.2.4.5 Number of clusters per plant

The hybrid 1x3 (22.36) exhibited superior mean than population mean (20.81), non significant regression coefficient (bi = 1.14) close to unity with non-significant S^2di (0.640) indicating their average stability i.e. suitable for all environments.

The hybrid 2x6 recorded high mean (22.07), regression coefficient (bi = 2.37) significantly greater than unity and non-significant deviation from regression (S^2di = -1.005) indicating their stability for favourable environment i.e. below average stability.

4.2.4.6 Number of seeds per fruit

Three hybrids showed less number of seeds per fruit than that of population mean. The hybrid 3x5 had lower mean (45.27) than the population mean (59.23), non-significant regression coefficient (bi = 0.86), non-significant deviation from regression (S^2di = -0.317), indicating their average stability for this trait.

The hybrid 2x6 exhibited significant values of deviation from regression (S^2di = 49.032) indicating its unpredictable performance for given character. None of the hybrids exhibited significant estimate of regression coefficient.

4.2.4.7 Shelf life (days)

Three hybrids showed highest shelf life than the population mean. The hybrid 2x6 had superior mean (11.11), non-significant regression coefficient (bi = 1.04) close to unity, non-significant deviation from regression (S^2di = -0.138) value indicating their average stability for this trait.

None of the hybrids exhibited significant estimate of regression coefficient. The hybrids 3x5, 3x7 and 6x7 had significant values of S^2di i.e. 0.690, 0.804, 1.106, respectively indicating their unpredictability for this character.

4.2.4.8 Yield per plant (kg)

Five hybrids *viz.,* 1x3, 2x6, 3x6, 6x7 and Suncherry Extra Sweet showed maximum yield per plant than that of population mean. The hybrids 1x3, 3x6, 6x7 and Suncherry Extra Sweet had superior mean (1.15 kg, 1.07 kg, 1.14 kg and 1.26 kg, respectively) than the population mean of 1.06 kg, non significant regression coefficient (bi = 1.03, 1.09, 1.07 and 0.98, respectively), non-significant deviation from regression (S^2di = -0.002, -0.002, 0.003 and 0.004, respectively) indicating their average stability for this character.

None of the hybrids exhibited significant estimate of regression coefficient. The hybrid 4x5 exhibited significant values of S^2di (0.007) indicating its unpredictability for the given character.

4.2.4.9 TSS (^{0}B)

Stability parameters in respect to TSS are presented in Table 14. Three hybrids showed highest TSS than that of population mean. The hybrids 6x7 (6.27) and Suncherry Extra Sweet (7.58) exhibited superior mean than population mean (5.91), non significant regression coefficient (bi = 1.15, 1.00, respectively) close to unity with non-significant S^2di (-0.024, -0.025, respectively) indicating their average stability i.e. suitable for all environments.

Table 14. Stability parameters for different traits in cherry tomato

Hybrids		Plant height (cm)			Days to 50 % flowering		
		Mean	bi	S²di	Mean	bi	S²di
1x3	EC 539 x EC 128021	243.90	0.94	236.800	56.22	0.08	0.501
2x6	CL 15-61-6-0-5 x EC 163615	246.90	0.96*	-137.800	52.22	1.37	3.131
3x5	EC 128021 x EC 885539	280.60	1.15	-131.300	51.56	1.11	-0.494
3x6	EC 128021 x EC 163615	273.90	1.04	39.800	49.89	0.22	-0.693
3x7	EC 128021 x EC 128618	276.00	1.01	-136.700	52.00	0.80	-1.300
4x5	EC 128013 x EC 885539	241.50	1.02	567.200*	55.00	2.54	0.614
6x7	EC 163615 x EC 128618	236.30	0.92	24.400	54.00	0.91	-1.114
SES	Suncherry Extra Sweet	244.90	0.97	251.700	51.33	0.98	0.256
	Population mean	255.51			52.78		
	S.E. ± (Mean)	10.70			0.84		
	S.E. ± (bi)	0.10			0.43		

Hybrids	Av. weight of fruit (g)			Polar diameter (cm)		
	Mean	bi	S²di	Mean	bi	S²di
1x3	9.49	0.52*	-0.099	2.50	1.01	-0.004
2x6	10.69	-2.93	-0.034	2.75	0.87	-0.005
3x5	7.88	1.39*	-0.098	2.30	0.77	-0.004
3x6	7.48	0.13	-0.052	2.26	0.73	-0.005
3x7	7.72	1.08	-0.095	2.22	1.29	0.003
4x5	8.92	1.01	-0.045	2.36	0.99	-0.003
6x7	8.18	1.22	0.236	2.32	0.84	0.001
SES	10.50	5.59	0.010	2.76	1.49	-0.003
Pop. mean	8.86			2.44		
S.E. ± (Mean)	0.20			0.03		
S.E. ± (bi)	1.00			0.28		

*, ** Significant at 5% and 1% level, respectively

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Table 14 (Contd...)

Hybrids	Equatorial diameter (cm)			Number of locules/fruit		
	Mean	bi	S^2di	Mean	bi	S^2di
1x3	2.72	0.95	-0.002	2.36	2.29	-0.005
2x6	2.82	1.02	-0.004	2.36	2.29	-0.005
3x5	2.48	0.77	-0.002	2.24	-0.57	-0.003
3x6	2.40	1.06	-0.003	2.16	-1.14	0.006
3x7	2.41	0.92	-0.002	2.29	-1.14	0.014
4x5	2.58	1.03	0.001	2.29	0.58	-0.003
6x7	2.43	1.10	-0.004	2.02	2.29	-0.005
SES	2.50	1.16	0.001	2.33	3.43	-0.001
Pop. mean	2.54			2.26		
S.E. ± (Mean)	0.03			0.05		
S.E. ± (bi)	0.27			4.22		

Hybrids	Pericarp thickness (mm)			Length of cluster (cm)		
	Mean	bi	S^2di	Mean	bi	S^2di
1x3	23.78	1.56	0.249	8.65	0.82	-0.147
2x6	24.11	0.77	0.232	9.62	0.70	0.086
3x5	22.49	1.46	-0.327	8.51	0.85	0.056
3x6	21.93	1.24	0.451	8.46	0.80	-0.121
3x7	21.58	0.20	0.576	8.86	1.02	-0.094
4x5	20.36	1.58	1.839*	8.64	1.22	0.021
6x7	23.38	0.59	-0.351	8.51	1.36	-0.141
SES	26.18	0.61*	-0.380	14.14	1.24	0.536*
Pop. mean	22.98			9.42		
S.E. ± (Mean)	0.58			0.31		
S.E. ± (bi)	0.57			0.32		

*, ** Significant at 5% and 1% level, respectively

Table 14 (Contd...)

Hybrids	Av. weight of cluster (g)			Number of fruits/cluster		
	Mean	bi	S^2di	Mean	bi	S^2di
1x3	45.13	1.38*	-2.442	5.84	1.42	0.080
2x6	49.76	0.75	-0.538	6.31	1.24	-0.028
3x5	32.78	1.24	-0.496	4.89	0.63	-0.054
3x6	36.40	1.20	-1.073	5.53	1.53	-0.053
3x7	35.98	0.72	-0.294	6.36	0.98	-0.020
4x5	41.82	1.78*	-2.415	5.09	0.46	0.195*
6x7	40.58	0.97	0.587	5.56	0.92	-0.041
SES	80.69	-0.04	-0.721	10.09	0.83	0.139
Pop. mean	45.39			6.21		
S.E. ± (Mean)	0.87			0.20		
S.E. ± (bi)	0.21			0.26		

Hybrids	Number of clusters/plant			Number of seeds/fruit		
	Mean	bi	S^2di	Mean	bi	S^2di
1x3	22.36	1.14	0.640	77.96	1.59	-0.285
2x6	22.07	2.37*	-1.005	75.16	-0.01	49.032**
3x5	20.51	0.31	-0.757	45.27	0.86	-0.317
3x6	23.76	-0.28	-0.936	69.80	2.27	-2.936
3x7	22.40	0.11	-0.094	59.80	1.15	-6.375
4x5	16.98	1.39	1.175	72.33	-0.79	1.222
6x7	22.98	2.48	0.111	53.20	2.25	1.455
SES	15.42	0.47	0.200	20.29	0.67	-6.029
Pop. mean	20.81			59.23		
S.E. ± (Mean)	0.68			2.43		
S.E. ± (bi)	0.49			0.57		

*, ** Significant at 5% and 1% level, respectively

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Table 14 (Contd...)

Hybrids	Shelf life (days)			Yield/plant (kg)		
	Mean	bi	S^2di	Mean	bi	S^2di
1x3	9.89	0.59	-0.137	1.15	1.03	-0.002
2x6	11.11	1.04	-0.138	1.30	1.45	-0.001
3x5	9.44	1.69	0.690*	0.85	0.43	0.000
3x6	9.39	2.02	-0.067	1.07	1.09	-0.002
3x7	8.28	0.72	0.804*	0.92	0.82	-0.001
4x5	8.22	0.57	0.050	0.81	1.13	0.007 *
6x7	9.67	0.43	1.106*	1.14	1.07	0.003
SES	11.89	0.95	-0.122	1.26	0.98	0.004
Pop. mean	9.74			1.06		
S.E. ± (Mean)	0.49			0.04		
S.E. ± (bi)	0.61			0.22		

Hybrids	Yield/ha (q)			Juice (%)		
	Mean	bi	S^2di	Mean	bi	S^2di
1x3	479.40	1.00	-305.200	68.09	1.86*	-1.479
2x6	538.70	1.34	223.400	68.69	1.67	1.932
3x5	357.70	0.60	1034.9 *	62.54	0.37	-1.103
3x6	444.80	1.11	-285.800	62.50	0.52	-0.337
3x7	384.20	0.98	-114.700	63.14	0.45	-1.208
4x5	338.60	1.58	-293.000	69.72	1.12	-1.456
6x7	473.20	0.76	115.800	62.66	0.68	6.860*
SES	523.50	0.64	-242.200	67.63	1.32*	-1.477
Pop. mean	442.50			65.62		
S.E. ± (Mean)	12.80			0.92		
S.E. ± (bi)	0.30			0.62		

*, ** Significant at 5% and 1% level, respectively

Table 14 (Contd…)

Hybrids	TSS (°B)			Acidity (%)		
	Mean	bi	S^2di	Mean	bi	S^2di
1x3	5.90	0.04	0.205**	0.34	1.56	0.000**
2x6	5.10	1.46	-0.020	0.39	0.67	0.002**
3x5	5.61	1.15	-0.020	0.41	1.48	0.001*
3x6	6.26	1.43	-0.007	0.40	1.01	0.002**
3x7	5.60	0.97	-0.023	0.32	1.32	0.000
4x5	4.92	0.81	0.049	0.44	0.34	0.000
6x7	6.27	1.15	-0.024	0.33	0.83	0.000
SES	7.58	1.00	-0.025	0.32	0.80	0.001*
Pop. mean	5.91			0.37		
S.E. ± (Mean)	0.15			0.02		
S.E. ± (bi)	0.36			0.35		

Hybrids	Ascorbic acid (mg/100g)			Total sugar (%)		
	Mean	bi	S^2di	Mean	bi	S^2di
1x3	33.44	0.69	1.116	3.91	0.42	0.158**
2x6	32.86	0.36	8.377*	3.76	0.26	0.013
3x5	38.45	0.84	-0.749	4.25	1.43	0.508**
3x6	37.58	1.15	-0.945	3.80	1.35	0.004
3x7	38.17	0.91	6.302*	3.83	0.78	0.261**
4x5	39.23	0.81	13.166**	4.04	1.07	-0.013
6x7	33.35	1.59	0.145	3.77	1.27	0.004
SES	35.20	1.65*	-1.382	3.83	1.43	-0.010
Pop. mean	36.03			3.90		
S.E. ± (Mean)	1.53			0.25		
S.E. ± (bi)	0.37			0.61		

*, ** Significant at 5% and 1% level, respectively

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Table 14 (Contd…)

Hybrids	Reducing sugar (%)			Lycopene (µg/g)		
	Mean	**bi**	**S^2di**	**Mean**	**bi**	**S^2di**
1x3	3.05	0.79	0.108**	4.05	1.20	0.014
2x6	2.98	0.00	0.009	4.49	1.48	0.269**
3x5	3.51	0.25	0.275**	4.84	0.85	0.024
3x6	3.00	1.30	-0.007	4.95	2.04*	-0.018
3x7	2.88	0.90	0.363**	5.11	-1.92*	-0.015
4x5	3.12	1.04	-0.005	4.07	1.98	0.032
6x7	3.06	1.60*	-0.008	5.32	3.96	0.040
SES	3.05	2.12	0.056**	4.72	-1.58	0.195**
Pop. mean	3.08			4.69		
S.E. ± (Mean)	0.23			0.21		
S.E. ± (bi)	1.44			1.04		

Hybrids	ß-carotene (µg/g)		
	Mean	**bi**	**S^2di**
1x3	19.23	4.01	15.480**
2x6	20.47	0.88	-0.185
3x5	18.72	2.03	2.879**
3x6	18.56	1.94*	-0.298
3x7	18.22	-3.59	4.645**
4x5	19.33	1.06	5.071**
6x7	19.05	2.55	0.001
SES	21.17	-0.88	0.794
Pop. mean	19.34		
S.E. ± (Mean)	1.39		
S.E. ± (bi)	2.58		

*, ** Significant at 5% and 1% level, respectively

None of the hybrids exhibited significant estimate of regression coefficient. The hybrid 1x3 had significant value of S^2di indicating its unpredictability for this trait.

4.2.4.10 Acidity (%)

Four hybrids showed maximum acidity than that of population mean. The estimates of regression coefficient ranged between 0.34 and 1.56.

None of the hybrids exhibited significant estimate of regression coefficient. The hybrids 1x3 (0.000), 2x6 (0.002), 3x5 (0.001), 3x6 (0.002) and Suncherry Extra Sweet (0.001) exhibited significant deviation from regression (S^2di) indicting their unpredictability for this trait.

4.2.4.11 Ascorbic acid (mg/100g)

Four hybrids showed maximum ascorbic acid than that of population mean. The hybrids 3x5 and 3x6 had regression coefficient (bi = 0.84, 1.15, respectively) near to unity, with non-significant S^2di (-0.749, -0.945, respectively) and high mean performance (38.45, 37.58, respectively) than population mean (36.03) indicating their average stability for this trait.

The hybrids 2x6, 3x7 and 4x5 exhibited significant values of deviation from regression (S^2di = 8.377, 6.302, 13.166, respectively) indicating their unpredictable performance for given character.

4.2.4.12 Total sugar (%)

Three hybrids showed high values of total sugar than that of population mean. The hybrid 4x5 had higher mean performance (4.04) than population mean (3.90), non significant regression coefficient (bi = 1.07) close to unity, non significant deviation from regression (S^2di = -0.013), indicating its average stability for this trait.

None of the hybrids exhibited significant estimate of regression coefficient. The hybrids 1x3, 3x5 and 3x7 had significant value (S^2di = 0.158, 0.508, 0.261, respectively) indicating their unpredictability for this trait.

4.2.4.13 Reducing sugar (%)

Two hybrids showed highest reducing sugar than that of population mean. The hybrid 4x5 exhibited higher mean (3.12), non-significant regression coefficient (bi = 1.04) close to unity and non-significant deviation from regression (S^2di = -0.005) values indicating its average stability for this trait.

The hybrids 1x3 (0.108), 3x5 (0.275), 3x7 (0.363) and Suncherry Extra Sweet (0.056) had significant value of S^2di indicating its unpredictability for this trait.

4.2.4.14 Lycopene (μg/g)

Five hybrids showed highest values for lycopene content than that of population mean. The hybrid 3x5 had higher mean performance (4.84) than population mean (4.69), non significant regression coefficient (bi = 0.85) close to unity, non significant deviation from regression (S^2di = 0.024), indicating its average stability for this trait.

The hybrids 3x6 and 3x7 recorded high mean performance (4.95 and 5.11, respectively), regression coefficient (bi = 2.04 and -1.92, respectively) significantly greater than unity and non-significant deviation from regression (S^2di = -0.018 and -0.015, respectively) indicating their stability for favourable environment i.e. below average stability.

The hybrids 2x6 and Suncherry Extra Sweet recorded significant values of S^2di (0.269, 0.195, respectively) indicating their unpredictability for the given character.

4.2.4.15 ß-carotene (µg/g)

Two hybrids showed highest values for ß-carotene content than that of population mean. The hybrid 2x6 and Suncherry Extra Sweet had higher mean (20.47 and 21.17, respectively) than population mean (19.34), non significant regression coefficient (bi = 0.88 and -0.88, respectively) close to unity, non significant deviation from regression (S^2di = -0.185 and 0.794), indicating their average stability for this trait.

The hybrids 1x3 (15.480), 3x5 (2.879), 3x7 (4.645) and 4x5 (5.071) had significant value of S^2di indicating their unpredictable performance for given character.

5. DISCUSSION

5.1 Mean performance

Significant differences were recorded for mean performance of the parents for various traits. Among the parents, EC 539 recorded least days to 50 % flowering (60 days) with highest length of cluster (8.08 cm). The parent CL 15-61-6-0-5 showed highest weight of cluster (49.40 g), shelf life (10.10 days) and TSS (5.46 ^{0}B). The parent EC 128021 recorded lowest weight of fruit (7.10 g), polar (2.13 cm) and equatorial (2.31 cm) diameter, while, it recorded maximum number of fruits per cluster (5.60), total (2.94 %) and reducing (2.43 %) sugar, lycopene (4.27 µg/g) content. The parent EC 128013 recorded highest values for ascorbic acid content (42.49 mg/100g) and minimum incidence of spotted wilt (4.55 %) disease. The parent EC 885539 recorded least seed per fruit (50.10), least white fly (0.70) and mites (0.37) per leaf with highest juice per cent (67.74), ß-carotene (26.44 µg/g) content. The parent EC 163615 recorded minimum days to 50 % flowering (60.00), locules (2.10) and thrips per leaf (1.06) and leaf curl (6.82 %) disease incidence. The parent EC 163615 also noticed maximum acidity (0.49 %). Among the parents, EC 128618 recorded highest mean values for plant height (120.60 cm), pericarp thickness (23.45 mm), number of clusters per plant (29.80), yield per plant and per hectare (1.26 kg, 464.81 q, respectively). The parent EC 128618 also recorded least incidence of spotted wilt disease (4.55 %).

Significant differences were recorded for mean performance of the F_1s for different characters. Among the F_1s, the cross 3x6 recorded maximum height of plant (137.80 cm), number of fruits per cluster (7.00), number of clusters per plant (36.60), TSS (5.96 ^{0}B), acidity (0.56 %), lycopene (4.83 µg/g), while lowest values were recorded for days to 50 % flowering (52.00), polar (2.19 cm) and equatorial (2.42 cm) diameter. The cross 2x6 recorded highest length of cluster (9.37 cm) and lowest days to 50 % flowering (52.00), least incidence of white fly per leaf (0.23), leaf curl (5.69 %) and spotted wilt (2.27 %) disease. The cross 4x7 shows minimum days to 50 % flowering (52.00), weight of fruit (7.00 g). Highest pericarp thickness (27.95 mm) and lowest number of locules per fruit (2.05) were recorded in cross 2x7. The check variety Suncherry Extra Sweet (SES) recorded maximum length of cluster (13.47 cm), weight of cluster (74.70 g), number of fruits per cluster (9.25), shelf life (12.00 days), TSS (6.96 ^{0}B), total sugar (3.26 %), while lowest number of seeds per fruit (23.30) and least incidence of leaf curl (2.28 %) and spotted wilt (2.27 %) disease. The highest average weight of cluster (65.50 g), shelf life (11.90 days), juice content (73.48 %) and least number of locules per fruit (2.05) was found in the cross 2x5. The lowest number of seeds per fruit (34.60) was recorded in the cross 5x6. The cross 1x3 recorded maximum yield per plant (1.74 kg) and per hectare (642.59 q). While, the cross 3x5 recorded highest ascorbic acid (50.16 mg/100g) content and less incidence of spotted wilt virus (2.27 %). The cross 6x7 recorded highest total sugar (3.15 %) and reducing sugar (2.63 %) content. The highest ß-carotene (26.29 µg/g) content and less incidence of thrips per leaf (0.76) was noticed in the cross 5x7. No incidence of mites was noticed in the cross the 2x3. The cross 1x6 recorded the less incidence of leaf curl (5.69 %) and spotted wilt (2.27 %) disease.

5.2 Analysis of variance

Analysis of variance indicated the presence of genetic variability for all the characters in parents, since variances were significant for all the characters. The mean sums of squares for all the crosses were significant for all the characters indicating presence of genetic variability amongst the crosses vs parents. The replication differences were non-significant for all the characters and variances exhibited significance for all the characters, indicating presence of appreciable magnitude of heterosis and genetic variability.

In previous studies, such observations were also noted by Shalini (2009) and Hosamani (2010) in tomato.

5.3 Heterosis

Heterosis breeding provides opportunity for improvement in productivity, earliness, uniformity, wider adaptability and quality (Riggs, 1988). Practically, in plant breeding, superiority over mid parent is of no use since it does not offer the hybrid any advantage over better parent. Therefore, increase over the better parent, top parent and commercial hybrid is more relevant. Furthermore, while selecting the potential crosses for further use in plant breeding programme, *per se* performance of parents and hybrids for various attributes must be taken into consideration in addition to per cent heterosis.

The significant positive heterosis for plant height over better parent was observed in seven cross combinations viz., 4x6, 2x5, 3x7, 1x7, 1x5, 1x6 and 1x3. The performance of these cross combinations can be attributed due to high *per se* performance, significant sca effects of particular cross. Similar results have been reported by Sharma and Thakur (2008), Yashavantakumar (2008), Dhadde *et al.* (2009), Shalini (2009), Virupannavar (2009), Hosamani (2010) and Sekhar *et al.* (2010).

It is desirable to develop cherry tomato varieties which mature early and having small fruit size with less locules and few seeds with great quality juice. The negative heterosis for days to 50 per cent flowering, average weight of fruit, polar and equatorial diameter of fruit, number of locules, pericarp thickness and number of seeds/fruit is desirable.

Regarding the days to 50 per cent flowering, seventeen crosses expressed significant negative heterosis over better parent (4x7, 2x6, 3x6, 3x5, 6x7, 2x3, 3x7, 2x4, 2x7, 1x2, 1x3, 1x4, 1x6, 5x6, 3x4, 2x5 and 4x5) and twelve crosses (2x6, 3x6, 4x7, 3x5, 6x7, 1x2, 1x3, 1x4, 1x6, 2x3, 3x7 and 5x6) showed superiority over top parent in desirable direction. Heterosis over better parent and top parent in these hybrids can be attributed due to better *per se* performance of hybrids, higher negative gca effects of female parent and negative sca effects of the crosses. The negative heterosis for days to 50 per cent flowering has been reported by Kulkarni (2003), Mahendrakar (2004), Duhan *et al.* (2005a), Shalini (2009), Hosamani (2010), Sekhar *et al.* (2010) and Ahmed *et al.* (2011) in tomato.

The significant negative heterosis for average weight of fruit over commercial hybrid were recorded by the hybrids 4x7, 3x6, 3x7, 6x7, 3x5, 3x4, 4x5 and 4x6. Similar results have been reported by Sajjan (2001), Kulkarni (2003), Mahendrakar (2004), Prashanth (2004), Duhan *et al.* (2005a) and Premalakshmi *et al.* (2006).

As regards the polar diameter, cross combinations 3x6, 3x7, 4x7, 4x5, 6x7 and 3x5 displayed the significant negative heterosis over commercial hybrid. However, these hybrids resulted in negative direction, which can be attributed due to high *per se* performance, significant gca effects of parents and significant sca effects of crosses. The superiority over commercial hybrid for polar diameter was noticed by Dhadde *et al.* (2009), Shalini (2009), Virupannavar (2009), Gul *et al.* (2010) and Hosamani (2010).

For number of locules per fruit, the cross combination 2x7 exhibited highest magnitude of significant negative heterosis over better parent and commercial hybrid. The superiority over better parent and commercial hybrid of the cross for number of locules per fruit can be attributed due to high *per se* performance of parents, significant gca effects of parents and significant sca effects of particular cross. The negative heterobeltiosis and standard heterosis were reported by Yashavanthakumar (2008), Dhadde *et al.* (2009), Shalini (2009), Virupannavar (2009) and Hosamani (2010).

The hybrid 2x7 recorded significant positive heterosis over better and top parent for pericarp thickness. The cross combination 2x7 resulted in positive direction, which can be attributed due to its significant sca effects of particular cross. These results were inconformity with Dhadde *et al.* (2009), Shalini (2009), Virupannavar (2009), Hosamani (2010) and Sekhar *et al.* (2010)

The highest significant positive heterosis over better and top parent for length of cluster was expressed in the hybrids 2x6 and 1x7. These hybrids expressed highest magnitude of significant heterosis for this trait in positive direction, which can be attributed due to its *per se* performance, significant positive gca effects of both the parents and significant sca effects of crosses.

As regards the average weight of cluster, cross combination 2x5 exhibited highest performance of significant positive heterosis over better and top parent. The cross expressed positive heterosis, which can be attributed due to better *per se* performance, significant positive sca effects of cross, which suggested that dominance variance was important for average weight of cluster.

For number of fruits per cluster, five (3x6, 1x2, 6x7, 3x4 and 3x7) and three (3x6, 3x4 and 3x7) hybrids expressed significant positive heterosis over better and top parent, respectively. Among these cross combinations, 3x6 recorded maximum positive heterosis. This can be attributed due to better *per se* performance and significant sca effects of particular cross. These findings were similar with the findings of Yashavantakumar (2008), Shalini (2009), Virupannavar (2009), Gul *et al.* (2010), Hosamani (2010) and Ahmed *et al.* (2011).

Regarding clusters per plant, two, two and sixteen hybrids exhibited significant positive heterosis over better, top parent and commercial hybrid, respectively. The highest percentage of positive heterosis was recorded by hybrid 3x6 over better parent, top parent and commercial hybrid. The parent one or two involved in these crosses were good combiner since those had exhibited significant gca effects. Thus, the high heterosis observed for this trait may be attributed due to dominance variance and heterosis breeding hold great promise for improving this trait in cherry tomato. Dharmatti (1995), Kulkarni (1999), Sajjan (2001), Kulkarni (2003), Duhan *et al.* (2005a), Yashavanthakumar (2008), Shalini (2009), Virupannavar (2009) and Sekhar *et al.* (2010) are in agreement with those findings.

As regards the number of seeds per fruit, cross combination 5x6 exhibited highest performance of significant negative heterosis over better and top parent. The cross 5x6 expressed negative heterosis, which can be attributed due to better *per se* performance, significant negative gca effects of both parents and significant sca effects of crosses, which suggested that dominance variance was important for number of seeds.

Five and two hybrids out of 21 hybrids recorded significant positive heterosis over better and top parent for shelf life. The cross combination 3x5 over better parent and 1x2 and 2x5 over top parent resulted in positive direction, which can be attributed due to its significant sca effects of particular cross. These results were inconformity with Prabhushankar (1990), Dundi (1991), Reddy and Reddy (1994), Premalakshmi *et al.* (2002), Saidi (2007) and Shalini (2009).

Eight and five hybrids exhibited positive heterosis over better and top parent for yield per plant and per hectare, respectively. The hybrids 2x6 followed by 1x3, 3x6, 1x4, 1x7, 1x6, 1x2 and 6x7 expressed significant positive heterosis over better parent, while, the hybrids *viz.,* 1x3, 2x6, 1x4, 1x7 and 6x7 showed significant heterosis over top parent in desirable direction. Heterosis over better and top parent in these hybrids can be attributed due to high *per se* performance, significant gca effects of either of or both the parents and significant sca effects of those crosses. These results are in agreement with the findings reported by Yashavantakumar (2008), Dhadde *et al.* (2009), Saleem *et al.* (2009), Shalini (2009), Virupannavar (2009), Gul *et al.* (2010), Hosamani (2010), Sekhar *et al.* (2010) and Ahmed et al. (2011). Yield is a complex character, evidences suggest that heterosis of such a compound character is much regulated by the vigour expressed by its component character (Sinha and Khanna, 1975), such as average fruit weight, clusters per plant and number of fruits per plant. In the present investigation the yield per plant increased mainly due to increase in average fruit weight and number of fruits per clusters and number of clusters per plant.

The hybrid 2x5 recorded highest significant positive heterosis over better, top parent and commercial hybrid for per cent juice content. The cross combination 2x5 resulted in positive direction, which can be attributed due to its significant sca effects of particular cross. These results were inconformity with Kulkarni (2006).

TSS is one of the most important quality parameter of cherry tomato. Three (4x5, 1x7 and 3x6) and one cross combination (3x6) exhibited significant positive heterosis over better and top parent for this trait, respectively. The cross expressed positive heterosis, which can be attributed due to better *per se* performance, and significant sca effects of crosses, which suggested that dominance variance was important for TSS. Similar findings were previously reported by Yashavantakumar (2008), Dhadde *et al.* (2009), Shalini (2009), Virupannavar (2009), Hosamani (2010) and Ahmed *et al.* (2011).

For acidity five, one and one hybrids expressed significant positive heterosis over better, top parent and commercial hybrid, respectively. This can be attributed due to better *per se* performance, significant positive gca effects of both the parents, significant sca effects of particular crosses. Similar results were found by research workers Duhan *et al.* (2005b), Kulkarni (2006), Kumar *et al.* (2006), Dhadde *et al.* (2009) and Shalini (2009).

Regarding ascorbic acid content, five, five and two hybrids exhibited significant positive heterosis over better, top parent and commercial hybrid, respectively. The highest percentage of positive heterosis was recorded by hybrid 3x5 over better parent, top parent and commercial hybrid. The parents one or two involved in these crosses were good combiner since those had exhibited significant gca effects. Thus, the high heterosis observed for this trait may be attributed due to dominance variance and heterosis breeding hold great promise for improving this trait in cherry tomato. These findings were in concurrence with those reported by Tendulkar (1994), Mahendrakar (2004), Duhan *et al.* (2005b), Kulkarni (2006), Kumar *et al.* (2006) and Shalini (2009).

As regards the total sugar, four cross combinations (1x2, 6x7, 4x5 and 2x7) exhibited performance of significant positive heterosis over better parent, which can be attributed due to better *per se* performance, significant positive gca effects of both the parents and significant sca effects of crosses, which suggested that dominance variance was important for total sugar. The heterosis over better parent has been observed for this character by Kulkarni (2006).

Three and one cross combinations exhibited significant positive heterosis over better and top parent for reducing sugar. The superiority over better parent and top parent of the crosses for this trait can be attributed due to high *per se* performance of parents and significant sca effects of particular cross. The positive heterobeltiosis was also reported by Kulkarni (2006).

The significant positive heterosis over better, top parent and commercial hybrid for lycopene content was expressed by four, two and eight cross combinations, respectively. The hybrids expressed significant heterosis for this trait in positive direction which can be attributed due to its *per se* performance and significant sca effects of crosses. Similar finding were reported by Kurian and Peter (2001) and Virupannavar (2009).

5.4 Combining ability

One of the major objectives in heterosis breeding is the selection of parents to be used in breeding programme and to identify suitable cross combinations that are likely to produce superior segregates or to release as a hybrid. Combining ability studies furnish useful information regarding the selection of suitable parents for effective hybridization and best cross combinations for exploitation of heterosis.

5.4.1 General combining ability

General combining ability for height of plant, parents EC 128618 and EC 128021 displayed significant positive gca effects. The results reported by Bhalekar (2003), Kulkarni (2003), Mahendrakar (2004), Prashanth (2004), Singh *et al.* (2005) and Premalakshmi *et al.* (2006) are in agreement with the above results.

The parents EC 128021, EC 128013, EC 163615 and EC 128618 exhibited significant negative gca effects for average weight of fruit. Bhalekar (2003), Kavitha *et al.* (2007), Singh *et al.* (2008), Yashavantakumar (2008) reported similar results.

The parent EC 128021, EC 128013 and EC 163615 showed significant negative gca effects for polar and equatorial diameter of fruit. These results are in conformity with Bhalekar (2003), Mahendrakar (2004), Singh *et al.* (2005).

For number of locules, parents CL 15-61-6-0-5 and EC 163615 displayed significant negative gca effects. The significant negative estimates for general combining ability were observed by Joshi *et al.* (2005), Joshi and Kohli (2006), Mahendrakar (2004) and Yashavantakumar (2008).

For pericarp thickness, the parents CL 15-61-6-0-5 and EC 128618 exhibited significant positive gca effects. Similar results were reported by Kulkarni (2003), Joshi *et al.* (2005), Thakur and Kohli (2005) and Mahendrakar (2004).

For length of cluster, parents EC 539 and CL 15-61-6-0-5 recorded positive significant gca effects, while the parents CL 15-61-6-0-5 followed by EC 539 and EC 885539 exhibited significant positive gca effects for average weight of cluster.

For number of fruits per cluster, parent EC 128021 displayed significant positive gca effects. These results are in conformity with those findings of Roopa *et al.* (2001) and Joshi *et al.* (2004).

The parents, EC 128021, EC 163615 and EC 128618 exhibited significant positive gca effects for number of clusters per plant. These results are in accordance with Tendulkar (1994). The parents, EC 128021, EC 885539 and EC 163615 showed significant negative gca effects for number of seeds per fruit. These results are in agreement with the findings of Hannan *et al.* (2007).

For shelf life, parents CL 15-61-6-0-5 and EC 539 displayed significant positive gca effects. The results reported by Joshi *et al.* (2005) and Thakur and Kohli (2005) are in agreement with the above results.

For fruit yield, parents EC 539 and EC 128618 displayed significant positive gca effects. These results are in conformity with those findings of Asati *et al.* (2007), Kavitha *et al.* (2007), Singh *et al.* (2008) and Yashavantakumar (2008).

For juice content, parents CL 15-61-6-0-5, EC 885539 and EC 128618 displayed significant positive gca effects. Significant positive estimates for general combining ability was observed by Kulkarni (2006).

The parents, CL 15-61-6-0-5, EC 163615, EC 128021 and EC 539 showed significant positive gca effects for TSS. Bhalekar (2003), Thakur and Kohli (2005), Joshi and Kohli (2006) and Mahendrakar (2004) depicted significant gca effects for this trait. The parent EC 163615 and CL 15-61-6-0-5 exhibited positive significant gca effects for acidity. Significant effects due to gca for acidity were observed by Bhatt *et al.* (2001), Bhalekar (2003), Kulkarni (2003), Mahendrakar (2004), Kulkarni (2006)

The parents, EC 128013, EC 128021 and EC 885539 exhibited significant positive gca effects for ascorbic acid. These results are in accordance with Joshi and Kohli (2006), Mahendrakar (2004) and Kulkarni (2006).

The parents EC 128021, EC 539, EC 163615 and EC 128618 showed significant positive gca effects for total sugar, while, the parent EC 128021, EC 539, EC 163615 and EC 128618 exhibited positive significant gca effects for reducing sugar. Kulkarni (2006) depicted significant gca effects for these trait.

The parent EC 128021, EC 163615 and EC 128013 showed significant positive gca effects for lycopene content. These results are in conformity with Mondal *et al.* (2009) and Virupannavar (2009). Significant positive gca effects were expressed by parents EC 885539, CL 15-61-6-0-5 and EC 128618 for ß-carotene content.

Most of the parents with high *per se* performance exhibited high gca effects indicating good correspondence between gca effects and *per se* performance for the characters studied.

5.4.2 Specific combining ability

Two cross combinations 4x7 and 3x5 has exhibited significant negative sca effects for days to 50 per cent flowering. These results are in conformity with Bhalekar (2003), Mahendrakar (2004).

For average weight of fruit, seven crosses *viz.,* 4x7, 3x5, 4x5, 6x7, 1x2, 3x7 and 2x6 exhibited significant negative sca effects. These combinations were derived from the parents having good x good, good x poor, good x poor, good x good, poor x poor, good x good, poor x good general combining ability. These results are in accordance with Saleem *et al.* (2009).

The significant negative sca effects for polar and equatorial diameter were recorded in four hybrids *viz.*, 3x5, 4x5, 4x7 and 6x7. These combinations were derived from either good x poor, good x poor, good x average, good x average general combiners. These results are in agreement with the findings Bhalekar (2003), Mahendrakar (2004) and Singh *et al.* (2005).

Two hybrids 2x5 and 2x7 exhibited significant negative sca effects for number of locules per fruit and significant positive sca effects for pericarp thickness. The cross combination 2x5 having parents of good x poor general combining ability displayed significant sca effects in favourable direction for these traits. Similar results were reported by Joshi *et al.* (2005) and Mahendrakar (2004). For length of cluster, two crosses, 2x6 and 1x7 recorded significant positive sca effects having parents of good x average, good x average general combining ability. While, significantly positive sca effects were recorded in the crosses 2x4, 1x3, 2x3, 2x5 and 5x7 for average weight of cluster. These combinations were derived from either good x poor, good x poor, good x poor, good x good, good x average general combiners.

Regarding the number of fruits per cluster, two crosses 1x2 and 4x5 recorded significantly positive sca effects derived from parents having average x average, average x poor general combining ability. Similar findings have been reported by Mahendrakar (2004) and Yashavantakumar (2008).

Five crosses 3x4, 2x6, 3x6, 1x2 and 6x7 expressed significantly positive sca effects for number of clusters per plant. The cross combinations derived from either poor x good, good x good, average x poor, good x good general combiners. Dharmatti (1995), Kulkarni (2003) and Yashavantakumar (2008) observed the similar results.

For number of seeds per fruit, four cross combinations 3x4, 5x6, 4x7 and 6x7 exhibited significantly negative sca effects having parents of good x poor, good x good, poor x average, good x average general combining ability, respectively. Hannan *et al.* (2007) noted similar observations in his studies.

For shelf life, the cross 2x5 recorded significant positive sca effects and derived from the parents having good x poor general combining ability. Saidi (2007) also reported positive significant sca effects for this character.

Five hybrids *viz.,* 2x6, 1x3, 1x4, 3x6 and 6x7 exhibited significantly positive sca effects for yield per plant and per hectare. These cross combinations derived from the parents having average x average, good x average, good x poor, average x average, average x good general combining ability. In this investigation, when majority of the characters are considered at a time for improvement of yield and quality, non-additive gene effect was more predominant than additive gene effects. Thus, heterosis breeding is most practicable approach for improvement of yield. These results are in agreement with Asati *et al.* (2007), Kavitha *et al.* (2007), Singh *et al.* (2008) and Yashavantakumar (2008).

Six crosses *viz.*, 2x6, 1x3, 5x7, 2x5, 1x4 and 1x2 recorded significant positive sca effects for the juice content. The crosses 2x6 and 1x3 derived from the parent of good x poor, average x poor general combining ability. Kulkarni (2006) depicted significant positive sca effects for these traits.

Ten hybrids *viz.*, 6x7, 3x6, 2x5, 1x7, 3x4, 3x5, 2x7, 2x4, 4x5 and 1x4 had recorded significantly positive sca effects for TSS. Highest significant positive sca effects exhibited by crosses 6x7 and 3x6 derived from parents of good x average, good x good general combining ability. These results are in conformity with Bhalekar (2003), Thakur and Kohli (2005), Joshi and Kohli (2006) and Mahendrakar (2004).

Regarding the acidity, significantly positive sca effects were recorded by eight crosses 2x7, 4x7, 1x4, 3x6, 1x3, 3x5, 4x5 and 2x5. The crosses 2x7 and 4x7 recorded highest significant sca effects having parents of good x poor, average x poor general combining ability. The results reported by Bhatt *et al.* (2001), Bhalekar (2003), Kulkarni (2003), Mahendrakar (2004) and Kulkarni (2006) are in agreement with the above results.

Significantly positive sca effects were noticed in seven crosses 5x6, 3x5, 2x4, 2x6, 1x4, 1x7 and 4x5 for ascorbic acid content. The cross 5x6 having parents of good x average general combining ability displayed the highest positive significant sca effects. Similar results were confirmed by Joshi and Kohli (2006), Mahendrakar (2004) and Kulkarni (2006).

Seven cross combinations *viz.,* 3x5, 4x5, 1x2, 6x7, 2x7, 2x4 and 3x7 showed significantly positive sca effects for total sugar content and five crosses *viz.,* 3x5, 6x7, 1x2, 4x5 and 1x7 expressed significantly positive sca effects for reducing sugar content. The crosses 3x5 and 6x7 having parents of good x poor, good x good general combiners for these traits. Kulkarni (2006) depicted significant positive sca effects for these traits.

Ten crosses *viz.*, 3x5, 1x5, 4x7, 1x2, 6x7, 3x6, 3x4, 2x5, 4x5 and 3x7 recorded significant positive sca effects for lycopene content. The cross combinations 3x5 and 1x5 possessing good x poor, average x poor general combining ability parents. These results are in accordance with those reported by Mondal *et al.* (2009) and Virupannavar (2009).

For ß-carotene content, the cross combinations 1x3, 5x6, 5x7 and 2x3 exhibited significant positive sca effects having parents of poor x poor, good x poor, good x good, good x poor general combining ability, respectively.

5.5 Performance of hybrids under growing conditions

Under the polyhouse condition, maximum plant height (401.33cm) was recorded by the hybrid 3x5. The greater plant height achieved could be due to stimulation of cellular expansion and cell division and the luxuriant growth of plants under polyhouse condition and might be due to prevalence of optimum heat units and protection from wind (Hellemans, 1998). The least days to 50 % flowering (49.00) was observed in the hybrid 3x5. This may be due to accumulation of maximum photosynthates by fast growth which triggered early initiation of flowers. Similar results were obtained by Rui *et al.* (1989) in capsicum. Similar results have been reported by Yama *et al.* (2006) and Chapagain *et al.* (2011) in tomato.

Under shade net house, lowest weight of fruit (7.30 g) and equatorial diameter (2.30 cm) by the hybrid 3x6 and lowest number of locules (2.00) recorded by the hybrid 6x7, maximum pericarp thickness (26.73 mm), length of cluster (15.10 cm), shelf life (12.50

days) and lowest number of seeds per fruit (18.53) was recorded by the check variety Suncherry Extra Sweet. While, maximum weight of cluster (71.87 g) and number of fruits per cluster (9.87) by the check Suncherry Extra Sweet (SES) and maximum yield per hectare (591.11 q) was recorded by the hybrid 2x6. This was supported by the findings of Gill and Gill (1995) reported that the growth of the plants were vigorous in shade net house and better exposure to optimum temperature which could have encouraged better fruit set. Further, the increased canopy growth of the plants raised under shade net house condition favoured the higher resource strength ultimately resulting with more photosynthetic activity and such photosynthesis might have partitioned effectively for better economic yield by increasing the number of fruits. The results are in accordance with the findings of Sun *et al.* (1990), who observed that the fruit setting rate in tomato decreased with increasing average maximum temperature. Similar to these finding was also supported by El-Aidy and Moustafa (1978), who inferred that the plants grown under shade tend to produce higher fruit yield than those in open field. The mean per cent fruit set over seasons, increased the fruit yield. Higher fruit set may be due to higher rate of anther dehiscence, higher pollen viability and pollen germination ability in PTR-1, PTR-4, PTR-6 and Arka Ashish as suggested by Banerjee and Kalloo (1991). Increased night temperature, decreases fruit set (Hood, 1962 and Rudich *et al.,* 1977) as observed in fruit set between the seasons. Cheema *et al.* (2004), Thangam and Thamburaj (2008) and Suchindra *et al.* (2012a) were also agreed with the above findings in tomato.

Under open field condition, lowest polar diameter (2.07 cm) was recorded by the hybrid 3x7, lowest number of locules (2.00) and highest number of clusters per plant (27.00) by the hybrid 6x7, highest yield per plant (1.52 kg) by the hybrid 2x6. This was supported by the findings of Cockshull and Ho (1995) reported that when tomato was grown under open condition, the single fruit weight and fruit number were affected by season largely through direct solar radiation on crop photosynthesis. Varietal difference in respect of fruit setting in *summer* tomato could be attributed due to variation of endogenous auxins before or after anthesis or response of varieties to application of hormone (Kuo *et al.,* 1989) in conjunction with physiological state of the tissues. Similar yield variation with regard to individual fruit weight and yield, among different *summer* tomato lines was reported by Patwary (2009). These results are in agreement with the findings reported by Londhe (2009) from MPKV., Rahuri in cherry tomato and Dar and Sharma (2011), Prema *et al.* (2011) and Jyothi *et al.* (2012) in tomato.

Regarding the quality parameters, maximum acidity (0.52 %), total (5.04 %) and reducing sugar (3.77 %) was recorded by the hybrid 3x5, ascorbic acid (43.67 mg/100g) by the hybrid 4x5, TSS (8.07 ^{0}B) by the check variety Suncherry Extra Sweet under open field condition. This was supported by the findings of Sinnadurai and Amuti (1970) who reported that the light increases the total soluble solid content of tomato. Hamner and Maynard (1992) inferred that the tomato fruits harvested from plants grown in full light contained more acidity and ascorbic acid than the fruits from shaded plants. The highest juice (71.40 %) by the hybrid 2x6 and maximum ß-carotene (22.17 µg/g) content was recorded by the check variety

Suncherry Extra Sweet under polyhouse condition. Maximum lycopene content (5.90 µg/g) was noticed in the hybrid 6x7 under shade net house. Goodwin and Jamikorn (1952) reported that in normal red tomato lycopene synthesis was inhibited at temperature above 30°C. Davies and Hobson (1981) also opined that tomato fruit colour was considerably affected by environmental conditions prevailing at the time of fruit development. Difference in pericarp thickness indicates that the hybrids might have differential keeping quality after harvest since tomato fruit with high pericarp thickness is associated with higher shelf life (Thakur and Kohli, 2005). These results were inconformity with Londhe (2009) in cherry tomato and Suchindra *et al.* (2012b) in tomato.

The less incidence of mites per leaf (1.30) was recorded in hybrid 3x7, while, the check variety Suncherry Extra Sweet under polyhouse condition showed least incidence of thrips per leaf (0.90), whitefly (0.63) and leaf curl virus (4.55 %). The incidence of pests and diseases was also studied by Nagendraprasad (2001) under greenhouse and open condition in capsicum. He noticed that the pests and diseases under greenhouse was comparatively lower (5% and 10%, respectively) as compared to open field condition (35% and 45%, respectively). Similar finding were reported by Cebolla-Cornejo *et al.* (2011) in tomato.

5.6 Stability analysis

There is considerable variation in cherry tomato in respect of quantitative and qualitative characters. The main objective of the present investigation was to identify various yield attributing traits for the ideal cherry type to increasing the fruit yield in cherry tomato. By studying the mean performance and heterosis studies, it is possible to identify the superior hybrids with respect to various yield and quality traits but their stability over the growing conditions with respect to yield and quality attributing characters is also important. Therefore stability analysis was done to identify the stable hybrids for yield and quality characters.

5.6.1 Stability for yield and quality parameters

Finlay and Wilkinson (1963) considered linear regression slope (bi) and emphasized the need of both 'bi' and deviation from regression 'S^2di' as measure of stability. Further Eberhart and Russell (1966) showed the need of both regression coefficient (linear) (bi) and deviation from regression (S^2di) (non linear) in evaluating genotypes for phenotypic stability by measuring G x E interactions.

The estimates of environmental indices showed that environment E_1 (Polyhouse) was favourable for plant height, days to 50 % flowering, pericarp thickness, length of cluster and average weight of cluster (g). The environment E_2 (Shade net house) was favourable for fruits per cluster, shelf life, yield per hectare, juice and lycopene content. The environment E_3 (Open field) was favourable for average fruit weight, polar and equatorial diameter, number of locules, clusters per plant, seeds per fruit, yield per plant, TSS, acidity, ascorbic acid, total and reducing sugar and β-carotene.

Overall, environment E_2 was most favourable for yield, while, environment E_3 was most favourable for quality characters.

5.6.1.1 Days to 50 % flowering

The hybrids 3x5 and Suncherry Extra Sweet showed better adaptability to all three environments as far as days to 50 per cent flowering is concerned, as indicated by stability parameters. The hybrid 3x6 exhibited regression value lesser than unity had above average stability. Similar finding were reported by Patil (1994) and Aravindkumar (2001) in tomato at UAS, Dharwad.

5.6.1.2 Average fruit weight (g)

The hybrids 3x7 and 6x7 showed average stability for average weight of fruit as exhibited lower mean values for with non significant regression value and non significant deviation from regression. The hybrid 3x5 had regression coefficient value significantly higher than unity indicating their average stability over favourable environment. Such kinds of results were obtained by Pandey (1983), Kalloo *et al.* (1998), Aravindkumar (2001) and Mane (2010) in tomato.

5.6.1.3 Average weight of cluster (g)

The hybrid 2x6 and Suncherry Extra Sweet exhibited regression value lesser than unity and had above average stability. The hybrids 1x3 and 4x5 had significant regression coefficient.

5.6.1.4 Number of fruits per cluster

Two hybrids 2x6 and 3x7 and check variety Suncherry Extra Sweet had non-significant regression value and deviation from regression with high mean indicated that there was more genotype x environment interaction present. The hybrid 4x5 was found unstable over all three growing conditions as the hybrid showed significant deviation from regression. Shalini (2009) and Hosamani (2010) also reported similar results in tomato.

5.6.1.5 Number of clusters per plant

Number of clusters per plant expressed highly significant positive correlation with total yield per plant in all the growing conditions both at phenotypic and genotypic levels. The hybrid 1x3 had high mean value for number of clusters per plant with non significant regression value and non significant deviation from regression. This suggested that this hybrid is well adapted to all the three growing conditions for this trait. The hybrid 2x6 had regression coefficient value significantly higher than unity indicating their average stability over favourable environment. Similar findings were reported by Shalini (2009) in tomato. The results suggest that, high number of clusters per plant can advantageously be used as criterion for selection.

5.6.1.6 Number of seeds per fruit

The hybrid 3x5 was found to be widely adapted to all the three locations as concerned number of seeds per fruit as the hybrid had non-significant regression coefficient and deviation from regression with low mean values. The hybrid 2x6 showed instability over all the three locations as it showed significant deviation from regression.

5.6.1.7 Shelf life (days)

The hybrid 2x6 had high mean values for shelf life with non significant regression value and non significant deviation from regression. This suggested that the hybrid is well adapted to all the three locations for this trait. Significant deviation from regression observed for the hybrids 3x5, 3x7 and 6x7 were instable over all three environments. Similar trend was observed for this trait by Shalini (2009) in tomato.

5.6.1.8 Yield per plant (kg)

The hybrids 1x3, 3x6, 6x7 and Suncherry Extra Sweet had high mean values for yield per plant with non significant regression value and non significant deviation from regression. This suggested that these hybrids are well adapted to all the three growing conditions for this trait. The hybrid 4x5 had significant deviation from regression suggesting this hybrid had unpredictable performance across the environments. Varied response of tomato genotypes to different environments in case of yield per plant was also observed by Kalloo and Pandey (1979), Kumarswamy and Madalagiri (1989), Kalloo *et al.* (1998), Aravindkumar (2001), Hosamani *et al.* (2003), Shalini (2009), Hosamani (2010) and Mane (2010) in tomato.

5.6.1.9 TSS (^{0}B)

The hybrid 6x7 and check variety Suncherry Extra Sweet had higher mean value and regression coefficient near to unity with non-significant S^2di values indicates that these hybrids were stable over the growing conditions. The hybrid 1x3 showed significant deviation from the regression coefficient indicating the instability of the hybrid over all growing conditions. These findings are in agreement with Ashwini (2005), Kulkarni (2006) and Revanasiddappa (2008) in tomato.

5.6.1.10 Acidity (%)

The hybrid 4x5 exhibited regression value lesser than unity which indicating that the hybrid had above average stability and can be well adopted under poor environment. The hybrids 1x3, 2x6, 3x5, 3x6 and Suncherry Extra Sweet showed significant deviation from the regression coefficient. This indicates that these hybrids were showing instability for this trait. Above findings are in confirmation with those findings of Mane (2010) in tomato.

5.6.1.11 Ascorbic acid (mg/100g)

The hybrids 3x5 and 3x6 had high mean value for ascorbic acid with non significant regression value and non significant deviation from regression. This suggested that these hybrids were well adapted to all the three growing conditions for this trait. The hybrids 2x6, 3x7 and 4x5 showed significant values of deviation variance from regression indicating instability of the hybrids for ascorbic acid content. These findings are in agreement with Prashanth (2003), Kulkarni (2006) and Revanasiddappa (2008) in tomato.

5.6.1.12 Total sugar (%)

The hybrid 4x5 shows average stability for total sugar as exhibits high mean value with non significant regression value and non significant deviation from regression. The hybrids 1x3, 3x5 and

3x7 shows instability for total sugar content as exhibited significant deviation from regression.

5.6.1.13 Reducing sugar (%)

The hybrid 4x5 displayed high mean value with non significant regression value and non significant deviation from regression for shows reducing sugar indicated that their stability across the growing conditions. The hybrids 1x3, 3x5 3x7 and Suncherry Extra Sweet exhibited significant deviation from regression thus indicating instability for this trait.

5.6.1.14 Lycopene (μg/g)

The hybrid 3x5 was well adapted to all the three growing conditions as far as lycopene is concerned, as indicated by stability parameters. The hybrids 3x6 and 3x7 had regression coefficient value significantly higher than unity indicating their average stability over favourable environment. Similar findings were reported by Mane (2010) in tomato.

5.6.1.15 ß-carotene (μg/g)

The hybrid 2x6 and Suncherry Extra Sweet had higher mean value and regression coefficient near to unity with non-significant deviation from regression indicates that these hybrids were stable over the growing conditions. The hybrids 1x3, 3x5, 3x7 and 4x5 possessed significant deviation from regression indicating instability for the ß-carotene content.

6. SUMMARY AND CONCLUSIONS

The present investigation, "Heterosis, combining ability and evaluation of F_1 hybrids of cherry tomato under different growing conditions" was undertaken to develop the cherry tomato hybrids having cherry size with good yield, quality characters and stability under different growing conditions.

The studies involved seven diverse genotypes and their 21 F_1s obtained by diallel mating system without reciprocals during *rabi*, 2010-11. The parents along with their F_1s were evaluated during *kharif*, 2011 in randomized block design with three replications.

The data was recorded for 31 quantitative, qualitative characters and disease and pest reaction *viz.,* growth habit, fruit colour, fruit shape, plant height (cm), days to 50 % flowering, average fruit weight (g), polar and equatorial diameter (cm), number of locules, pericarp thickness (mm), length of cluster (cm), average weight of cluster (g), fruits per cluster, clusters per plant, seeds per fruit, shelf life (days), yield per plant (kg) and per hectare (q), juice (%), TSS (^{0}B), acidity (%), ascorbic acid (mg/100g), total and reducing sugar (%), lycopene (μg/g), β-carotene (μg/g), thrips per leaf, whitefly per leaf, mites per leaf and incidence of leaf curl and spotted wilt virus disease (%).

On the basis heterosis over better parent for yield and quality characters seven promising crosses *viz.,* 1x3, 2x6, 3x5, 3x6, 3x7, 4x5 and 6x7 were selected and evaluated with one commercial hybrid under different growing conditions *viz.,* polyhouse, shade net house and open field during *summer*, 2011-12. The data were recorded on five plants each for different characters.

The promising hybrids were also tested for stability parameters over three growing conditions (environments).

6.1 Summary

6.1.1 Mean performance

Regarding the mean performance of parents, EC 163615 recorded maximum acidity (0.49 %), while, EC 128021 recorded lowest fruit weight (7.10 g) and maximum fruits per cluster (5.60) and lycopene (4.27 µg/g), EC 539 recorded highest length of cluster (8.08 cm), CL 15-61-6-0-5 recorded highest cluster weight (49.40 g), shelf life (10.10 days) and TSS (5.46 ^{0}B), EC 128618 recorded highest clusters per plant (29.80), yield per plant and per hectare (1.26 kg, 464.81 q, respectively). Less incidence of white fly per leaf (0.80) recorded by the parent CL 15-61-6-0-5, whereas, spotted wilt (4.55 %) by EC 128618, white fly (0.70) and mites (0.37) per leaf by EC 885539, thrips per leaf (1.06) and leaf curl (6.82 %) by parent EC 163615.

Hybrid 3x6 recorded maximum fruits per cluster (7.00), clusters per plant (36.60), TSS (5.96 ^{0}B), acidity (0.56 %) and lycopene (4.83 µg/g), whereas, highest length of cluster (9.37 cm) by 2x6, maximum reducing sugar (2.63 %) by 6x7, highest ascorbic acid (50.16 mg/100g) by 3x5. Less incidence of white fly per leaf (0.23) and spotted wilt (2.27 %) recorded by the hybrid 2x6, thrips per leaf (1.34) by 2x7, mites per leaf (0.28) by 3x6, whereas, leaf curl (5.69 %) and spotted wilt (2.27 %) disease by 1x6.

6.1.2 Heterosis

The mean performance of parents and hybrids for different characters in cherry tomato were found to be significant. Presence of considerable heterosis was noticed in all the characters studied.

Significantly highest positive heterosis was recorded for height of plant by the hybrid 4x6 (24.74 %) over better parent, pericarp thickness by 2x7 (19.19 %) over better and top parent, length of cluster by 2x6 (23.13 %, 15.97 %) over better and top parent, respectively, average weight of cluster by 2x5 (32.59 %) over better parent and top parent, number of fruits per cluster by 3x6 (25.00 %) over better and top parent, number of clusters per plant by 3x6 (24.91 %, 22.82 %, 101.10 %) over better, top parent and commercial hybrid, respectively, shelf life by 3x5 (27.14 %) over better parent and 1x2 and 2x5 (17.82 %) over top parent, fruit yield by 2x6 (46.52 %) and 1x3 (38.25 %) over better and top parent, respectively, TSS by 4x5 (17.68 %) and 3x6 (9.26 %) over better parent and top parent, respectively, acidity by 1x4 and 4x7 (16.67 %) over better parent and 3x6 (14.43 %, 13.27 %) over top parent and commercial hybrid, respectively, ascorbic acid content by 3x5 (19.30 %, 18.04 %, 11.38 %) over better, top parent and commercial hybrid, respectively, total sugar by 1x2 (13.19 %) over better parent, reducing sugar by 1x2 (12.93 %) and 6x7 (7.01 %) over better and top parent, respectively, juice per cent by 2x5 (8.47 %, 8.47 %, 5.54 %) over better parent, top parent and commercial hybrid, respectively, lycopene content by 4x7 (14.75 %) over better parent and 3x6 (11.74 %, 37.90 %) over top parent and commercial hybrid, respectively.

Significantly highest negative heterosis was recorded for days to 50 % flowering by the hybrid 4x7 (-15.45 %, -13.33 %) over better and top parent, respectively, average weight of fruit by 4x7 (-31.71 %) over commercial hybrid, polar diameter by 3x6 (-19.96 %) over commercial hybrid, number of locules by 2x7 (-10.87 %) over better parent and commercial hybrid, seeds per fruit by 5x6 (-30.94 %) over better and top parent.

6.1.3 Combining ability

Significant gca and sca variances were observed for all the characters. None of the parent was found good general combiner for all the characters studied.

6.1.3.1 General combining ability effects

The data pertaining to the gca indicated that most of the parents possessed good general combining ability effect for most of the traits.

The parent EC 539 recorded significant positive gca effects for length of fruit cluster, average weight of cluster, shelf life, yield per plant and per hectare, TSS, total sugar and reducing sugar. The parent CL 15-61-6-0-5 exhibited significant positive gca effects for pericarp thickness, length of fruit cluster, average weight of cluster, shelf life, juice, TSS, acidity and ß-carotene content and significant negative gca effects for number of locules.

For the height of plant, number of fruits per cluster, number of clusters per plant, TSS, ascorbic acid, total sugar, reducing sugar, lycopene content the parent EC 128021 displayed significant positive gca effects. Moreover, this parent showed significant negative gca effects for average weight of fruit, polar diameter, equatorial diameter and number of seeds per fruit.

The parent EC 128013 recorded significant positive gca effects for ascorbic acid and lycopene content, while significant negative gca effects for average weight of fruit, polar diameter and equatorial diameter.

The parent EC 885539 recorded significant positive gca effects for average weight of cluster, juice, ascorbic acid and ß-carotene content and significant negative gca effects for number of seeds per fruit.

The parent EC 163615 displayed significant positive gca effects for number of clusters per plant, TSS, acidity, total sugar, reducing sugar and lycopene content and significant negative gca effects for average weight of fruit, polar diameter, equatorial diameter, number of locules and number of seeds per fruit.

The parents EC 128618 exhibited significant positive gca effects for height of plant, pericarp thickness, number of clusters per plant, yield per plant and per hectare, juice, total sugar, reducing sugar and ß-carotene content and significant negative gca effects for average weight of fruit.

6.1.3.2 Specific combining ability effects

The data pertaining to the sca indicated that most of the crosses possessed good specific combining ability effects for most of the traits in favourable direction.

The highest significant negative sca effects was recorded for days to 50 % flowering and average weight of fruit by the cross 4x7, similarly for polar and equatorial diameter by the crosses 4x5 and 3x5, respectively, while, for number of locules per fruit the cross 2x5 and for seeds per fruit the cross 3x4 recorded significant negative sca effects.

The highest significant positive sca effects was recorded for pericarp thickness by the cross 2x5 and length of cluster by the hybrid 2x6, similarly for average weight of cluster by the cross 2x4, fruits per cluster by cross 1x2 and clusters per plant by the cross 3x4, while, for shelf life the cross 2x5 and yield per plant and per hectare the hybrid 2x6 recorded significant positive sca effects.

Regarding the quality parameters, highest and significant positive sca effects for TSS recorded by the cross combination 6x7, similarly for acidity by the cross 2x7, ascorbic acid by the cross 5x6, total and reducing sugar content by the hybrid 3x5 and juice content by the cross 2x6, while, for lycopene the hybrid 3x5 and ß-carotene content the hybrid 1x3 recorded significant positive sca effects.

In general, the hybrids involving the parents with good *per se* performance and high gca effects in desired direction exhibited high heterosis. However, in some cases, the average or poor performing parents with low or negative gca effects also produced significant heterosis over better parent indicating the predominant role of non-additive gene action. The variances due to gca and sca were highly significant for all the characters studied. In most of cases the high heterosis observed was due to the better *per se* performance of parents with good sca effects. The high genetic diversity also might have played the important role.

6.1.4 Performance of hybrids under growing conditions

Under polyhouse condition, significantly highest plant height (401.33cm) and least days to 50 % flowering (49.00) was recorded by the hybrid 3x5, lowest weight of fruit (7.30 g) and equatorial diameter (2.30 cm) by the hybrid 3x6 and lowest number of locules (2.00) by the hybrid 6x7, least incidence of mites per leaf (1.30) by the hybrid 3x7, highest juice per cent (71.40 %) by the hybrid 2x6, maximum pericarp thickness (26.73 mm), length of fruit cluster (15.10 cm), lowest number of seeds per fruit (18.53), shelf life (12.50 days), ß-carotene (22.17 µg/g) content, less incidence of thrips (0.90), whitefly per leaf (0.63) and leaf curl virus (4.55 %) was recorded by the check variety Suncherry Extra Sweet.

Maximum yield per hectare (591.11 q) by the hybrid 2x6, weight of cluster (71.87 g) and number of fruits per cluster (9.87) was recorded by the check variety Suncherry Extra Sweet, lycopene content (5.90 µg/g) by the hybrid 6x7 was recorded under shade net house.

Under open field condition, lowest polar diameter (2.07 cm) was noticed in the hybrid 3x7, lowest number of locules (2.00) and highest clusters per plant (27.00) in the hybrid 6x7, maximum yield per plant (1.52 kg) in the hybrid 2x6, TSS (8.04 ^{0}B) in Suncherry Extra Sweet, highest acidity (0.52 %) in the hybrid 3x5, ascorbic acid (43.67 mg/100g) in the hybrid 4x5, total sugar (5.04 %) and reducing sugar (3.77 %) in the hybrid 3x5.

6.1.5 Stability analysis

Analysis of variance revealed significant differences among the hybrids at all the three growing conditions indicating a high degree of variability among the hybrids tested. Pooled analysis of variance revealed significant differences among the hybrids for all the characters, indicating diverse nature of hybrids. Significant differences among the environments for most of the characters indicated that environments are diverse in nature. Similarly, genotype x environment interaction was significant for most of the characters *viz.,* days to 50 % flowering, average fruit weight, average weight of cluster, number of fruits per cluster, number of clusters per plant, number of seeds per fruit, shelf life, yield per plant, total soluble solids, acidity, ascorbic acid content, total sugar, reducing sugar, lycopene and ß-carotene content suggesting that genotype interacted significantly with the environments.

The estimates of environmental indices indicated that environment E_1 (Polyhouse) was favourable for plant height, days to 50 % flowering, pericarp thickness. The environment E_2 (Shade net house) was most favourable for fruits per cluster and fruit yield while, environment E_3 (Open field) was most favourable for quality characters viz., TSS, acidity, ascorbic acid, total and reducing sugar and β-carotene.

On the basis of stability parameters it was revealed that the five hybrids *viz.,* 1x3, 6x7, 3x6, 2x6 and 3x5 were most stable for majority of characters over all three growing conditions. The hybrids 3x5 and check variety Suncherry Extra Sweet for days to 50 % flowering, 3x7 and 6x7 for average weight of fruit, 2x6 for Average weight of cluster, 2x6, 3x7 and Suncherry Extra Sweet for number of fruits per cluster, 1x3 for number of clusters per plant, 3x5 for number of seeds per fruit, 2x6 for shelf life, 1x3, 3x6, 6x7 and check variety Suncherry Extra Sweet for yield per plant were found most stable over all growing conditions (environments). Regarding the quality parameters, the hybrids 6x7 and Suncherry Extra Sweet for total soluble solids, 4x5 for acidity, 3x5 and 3x6 for ascorbic acid, 4x5 for total sugar and reducing sugar, 3x5 for lycopene and 2x6 and Suncherry Extra Sweet for ß-carotene content were noticed most stable hybrids over the growing conditions.

6.2 Conclusions

1. Significant heterosis for yield, quality and small fruit size was recorded for fruits per cluster, clusters per plant and lycopene by the cross combination EC 128021 x EC 163615, for fruits per cluster, fruit yield, reducing sugars by EC 163615 x EC 128618, for fruit yield and acidity by EC 539 x EC 128021, for length of cluster, fruit yield and juice by CL 15-61-6-0-5 x EC 163615, for shelf life, acidity and ascorbic acid by EC 128021 x EC 885539, for TSS and total sugars by EC 128013 x EC 885539, for fruits per cluster by EC 128021 x EC 128618.

2. The parent EC 128021 was observed as good general combiner for fruits per cluster, clusters per plant, TSS and ascorbic acid and fruit weight. EC 163615 for clusters per plant, TSS, acidity and lycopene. EC 128618 for clusters per plant, fruit yield, juice and ß-carotene. EC 539 for cluster weight, shelf life, fruit yield and TSS.

3. The cross combination EC 163615 x EC 128618 was recorded significant sca effects fruit weight, clusters per plant, yield per plant and TSS, similarly, EC 128013 x EC 885539 for fruit weight, fruits per cluster, TSS, acidity and ascorbic acid, EC 128021 x EC 885539 for fruit weight, total and reducing sugars and lycopene, CL 15-61-6-0-5 x EC 163615 for fruit weight, cluster length, clusters per plant, fruit yield per plant and juice, EC 128021 x EC 163615 for clusters per plant, yield per plant, TSS and acidity, EC 539 x EC 128021 for cluster weight, yield per plant and β-carotene.

4. Under polyhouse condition, the hybrid EC 128021 x EC 885539 found best for days to 50 % flowering and mites per leaf, EC 128021 x EC 128618 for ascorbic acid and mites per leaf, CL 15-61-6-0-5 x EC 163615 for fruit yield, juice and thrips and white fly per leaf.

5. Under shade net house condition, the hybrid EC 128021 x EC 128618 found best for reducing sugar, white fly and mites per leaf, CL 15-61-6-0-5 x EC 163615 for fruit yield, white fly per leaf and leaf curl, EC 128021 x EC 163615 for fruit weight, cluster per plant and mites per leaf.

6. The hybrid EC 163615 x EC 128618 found better for clusters per plant and thrips per leaf, CL 15-61-6-0-5 x EC 163615 for fruit yield, thrips, white fly and mites per leaf, EC 128021 x EC 163615 for fruit weight and white fly per leaf, EC 128021 x EC 885539 for acidity under open field condition.

7. On the basis of stability parameters, the hybrids *viz.,* EC 163615 x EC 128618, EC 128021 x EC 163615, EC 539 x EC 128021 and CL 15-61-6-0-5 x EC 163615 were found as stable for yield and majority of characters over all the three growing conditions.

Future line of work

1. The crosses *viz.,* EC 539 x EC 128021 (41.06 %) and EC 128021 x EC 163615 (38.32 %) and EC 163615 x EC 128618 (16.33 %) recorded high heterosis, similarly, these crosses are also found stable for yield, which can be exploited as a commercial hybrids in cherry tomato by confirming the results by further evaluation.

2. The parents EC 539, EC 128021, EC 163615 and EC 128618 were observed good general combiners for most of the characters, which can be used in future breeding programme.

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*Originals not seen

8. APPENDICES

Appendix I

Morphological characters of parents and their hybrids

Sr. No.	Parents / Hybrids	Plant growth habit	Fruit colour	Shape of fruit
Parents				
1	EC 539	Indeterminate	Dark red	Slightly flattened
2	CL 15-61-6-0-5	Indeterminate	Dark red	Round
3	EC 128021	Indeterminate	Dark red	Round
4	EC 128013	Indeterminate	Dark red	Slightly flattened
5	EC 885539	Indeterminate	Orange red	Round
6	EC 163615	Indeterminate	Dark red	Round
7	EC 128618	Indeterminate	Light red	Round
Hybrids				
1	1 x 2	Indeterminate	Dark red	Round
2	1 x 3	Indeterminate	Dark red	Round
3	1 x 4	Indeterminate	Dark red	Flattened
4	1 x 5	Indeterminate	Dark red	Slightly flattened
5	1 x 6	Indeterminate	Orange red	Round
6	1 x 7	Indeterminate	Dark red	Round
7	2 x 3	Indeterminate	Dark red	Round
8	2 x 4	Indeterminate	Dark red	Round
9	2 x 5	Indeterminate	Orange red	Round
10	2 x 6	Indeterminate	Light red	Round
11	2 x 7	Indeterminate	Dark red	Round
12	3 x 4	Indeterminate	Dark red	Slightly flattened
13	3 x 5	Indeterminate	Dark red	Round
14	3 x 6	Indeterminate	Dark red	Round
15	3 x 7	Indeterminate	Light red	Round
16	4 x 5	Indeterminate	Orange red	Round
17	4 x 6	Indeterminate	Dark red	Oblate
18	4 x 7	Indeterminate	Light red	Slightly flattened
19	5 x 6	Indeterminate	Light red	Round
20	5 x 7	Indeterminate	Orange red	Round
21	6 x 7	Indeterminate	Dark red	Round

Appendix II

Monthly weather data recorded during experimental period from January 2012 to July 2012

Month	Polyhouse				Shade net house				Open field				Rain fall (mm)
	Temp (^{o}C)		RH (%)		Temp (^{o}C)		RH (%)		Temp (^{o}C)		RH (%)		
	Max	Min	Morn	Even	Max	Min	Morn	Even	Max	Min	Morn	Even	
Jan	32.15	13.61	64.26	32.26	30.28	11.72	61.94	31.35	29.02	10.77	60.94	27.90	0.00
Feb	35.27	14.73	58.55	26.55	33.55	13.47	55.93	23.69	32.21	12.22	53.34	20.72	0.00
Mar	38.06	16.27	46.87	20.97	36.62	14.85	44.06	17.81	35.50	13.58	42.61	14.32	0.00
April	42.09	23.57	46.37	21.27	39.34	21.23	45.57	19.00	38.08	20.46	44.20	17.87	7.40
May	42.66	23.03	49.16	21.48	40.17	21.65	48.06	20.65	38.83	20.91	49.23	18.97	17.40
June	38.14	25.39	62.10	41.77	36.38	24.46	64.17	37.90	35.69	23.77	61.03	35.93	29.40
July	33.30	24.77	76.90	60.81	32.08	23.94	78.58	63.26	31.43	23.38	74.39	58.32	60.60

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9. VITA

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A candidate for the degree

of

DOCTOR OF PHILOSOPHY (AGRICULTURE)

in

(HORTICULTURE) VEGETABLE SCIENCE

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Biographical information

Personal : Born at Junnar, Dist- Pune on 19th September, 1977. Son of Mr. Kisan Dadabhau Marbhal

Educational :

- Passed SSC examination from Annasaheb Awate Vidyamandir, Junnar in 1993.
- Passed HSC examination from Shri Shiv Chattrapati College, Junnar in 1995.
- Received Bachelor of Science (Hort.) degree from College of Agriculture, Pune (MPKV., Rahuri) in first class during 1999.
- Received Master of Science (Agri.) degree in Horticulture from Post Graduate Institute, MPKV., Rahuri in first class during 2002.

Academic performance :

- Successfully cleared the ICAR's All India examination, ICAR-JRF in 1999.
- Successfully cleared the NET examination (Discipline–Vegetable Science) in 2008.

Professional :

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- At present working as Officer Incharge (Asstt. Prof. of Hort.), Pomegranate Research and Technology Transfer Centre, MPKV., Lakhmapur, Tal. Baglan, Dist. Nashik

Publications :

- Associated in the development of garlic var. Phule Baswant.
- Associated in 3 research recommendations.
- Published 12 research papers in recognized journals and 15 popular articles in different magazines.
- Delivered 8 Radio talks at Akashwani Nashik

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