

HETEROSIS AND COMBINING ABILITY STUDIES IN
TOMATO (*Solanum lycopersicum* L.)

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JUNE, 2014

HETEROSIS AND COMBINING ABILITY STUDIES IN
TOMATO (*Solanum lycopersicum* L.)

Thesis submitted to the

University of Horticultural Sciences, Bagalkot

in fulfillment of the requirements for the

Degree of

MASTER OF SCIENCE (HORTICULTURE)

in

VEGETABLE SCIENCE

By

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CERTIFICATE

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

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ACKNOWLEDGEMENT

With feelings of satisfaction, I take this opportunity to share some of the moments associated with my research work and preparation of this thesis.

I would like to express my sincere and heartfelt gratitude to Mr. V. D. GASTI Associate Professor, Department of Vegetable Science, Kittur Rani Channamma College of Horticulture, Arabhavi, the esteemed chairman of my advisory committee, for his constant encouragement, decisions, inspiring guidance, unique and compassionate steering of the challenging task and affection showing throughout the course of my study and research.

I consider myself fortunate to have eminent personalities like Dr. SHANTAPPA TIRAKANNANAVAR, Professor of Seed Technology, Department of CIB, College of Horticulture, Sirsi, Dr. SHANKARAPPA K. S., Assistant Professor of Horticultural Plant Pathology, Mr. VIJAYAKUMAR RATHOD, Assistant Professor, Department of Vegetable Science, for serving as members of my advisory committee and for providing valuable suggestions and facilities for my research work during the course of my study.

I owe my special thanks to Mr. Shellikeri, former messenger, Mr. Appalal, K. Lab Assistant and other farm labours, Department of Vegetable Science, all teachers and staff members of Kittur Rani Channamma College of Horticulture, Arabhavi for their utmost help and cooperation and their wishes and encouragement.

Colourful blossoms would not have bloomed without the company of my lovely juniors, senior and friends Nagesh, G. C., Umesh S., Parashuram, G., Mahaveer, Ramesh, Sunil, Muthya, Santush, Siddappa, S., Parmmappa, K., Pradipika, C., Prajna, Udachappa, Sridhar, P., Shafeeque, B., Anand N., Honnappa, A., Ravindar, C., Chandan, Sachin, H., Mahesh K., Shivanand, Ramdas, Rahul, Praveen, A., Prashant, P., Shabrish, R., Kavy, Savitha, Pooja H., Deepika, Vidya K., Vittal M., Shivananda K., Siddappa B., Sudakar T., Aravind, Santhosh C., Srikanth R., Shivanand, Rahul P., Ravi. Suresh C., Shivaya M., Abyakumar G., Jalyanth S., Shivaling P., Vinod, B., Giriraj, K., Gururaj K., Ajit, Anand, Chandru, Abhijeet, Tyagaraj, Kiran, K., Vijay, K., Vijit, H., Ravi, Harshvarghangouda, Surykanth, Shivakumar, Thoufeeque, Shivaling, Shashidhare D., Jaishankar, Erigegouda, Kishore, Sadanand H., Mahantesh Y., Ninganagouda P., Arunkumar H., Jeetendra C., Manjunath H., Ranganath G. K., Shivaraj G. all UG and PG friends for their help and suggestions during my study.

The presentation that follows is the work assisted by many seen and unseen hands and minds, I am thankful to all of them.

I acknowledged National Bureau of Plant Genetic Resources (NBPGR) New Delhi and Indian Institute of Vegetable Research (IIVR) Varanasi for supplying seeds for my research work.

ARABHAVI
JUNE, 2014

(BASAVARAJ L. BOMMANAHALLI)

Affectionately

Dedicated to

My beloved parents, brothers,

Sisters and TEACHERS

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LIST OF ABBREVIATIONS

cm	Centimeter
mm	Millimeter
g	Gram
kg	Kilogram
DAS	Days After Transplanting
FYM	Farmyard Manure

1. INTRODUCTION

Tomato (*Solanum lycopersicum* L.) belonging to the family *Solanaceae* with the chromosome number of $2n = 24$. Tomato was once considered poisonous and inedible. It has now become one of the most popular and extensively consumed vegetable. It ranks second only after potato in production. Peru Ecuador region is considered to be the center of origin. Tomato is presumed to have been brought to India during the second half of the 16th century through far eastern countries. In nineteenth century plant explorers in India noted the tomato plant to be very common, highly variable and growing as a cultivated crop as well as an escape. These materials formed the base of the first indigenous selections released as improved cultivars in the middle of the 20th century. From 1950 onwards major boost to tomato cultivation was provided by the introduction of high-yielding exotic cultivars like Sioux, Roma and Marglobe in the country. Over the years, indigenous high-yielding cultivars have been bred from the old local cultivars, early introductions and more significantly, the newly introduced cultivars and breeding lines. Majority of these new and popular cultivars have come from three breeding centers namely Indian Agricultural Research Institute, New Delhi (Pusa cultivars), Punjab Agricultural University, Ludhiana (Punjab cultivars) in north India and Indian Institute of Horticultural Research, Bengaluru (Arka cultivars) in south India. It stands unique among vegetables because of its high nutritive values and myriad uses.

Tomatoes are being used as raw vegetable in sandwiches, salads and as processed products like paste, puree, soup, sauce, juice, ketchup, whole canned fruit and drinks (Bose *et al.*, 2002). The fruits are mainly consumed either as raw or in the preparation of sambar, chutni, pickles etc in our country. In many countries, it is considered as “poor man’s orange” because of its attractive appearance and nutritive value (Singh *et al.*, 2004). It is considered as an important source of vitamin A, C and minerals (Hari, 1997). Apart from these, lycopene is valued for its anti-cancer property (Bose *et al.*, 2002). It acts as an antioxidant and scavenger of free radicals, which is often associated with anticarcinogenesis. Thus, lycopene has got great beneficial effects on human health. It may also interfere with oxidative damage to DNA and lipoproteins and inhibits the oxidation of LDL (Low Density Lipoprotein) cholesterol.

Tomato is being grown worldwide with China, Turkey, Italy, Egypt, India, Spain, Brazil, Iran and Mexico as leading countries. In India the crop was grown in an area of 8.79 lakh hectares and production was 18.22 lakh tonnes with a productivity of 20.7 tonnes per hectare (Anonymous, 2013). In Karnataka, the crop is grown in an area of 57.80 thousand hectares with the production of 1916.6 thousand tonnes with a productivity of 33.2 tonnes per hectare (Anonymous, 2013).

Tomato is an annual and short lived perennial herbaceous plant. It is a typical day neutral plant and self pollinated crop, but certain percentage of cross pollination may also

occurs. It is a warm season crop reasonably resistant to heat, drought and grows under wide range of soil and climatic conditions. So far efforts of many vegetable breeders from both public and private sector have resulted in spectacular improvement in yield and quality characters. As a result of these efforts, hundreds of new cultivars have been developed since 50 years to meet the diverse needs and varied situations and climates under which tomato is grown.

Though tomato, is a self pollinated crop, has a tremendous potential for heterosis breeding, the commercial exploitation of hybrid vigour in tomato has received greater importance, there are several advantages of hybrids over pureline varieties with response to marketable fruit yield and its component traits as well as resistance to biotic and abiotic stresses. Therefore a large number of commercial hybrids has been developed in the country in this crop, with increasing popularity of F₁ hybrids in tomato. It is imperative to obtain such hybrids which have excellent qualities and yield coupled with resistance to diseases.

Identification of high yielding, stable varieties and the development of F₁ hybrids will help the farmers to adopt variety/hybrid for successful commercial cultivation of tomatoes. Considering the spectrum of aforesaid requirement in tomato, the present investigations were taken up with the following objectives.

1. To assess the magnitude and direction of heterosis for growth, earliness, yield and quality parameters in tomato.
2. To study the combining ability of parents for growth, earliness, yield and quality parameters in tomato.
3. To study the association among for growth, earliness, yield and quality parameters in tomato.

2. REVIEW OF LITERATURE

Tomato (*Solanum lycopersicum* L.) is one of the most important solanaceous vegetables grown worldwide under open and protected conditions. Now a day, it has become an important commercial vegetable crop so far as the area, production, industrial values and its contributed to the knowledge and understanding of various areas of crop production and voluminous literature has been generated.

The main aim of any breeding programme is the improvement of both qualitative and quantitative characters of the crop. The information on genetics of various quantitative traits particularly of those that contribute to yield, disease resistance and quality would be most useful in planning the breeding programmes so as to make effective selections. The purpose of this selection is to give a comprehensive up-to-date treatment to the various aspects of genetic improvement.

2.1 Heterosis

Heterosis is the superiority of the F_1 hybrid over its parent's value. Shull (1914) coined the classical term heterosis meaning extra vigour on crossing two inbreds. The phenomenon of heterosis in plants is well known today and breeders exploit it for higher yield in crop plants. This relationship is evidenced in the basic formula for heterosis (Falconer, 1981).

$$\text{Heterosis in } F_1 = \sum dy^2$$

Where,

d = Magnitude of dominance

y = Difference between the parental population for allelic frequencies at the locus.

The term heterobeltiosis coined by Fonesca and Patterson (1968) refers to the increased or decreased vigour of F_1 over its better parent. Hybrids offer opportunities for improvement in earliness, uniformity, productivity, quality, wider adaptability and for rapid development of dominant genes for resistance to disease and pests (Riggs, 1988). In vegetable plants, heterosis breeding has been found useful in the improvement of yield potential of self as well as cross-pollinated crops. Literature on heterosis for yield and yield attributes in tomato crop is presented in tabular form (Table 1).

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 (Rick, 1965). Based on reports of various scientists, the heterosis of some traits is presented in table 1.

2.2 Combining ability

The concept of combining ability was developed by Sprague and Tatum (1942). According to them the general combining ability (gca) is the comparative ability of the line to combine with other lines. Specific combining ability (sca) was defined as the deviation in the performance of the specific cross from the performance expected on the basis of general combining ability effects of the parents involved in the cross. The expression of heterosis is highly associated with specific combining ability (sca) of the crosses. The line x tester analysis design developed by Kempthorne (1957) is a powerful and commonly used tool for estimation of general and specific combining abilities of parents and hybrids, respectively. The genetic potential of parents is expressed in terms of combining ability. Among the parents involved in a large number of crosses, only few exhibits, superiority and such parents producing good hybrids are considered as good general combiners.

The general combining ability is the measure of additive genetic factor where as specific combining ability is due to non additive genetic factors like dominance, over dominance and epistasis. For the any successful breeding programme, knowledge on these aspects is most important. Review of literature on combining ability and gene action in tomato is presented in tabular form (Table 2).

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

Sl. No.	Characters	Hybrids studied	Range of per cent heterosis over			References
			Heterobeltiosis (%)	Heterosis over best parent (%)	Standard Heterosis (%)	
1	Plant height	15	-	53.73 to 36.33	-	Bhutani <i>et al.</i> (1973)
		28	-	1.90 to 41.10	-	Singh <i>et al.</i> (1976)
		20	2.86 to 83.19	0.42 to 45.37	-	Mishra and Khanna (1977)
		30	-	12.10 to 26.40	-	Singh <i>et al.</i> (1978)
		16	-	-	-23.29 to 2.23	Peter and Rai (1978)
		21	Upto 50.16	Upto 26.34	-	Sidhu <i>et al.</i> (1981)
		44	Upto 82.00	-	-	Govindarasu <i>et al.</i> (1982)
		5	6.5 to 16.56	4.5 to 12.80	-	Ramamohan (1988)
		45	-2.775 to 8.87	5.27 to 5.63	-	Kanthaswamy and Balakrishnan (1989)
		28	-	-	-22.27 to 23.92	Dundi (1991)
		36	-	7.40 to 40.10	-	Dod and Kale (1992)
		16	37.5 to 5.1	-	-	Singh and Singh (1993)
		50	-65.52 to 81.27	-50.98 to 60.45	-58.82 to 148.64	Dharmatti (1995)
		36	-	4.65 to 13.06	-	Dod <i>et al.</i> (1995)
		6	-8.37 to 24.05	-25.53 to 14.28	-	Nagaraja (1995)
		45	-63.41 to -5.26	-	-	Raijadhav <i>et al.</i> (1996)
		28	-	-10.00 to 59.00	Negative	Patil (1996)
		36	39.70 to 42.99	12.74 to 13.94	-	Ghosh <i>et al.</i> (1997)
		28	-6.22 to 6.51	-	3.10 to 15.30	Patil (1997)
		16	-53.33 to 29.41	-	-23.61 to 75.00	Lakshmi (1997)
45	159.1 to 190.7	-53.73 to 36.33	-	Srivastava <i>et al.</i> (1998)		

Table 1 Contd.....

Sl. No.	Characters	Hybrids studied	Range of per cent heterosis over			References
			Heterobeltiliosis (%)	Heterosis over best parent (%)	Standard Heterosis (%)	
		15	-23.80 to 6.81	-	-14.44 to 29.46	Kulkarni (1999)
		91	0.53 to 123.40	-	-	Bhatt <i>et al.</i> (1999)
		36	-10.98 to 37.18	-	-	Baishya <i>et al.</i> (2001)
		24	-40.94 to -2.36	-	-36.31 to 4.64	Sharma <i>et al.</i> (2001)
		41	-	14.29 to 27.73	52.81 to 70.79	Fageria <i>et al.</i> (2001)
		36	-23.80 to 6.81	-	-14.44 to 26.46	Sajjan (2002)
		15	-19.36 to 49.21	-	23.04 to 58.00	<i>Padma et al.</i> (2002)
		36	-	15.71 to 129.67	-	Joshi and Thakur (2003)
		50	-18.94 to 20.45	-20.98 to 17.57	48.89 to 0.07	Kulkarni (2003)
		45	-21.54 to 55.05	-27.93 to 34.62	-10.94 to 72.95	Prashanth (2004)
		9	-32.7 to 47.6	-45.9 to 37.5	-45.6 to 38.7	Tiwari and Lal (2004)
		45	-	-24.22 to -25.76	6.22 to 55.70	Mahendrakar (2004)
		40	31.46 to 69.13	-45.30 to 62.38	-	Ashwini (2005)
		30	-33822 to 20.16	-43.98 to 14.43	-	Premalakshmi <i>et al.</i> (2006)
		45	-	37.28	-	Asati <i>et al.</i> (2007)
		45	-	2.28 to 74.91	-	Singh <i>et al.</i> (2007)
		24	-	-34.44 to 43.67	-55.32 to 26.19	Sharma and Thakur (2008)
		49	-	117.29	-	Singh <i>et al.</i> (2008)
		36	-22.52 to 44.19	-35.99 to 26.02	-40.99 to 4.73	Yashavantakumar (2008)
		45	-43.48 to 30.76	-	-	Sekhar <i>et al.</i> (2010)

Table 1 Contd.....

Sl. No.	Characters	Hybrids studied	Range of per cent heterosis over			References
			Heterobeltiliosis (%)	Heterosis over best parent (%)	Standard Heterosis (%)	
		45	-17.83 to 31.08	-	-17.83 to 16.36	Kumari and Sharma (2011)
		15	-8.57	Negative	-	Premalakshmi (2010)
		39	Up to 70.06	-	-	Singh and Asati (2011)
		14	-0.70 to 70.16	-	-	Ahmad <i>et al.</i> (2011)
		19	-7.51 to 75.54	-	-	Islam <i>et al.</i> (2012)
		49	-12.79 to 68.58	-0.29 to 17.29	-	Singh <i>et al.</i> (2012)
		30	-47.6 to 45.94	-	-42.77 to 55.50	Sunilet <i>et al.</i> (2013)
		72	-4.88 to 8.83	-	-	Akram <i>et al.</i> (2013)
2	Number of branches per plant	20	5.71 to 76.00	1.77 to 67.20	-	Mishra and Khanna (1977)
		16	-	-	55.84 to 93.89	Peter and Rai (1978)
		21	Negative	Positive	55.84 to 93.49	Sidhu <i>et al.</i> (1981)
		15	Positive	Positive	-	Patil (1984)
		45	-	-8.77 to 31.58	-	Kumar <i>et al.</i> (1988)
		5	24.80 to 72.50	-6.70 to 15.67	-	Ramamohan (1988)
		19	17.824 to 60.367	16.06 to 57.237	-	Kanthaswamy and Balakrishnan (1989)
		28	-	-	-32.77 to 71.11	Dundi (1991)
		16	-12.66 to 12.26	-	-	Singh and Singh (1993)
		36	-	-3.22 to 6.47	-	Dod <i>et al.</i> (1995)
		50	-78.84 to 83.23	-79.88 to 62.16	-76.07 to 231.29	Dharmatti (1995)
		36	43.26 to 45.67	22.54 to 28.74	-	Ghosh <i>et al.</i> (1997)
		28	-	-33.33 to 54.5	15.00 to 60.00	Patil (1996)

Table 1 Contd.....

Sl. No.	Characters	Hybrids studied	Range of per cent heterosis over			References
			Heterobeltiliosis (%)	Heterosis over best parent (%)	Standard Heterosis (%)	

		28	-2.99 to 46.02	-	-32.26 to 90.65	Patil (1997)
		45	66.57 to 122.16	-	-	Srivastava <i>et al.</i> (1998)
		15	28.95 to 20.12	-	-17.81 to 38.36	Kulkarni (1999)
		36	-18.88 to 21.82	-25.35 to 1.01	-21.30 to 8.26	Sajjan (2002)
		50	-53.85 to 34.02	-57.4 to 30.49	-52.61 to 33.18	Kulkarni (2003)
		9	25.6 to 50.8	-18.90 to 38.90	36.2 to 59.6	Tiwari and Lal (2004)
		45	-	-14.35 to 18.66	-9.92 to 23.35	Mahendrakar (2004)
		30	-	-19.27 to 35.21	-18.86 to 23.13	Duhan <i>et al.</i> (2005)
		45	-	48.93	-	Asati <i>et al.</i> (2007)
		49	-	155.8	-	Singh <i>et al.</i> (2008)
		36	-38.07 to 55.52	-42.15 to 39.46	-65.10 to 15.86	Yashavantakumar (2008)
		45	-34.69 to 22.47	-	-	Sekhar <i>et al.</i> (2010)
		45	13.90	1.34	-	Premalakshmi (2010)
		45	-17.83 to 31.08	-	-17.83 to 16.36	Kumari and Sharma (2011)
		39	Upto 43.84	-	-	Singh and Asati (2011)
		49	-3.97 to 29.47	-64.23 to 59.78	-	Singh <i>et al.</i> (2012)
		30	-59.33 to 25.22	-	-55.56 to 36.81	Sunilet <i>et al.</i> (2013)
3	Days to first flowering	45	-42.85 to 9.22	-33.33 to 16.66	16.66 to 103.29	Tendulkar (1994)
		48	-14.76 to 15.66	-	-	Rajadhav <i>et al.</i> (1996)
		16	-33.60 to -3.89	-	-29.50 to -3.82	Lakshmi (1997)
		21	-16.44 to 26.67	-	-	Rai <i>et al.</i> (1997)

Table 1 Contd.....

Sl. No.	Characters	Hybrids studied	Range of per cent heterosis over			References
			Heterobeltiosis (%)	Heterosis over best parent (%)	Standard Heterosis (%)	
		45	Uoto -17.58	-	-	Srivastava <i>et al.</i> (1998)

		36	-17.79 to 2.82	-	-	Baishaya <i>et al.</i> (2001)
		36	-16.36 to 11.76	-	-	Joshi and Thakur (2003)
		45	Upto to 47.69	Upto -35.98	Upto -54.71	Mahendrakar (2004)
		30	Upto -8.57	-	-	Premalakshmi <i>et al.</i> (2006)
		15	-8.87	Negetive	-	Premalakshmi (2010)
		45	-8.41 to 10.87	-	-1.00 to 15.15	Kumari and Sharma (2011)
		45	-6.50 to 16.31	-	-3.03 to 15.50	Santosh and Manish (2011)
		49	Upto 63.44	-	-	Singh <i>et al.</i> (2012)
		72	-26.7 to 15.50	-	-	Akram <i>et al.</i> (2013)
4	Days to 50 per cent flowering	28	-44.53 to 8.74	-34.89 to 17.36	-	Pujari and Kale (1994)
		45	-33.56 to 18.29	-28.46 to 21.26	0.00-67.25	Tendulkar (1994)
		28	-	2.43 to 22.2	-	Patil (1996)
		28	-10.25 to 8.98	-	-22.93 to 12.10	Patil (1997)
		15	-5.08 to 12.62	-	-11.22 to 5.10	Padma <i>et al.</i> (2002)
		50	-13.38 to 9.89	-13.10 to 20.64	-14.28 to 3.41	Kulkarni (2003)
		45	-	-24.36 to 25.76	-30.56 to 3.52	Mahendrakar (2004)
		30	-	-7.63 to 12.71	-3.27 to 10.60	Duhan <i>et al.</i> (2005)
		49	-	-4.13	-	Singh <i>et al.</i> (2008)
		45	-17.43 to 17.56	-	-	Kumari and Sharma (2011)
		15	Upto -34.55	-	Upto 34.55	Kumar <i>et al.</i> (2013)

Table 1 Contd.....

Sl. No.	Characters	Hybrids studied	Range of per cent heterosis over			References
			Heterobeltiosis (%)	Heterosis over best parent (%)	Standard Heterosis (%)	
		49	Upto -5.70	-	-	Singh <i>et al.</i> (2012)
		19	-	negative	-	Islam <i>et al.</i> (2012)
5	Days to first	18	-31.03 to 3.44	-	-	Viredelwala <i>et al.</i> (1981)

	fruit set	50	-	-	-81.98 to 33.23	Dharmatti (1995)
		45	-51.84 to 14.05	-	-	Rajadhav <i>et al.</i> (1996)
		45	-	14.52	-	Mahendrakar (2004)
		40	-	-62.45 to 68.56	-63.53	Ashwini (2005)
6	Days to first fruit maturity	18	-11.42 to 12.50	-	-	Viredelwala <i>et al.</i> (1981)
		45	-20.27 to 15.50	-9.96 to 20.93	8.16 to 45.28	Tendulkar (1994)
		90	High	-	-	Uppal <i>et al.</i> (1997)
		45	Upto -9.61	-	-	Srivastava <i>et al.</i> (1998)
		91	-14.73 to -0.39	-	-	Bhatt <i>et al.</i> (1999)
		36	-9.15 to 27.67	-	-	Baishya <i>et al.</i> (2001)
		24	-11.20 to -2.90	-	-11.39 to -0.40	Sharma <i>et al.</i> (2001)
		45	18.97	-	14.52	Mahendrakar (2004)
		15	5.59 to 21.37	-	-	Alice <i>et al.</i> (2011)
		15	-8.88 to 8.92	-6.99 to 9.33	-8.87 to 6.07	Hannan <i>et al.</i> (2007)
		19	-	-13.95 to 4.90	-	Islam <i>et al.</i> (2012)
		49	-11.52 to 14.59	-0.29 to 17.29	-	Singh <i>et al.</i> (2012)
7	Equatorial diameter of fruit	24	-	-37.88 to 3.15	-18.55 to 26.61	Sharma <i>et al.</i> (2001)
		15	-27.12 to 14.48	-	-33.42 to -9.31	Padma <i>et al.</i> (2002)

Table 1 Contd.....

Sl. No.	Characters	Hybrids studied	Range of per cent heterosis over			References
			Heterobeltiosis (%)	Heterosis over best parent (%)	Standard Heterosis (%)	
		28	Upto 4.16	-	-	Patagaonkar <i>et al.</i> (2003)
		45	-	-37.14 to 23.36	-27.30 to 23.68	Mahendrakar (2004)
		30	Upto 8.70	-	-	Gul <i>et al.</i> (2010)
		14	0.53 to 15.49	-	-	Ahmad <i>et al.</i> (2011)

		19	-	-16.37 to 14.11	-	Islam <i>et al.</i> (2012)
		49	Upto 16.50	-	-	Singh <i>et al.</i> (2012)
		30	-49.33 to 29.70	-	-42.50 to 42.97	Sunilet <i>al.</i> (2013)
8	Polar diameter of fruit	24	-	-19.65 to 10.17	-17.67 to 3.24	Sharma <i>et al.</i> (2001)
		28	Upto 4.16	-	-	Patagaonkar <i>et al.</i> (2003)
		45	-	-43.46 to 29.16	-43.46 to 29.16	Mahendrakar (2004)
		14	0.56 to 24.11	-	-	Ahmad <i>et al.</i> (2011)
		49	Upto 4.83	-	-	Singh <i>et al.</i> (2012)
		19	-	-17.87 to 3.09	-	Islam <i>et al.</i> (2012)
		30	-44.97 to 27.28	-	-42.97 to 27.27	Sunilet <i>al.</i> (2013)
9	Number of fruits per cluster	16	-	57.78 to 66.92	87.06 to 96.55	Peter and Rai (1978)
		16	-8.70 to 16.88	-	-	Singh and Singh (1993)
		28	-	10.07 to 21.07	-	Pujari and Kale (1994)
		45	-25.50 to 25.60	-31.76 to 17.23	-49.39 to 11.87	Tendulkar (1994)

Table 1 Contd.....

Sl. No.	Characters	Hybrids studied	Range of per cent heterosis over			References
			Heterobeltiosis (%)	Heterosis over best parent (%)	Standard Heterosis (%)	
		50	-100.0 to 40.62	-100.00 to 7.94	-100.00 to 278.35	Dharmatti (1995)
		16	-26.92 to 11.11	-	13.33 to 66.66	Lakshmi (1997)
		28	-	-	-21.43 to 50.00	Patil (1997)
		91	0.36 to 65.68	-	-	Bhatt <i>et al.</i> (1999)
		15	-19.19 to -2.02	-	-8.05 to 11.49	Kulkarni (1999)

		45	-	-33.83 to 21.19	102.27 to 140.91	Fageria <i>et al.</i> (2001)
		45	-19.28 to 62.26	-34.37 to 20.62	-34.37 to 34.37	Sajjan (2002)
		36	-	-31.56 to 51.64	-	Joshi and Thakur (2003)
		50	-48.42 to 30.58	-55.86 to 21.09	-47.55 to 16.43	Kulkarni (2003)
		45	-20.19 to 33.58	-32.12 to 37.45	-12.24 to 35.57	Prashanth (2004)
		45	Upto 58.83	44.80	29.32	Mahendrakar (2004)
		45	-47.20 to 117.00	-59.19 to 60.49	105.34	Ashwini (2005)
		36	-	-34.39 to 33.30	-41.89 to 11.03	Sharma and Thakur (2008)
		36	-43.54 to 84.54	-47.57 to 71.31	-62.89 to 7.44	Yashavantakumar (2008)
		45	-33.71 to 100.00	-	-	Sekar <i>et al.</i> (2011)
		45	-15.87 to 47.26	-	-35.50 to 3.44	Kumari and Sharma (2011)
		14	1.33 to 23.73	-	-	Ahmad <i>et al.</i> (2011)
		19	-	-27.93 to 21.73	-	Islam <i>et al.</i> (2012)
		49	-2.97 to 29.47	-	-	Singh <i>et al.</i> (2012)

Table 1 Contd.....

Sl. No.	Characters	Hybrids studied	Range of per cent heterosis over			References
			Heterobeltiosis (%)	Heterosis over best parent (%)	Standard Heterosis (%)	
10	Average fruit weight	45	-	0.67 to 36.59	-	Dixit <i>et al.</i> (1980)
		21	-	67.28 to 88.39	-	Anbu <i>et al.</i> (1981)
		28	-35.40 to 65.30	-	-	Rajput (1987)
		50	-	Positive	-	Ahmed <i>et al.</i> (1988)
		45	-	-	11.20 to 28.30	Kumar <i>et al.</i> (1988)
		5	31.50	31.50	-	Ramamohan (1988)

		36	-	-29.11 to 25.70	-	Yadav <i>et al.</i> (1989)
		21	-37.63 to 55.40	-49.62 to 38.53	-72.40 to 114.95	Dundi (1991)
		28	-	-30.47 to 76.45	-	Pujari and Kale (1994)
		78	-8.07 to 38.98	-7.18 to 29.28	-	Reddy and Reddy (1994)
		45	-36.21 to 22.95	-51.13 to 8.71	-52.58 to 62.23	Tendulkar (1994)
		50	-100 to 106.14	-100 to 106.16	-100 to 258.29	Dharmatti (1995)
		40	-	13.13 to 24.91	-	Dod <i>et al.</i> (1995)
		36	-46.38 to 93.89	-96.88 to 72.45	-	Nagaraja (1995)
		45	-70.93 to 37.74	-	-	Raijadhav <i>et al.</i> (1996)
		16	-46.88 to 27.39	-	-33.33 to 133.33	Lakshmi (1997)
		36	43.07 to 57.99	10.28 to 21.05	-	Ghosh <i>et al.</i> (1997)
		28	-34.09 to 10.00	-	-4.49-78.83	Patil (1997)
		15	-15.95 to 28.22	-	18.08 to 60.71	Kulkarni (1999)

Table 1 Contd.....

Sl. No.	Characters	Hybrids studied	Range of per cent heterosis over			References
			Heterobeltiosis (%)	Heterosis over best parent (%)	Standard Heterosis (%)	
		40	-64.90 to 66.50	-	-	Mageswari and Natarajan (1999)
		24	-103.83 to 205.17	-80.59 to 80.63	-	Sharma <i>et al.</i> (2001)
		45	-	-26.79 to 7.33	9.43 to 35.85	Fageria <i>et al.</i> (2001)
		45	-70.83 to 53.65	-76.29 to 42.40	-73.55 to 19.21	Sajjan (2002)
		36	-11.93 to 120.00	-36.36 to 96.88	-	Baishya <i>et al.</i> (2001)
		15	-36.84 to 21.68	-	-58.14 to 23.73	Padma <i>et al.</i> (2002)
		36	-31.16 to 41.13	-	-	Joshi and Thakur (2003)
		50	-45.73 to 57.59	-59.49 to 44.07	-59.52 to 71.23	Kulkarni (2003)

		28	Upto 3.82	-	-	Patagaonkar <i>et al.</i> (2003)
		45	-	-71.78 to 24.14	-64.55 to 70.95	Mahendrakar (2004)
		45	-42.54 to 52.92	-45.97 to 29.66	-51.80 to 55.37	Prashanth (2004)
		40	-38.95 to 90.69	-	-	Ashwini (2005)
		30	-	-44.05 to 73.64	-2.37 to 98.81	Duhan <i>et al.</i> (2005)
		30	-61.49 to 45.01	-62.50 to 40.31	-	Premalakshmi <i>et al.</i> (2006)
		45	-	42.87	-	Asati <i>et al.</i> (2007)
		24	-	-21.60 to 23.52	-33.57 to 10.22	Sharma and Thakur (2008)
		49	-	2.04 to 40.00	-	Singh <i>et al.</i> (2008)
		36	-30.50 to 30.50	-37.76 to 30.05	-28.71 to 32.84	Yashavantakumar (2008)
		45	45	-54.89 to 12.23	-	Sekar <i>et al.</i> (2011)
		45	-29.85 to 14.82	-	-41.66 to 0.91	Kumari and Sharma (2011)
		15	40.31	-	-	Premalakshmi (2010)

Table 1 Contd.....

Sl. No.	Characters	Hybrids studied	Range of per cent heterosis over			References
			Heterobeltiosis (%)	Heterosis over best parent (%)	Standard Heterosis (%)	
		39	63.14	-	-	Singh and Asati (2011)
		15	-60.06 to 15.98	-	-	Alice <i>et al.</i> (2011)
		14	-4.76 to 16.67.	-	-	Ahmad <i>et al.</i> (2011)
		81	-10.67 to 14.92	-	-	Akram <i>et al.</i> (2012)
		19	-	- 42.84 to 21.21	-	Islam <i>et al.</i> (2012)
		49	-52.07 to 98.70	-25.67 to 69.81	-	Singh <i>et al.</i> (2012)
		30	-61.37 to 26.58	-	60.21 to 29.51	Sunilet <i>et al.</i> (2013)
11	Number of fruits per	45	-	0.79 to 38.75	-	Dixit <i>et al.</i> (1980)
		21	Upto 61.14	Upto 28.85	-	Sidhu <i>et al.</i> (1981)

plant	18	-35.93 to 82.64	-	-	Viredelwala <i>et al.</i> (1981)
	44	Upto 81.80	Upto 54.00	-	Govindarasu <i>et al.</i> (1982)
	84	-	-45.92 to 81.28	-	Jamwal <i>et al.</i> (1984)
	30	-	Positive	-	Ahmed <i>et al.</i> (1988)
	36	-	-23.31 to 48.68	-	Yadav <i>et al.</i> (1989)
	45	20.65 to 98.93	-25.69 to 13.25	-	Kanthaswamy and Balakrishnan (1989)
	28	-	-	23.93 to 207.9	Dundi (1991)
	16	-7.58 to 24.44	-	-	Singh and Singh (1993)
	28	-	-47.61 to 58.00	-	Pujari and Kale (1994)
	45	-17.38 to 114.2	34.10 to 96.89	-47.87 to 114	Tendulkar (1994)

Table 1 Contd.....

Sl. No.	Characters	Hybrids studied	Range of per cent heterosis over			References
			Heterobeltiliosis (%)	Heterosis over best parent (%)	Standard Heterosis (%)	
		50	-100 to 142.62	-100 to 94.74	-100 to 1133.50	Dharmatti (1995)
		36	-	10.78 to 46.51	-	Dod <i>et al.</i> (1995)
		21	Upto 193.55	Upto 35.66	Upto 36.62	Kumar <i>et al.</i> (1995)
		6	-40.51 to -0.83	-	-	Nagaraja (1995)
		21	-	3.8 to 132.1	-50.7 to 35.9	Sureshkmar <i>et al.</i> (1995)
		36	47.15 to 55.96	30.94 to 53.51	-	Ghosh <i>et al.</i> (1997)
		16	-85.00 to 19.15	-	-70.00 to 180.00	Lakshmi (1997)
		28	-	-	-40.59 to 33.75	Patil (1997)
		21	25.00 to 79.66	-	-	Rai <i>et al.</i> (1998)
		45	Upto 74.15	-	-	Srivastava <i>et al.</i> (1998)
		91	1.74 to 132.98	-	-	Bhatt <i>et al.</i> (1999)

		15	-50.41 to 1.29	-	-46.11 to 10.07	Kulkarni (1999)
		36	-60.00 to 122.00	-	-	Baishya <i>et al.</i> (2001)
		28	-4.27 to 137.82	-16.93 to 87.32	24.65 to 50.26	Sajjan (2002)
		15	-53.79 to 14.86	-	-21.17 to 94.11	Padma <i>et al.</i> (2002)
		36	-	-27.69 to 49.37	-	Joshi and Thakur (2003)
		50	-27.78 to 181.52	-40.50 to 123.39	-40.41 to 181.51	Kulkarni (2003)
		45	-	-24.17 to 52.28	-17.07 to 60.06	Mahendrakar (2004)
		45	42.52 to 52.92	-45.97 to 29.66	-59.64	Prashanth (2004)

Table 1 Contd.....

Sl. No.	Characters	Hybrids studied	Range of per cent heterosis over			References
			Heterobeltiosis (%)	Heterosis over best parent (%)	Standard Heterosis (%)	
		9	5.90-248.9	25.90 to 153.8	15.90 to 137.5	Tiwari and Lal (2004)
		40	-65.64 to 353.91	-79.27 to 29.21	300.00	Ashwini (2005)
			-	-56.81 to 77.90	-42.64 to 69.50	Duhan <i>et al.</i> (2005)
		20	-	-	-	Sharma <i>et al.</i> (2006)
		30	15.52 to 213.52	6.96 to 210.70	-	Premalakshmi <i>et al.</i> (2006)
		45	-	38.96	-	Asati <i>et al.</i> (2007)
		49	-	165.43	-	Singh <i>et al.</i> (2008)
		36	-18.45 to 232.37	-30.37 to 215.77	-63.11 to 24.41	Yashavantakumar (2008)
		15	210.70	121.48	-	Premalakshmi (2010)
		45	-50.82 to 28.57	-	-	Sekar <i>et al.</i> (2011)
		45	-19.22 to 22.64	-28 to 15.31		Kumari and Sharma (2011)
		45	-16.48 to 34.13	-	28.08 to 16.33	Santosh and Manish (2011)
		14	3.76 to 83.88	-	-	Ahmad <i>et al.</i> (2011)

		81	-9.2125.03	-	-	Akram <i>et al.</i> (2012)
		19	-	-43.30 to 67.44	-	Islam <i>et al.</i> (2012)
		49	-20.30 to 102.08	-58.37 to 59.69	-	Singh <i>et al.</i> (2012)
		30	-67.58 to 40.20	-	-52.50 to 58.50	Sunilet <i>et al.</i> (2013)
12	Yield per plant	45	0.40 to 60.36	-	-	Dixit <i>et al.</i> (1980)
		21	45.50 to 74.15	-	-	Anbu <i>et al.</i> (1981)
		30	-54.40 to 31.44	-	-	Jamwal <i>et al.</i> (1984)

Table 1 Contd.....

Sl. No.	Characters	Hybrids studied	Range of per cent heterosis over			References
			Heterobeltiosis (%)	Heterosis over best parent (%)	Standard Heterosis (%)	
		28	-12.60 to 84.10	-28.90 to 69.20	-	Rajput (1987)
		5	87.60	14.60	-	Ramamohan (1988)
		45	-24.96 to 29.51	-41.67 to 7.68	-	Kanthaswamy and Balakrishnan (1989)
		36	-	-166.83 to 62.36	-	Yadav <i>et al.</i> (1989)
		28	-25.39 to 88.85	27.87 to 72.89	-37.55 to 44.98	Dundi (1991)
		56	39.60 to 14.40	-	-	Singh and Singh (1993)
		28	-	-30.47 to 76.45	-	Pujari and Kale (1994)
		45	-	-	-45.61 to 22.07	Tendulkar (1994)
		36	-	13.97 to 94.66	-	Dod <i>et al.</i> (1995)
		50	-100 to 142.62	-	-	Dharmatti (1995)
		6	-85.92 to 38.11	-92.09 to 22.89	-	Nagaraja (1995)
		28	-	-10.14 to 26.65	-30.47 to -17.20	Patil (1996)
		36	47.15 to 55.96	30.94 to 53.51	-	Ghosh <i>et al.</i> (1997)
		28	-21.97 to 40.27	-	-30.11 to 47.16	Patil (1997)

		45	45.01 to 138.94	-	-	Srivastava <i>et al.</i> (1998)
		45	-	17.28 to 48.21	-23.89 to -4.71	Fageria <i>et al.</i> (2001)
		24	-	15.44 to 58.59	-18.49 to 31.21	Sharma <i>et al.</i> (2001)
		45	-57.22 to 172.52	-70.48 to 108.60	-22.04 to 376.27	Sajjan (2002)
		36	-41.85 to 129.67	-80.92 to 113.03	-	Baishya <i>et al.</i> (2001)
		15	-40.74 to 93.13	-41.30 to 87.41	-47.06 to 65.36	Kulkarni (2003)

Table 1 Contd.....

Sl. No.	Characters	Hybrids studied	Range of per cent heterosis over			References
			Heterobeltiliosis (%)	Heterosis over best parent (%)	Standard Heterosis (%)	
		36	-	-10.22 to 42.49	-	Joshi and Thakur (2003)
		91	0.47 to 120.41	2.92 to 54.17	4.80 to 48.00	Bhatt <i>et al.</i> (2004)
		45	-	-46.01 to 91.63	-53.72 to 55.38	Mahendrakar (2004)
		9	65.8 to 402.7	16.6 to 222.6	13.3 to 109.1	Tiwari and Lal (2004)
		40	-78.09 to 682.11	-	55.38	Ashwini (2005)
		30	-	-52.33 to 116.03	-47.90 to 60.13	Duhan <i>et al.</i> (2005)
		20	0.06-179.45	-38.99 to 177.84	-	Premalakshmi <i>et al.</i> (2006)
		30	-	75.68	-	Asati <i>et al.</i> (2007)
		45	-	-29.04 to 40.74	-48.87 to 12.28	Sharma and Thakur (2008)
		45	-	210.45	-	Singh <i>et al.</i> (2008)
		36	0.40 to 60.36	-43.67 to 310.91	-69.58 to 42.40	Yashavantakumar (2008)
		30	45.50 to 74.15	-	-	Gul <i>et al.</i> (2010)
		45	-54.40 to 31.44	-	-15.90 to 30.97	Santosh and Manish (2011)
		39	Upto 212.12	-	-8.54 to 31.14	Singh and Asati (2011)
		14	0.56 to 62.31	-	-	Ahmad <i>et al.</i> (2011)

		49	Upto 45.89	-	-	Singh <i>et al.</i> (2012)
		66	Upto 193.30	-	291.11	Gaikwad and Cheema (2012)
		81	-10.00 to 36.82	-	-	Akram <i>et al.</i> (2012)
		19	-	-21.74 to 54.82	-	Islam <i>et al.</i> (2012)

Table 1 Contd.....

Sl. No.	Characters	Hybrids studied	Range of per cent heterosis over			References
			Heterobeltiosis (%)	Heterosis over best parent (%)	Standard Heterosis (%)	
		49	Upto 45.89	-	-	Brajendra <i>et al.</i> (2013)
		30	-68.45 to 34.85	-	-55.52 to 29.57	Sunilet <i>al.</i> (2013)
13	Yield per ha	30	-68.45 to 34.82		-55.52 to 29.57	Sunilet <i>al.</i> (2013)
14	Number of locules per fruit	16	-	-	Upto 55.10	Peter and Rai (1978)
		21	Upto -21.09	Upto -5.67	-	Sidhu <i>et al.</i> (1981)
		28	-27.97 to 133.33	-	-45.50 to 99.82	Dundi (1991)
		156	Upto 34.50	-	-	Reddy and Reddy (1994)
		45	-32.02 to 111.65	1.50 to 163.50	-36.10 to 68.37	Tendulkar (1994)
		50	-100.00 to 87.36	-	-100.00 to 103.50	Dharmatti (1995)
		36	37.88 to 46.59	-	-	Ghosh <i>et al.</i> (1997)
		28	-	-	-18.98 to 8.48	Patil (1997)
		45	Upto 141.71	-	-	Srivastava <i>et al.</i> (1998)
		15	-44.75 to -17.35	-	-	Kulkarni (1999)
		74	-	-3.33 to 136.67	-	Chadha and Kumar (2001)
		28	Upto -24.28	-	-	Patagaonkar <i>et al.</i> (2003)
		30	-35.62 to 65.00	13.21 to 75.47	-	Premalakshmi <i>et al.</i> (2003)
		45	Upto -24.07	-	-15.69	Mahendrakar (2004)

		14	5.41 to 27.5	-	-	Ahmad <i>et al.</i> (2011)
		49	-61.43 to 165.03	-46.23 to 109.05	-	Singh <i>et al.</i> (2012)
		81	-8.71 to 8.18	-	-	Akram <i>et al.</i> (2012)
		19	Positive	-	-	Islam <i>et al.</i> (2012)

Table 1 Contd.....

Sl. No.	Characters	Hybrids studied	Range of per cent heterosis over			References
			Heterobeltiosis (%)	Heterosis over best parent (%)	Standard Heterosis (%)	
15	Rind thickness	28	-7.57 to 73.29	-17.22 to 63.16	-44.40 to 55.5	Dundi (1991)
		40	-	9.91	-	Dod and Kale (1992)
		45	-11.50 to 50.27	-13.67 to 40.98	-39.60 to 0.77	Tendulkar (1994)
		40	-	-7.41 to 5.69	-	Dod <i>et al.</i> (1995)
		36	-48.21 to 57.72	-38.63 to 47.61	-	Ghosh <i>et al.</i> (1997)
		28	-4.41 to 14.22	-	-18.98 to 8.48	Patil (1997)
		50	-43.71 to 94.10	-45.73 to 73.22	-67.17 to 26.16	Kulkarni (2003)
		45	-23.92 to 58.02	-29.50 to 5.93	-26.18 to 40.14	Prashanth (2004)
		9	-12.6 to 41.70	-29.40 to -23.40	-30.20 to 31.40	Tiwari and Lal (2004)
		24	-38.34 to 48.31	-47.26 to 45.83	-30.00 to 84.33	Prabhushankar (1990)
		24	-	-13.33 to 4.27	-3.74 to 14.02	Sharma <i>et al.</i> (2001)
		45	-12.00 to 40.74	-13.95 to 37.83	8.82 to 50.00	Sajjan (2002)
		45	-	-19.56 to 22.37	-30.22 to 0.70	Mahendrakar (2004)
		9	-12.6 to 41.7	-29.4 to 23.4	-30.2 to 31.4	Tiwari and Lal (2004)
		45	-	-43.40 to 29.19	-43.40 to 32.35	Joshi <i>et al.</i> (2005)
		45	-25.00 to 57.89	-30.77 to 66.67	-	Kumar <i>et al.</i> (2006)
45	-	38.24	-	Asati <i>et al.</i> (2007)		
45	-8.04 to 5.36	-	-	Kumari and Sharma (2011)		

Table 1 Contd.....

Sl. No.	Characters	Hybrids studied	Range of per cent heterosis over			References
			Heterobeltiosis (%)	Heterosis over best parent (%)	Standard Heterosis (%)	
		45	0.08	0.06	-	Dechinet <i>et al.</i> (2012)
		49	Upto 21.05	-	-	Brajendra <i>et al.</i> (2013)
		30	-48.72 to 36.96	-	-31.90 to 32.52	Vinod <i>et al.</i> (2013)
16	Total soluble solids	16	-	-	1.44 to 24.22	Peter and Rai (1978)
		21	Upto 1.85	-	-	Sidhu <i>et al.</i> (1981)
		20	-	-32.72 to 35.45	-	Patil and Bojappa (1988)
		28	-32.82 to 65.28	-	-7.14 to 126.19	Dundi (1991)
		156	Upto 12.80	-	-	Reddy and Reddy (1994)
		45	-33.94 to 48.04	42.26 to 13.85	-40.17 to 17.38	Tendulkar (1994)
		50	-100.00 to 282.59	-	-100.00 to 68.11	Dharmatti (1995)
		6	-23.68 to -8.85	-	-	Nagaraja (1995)
		16	-18.18 to 10.71	-	-13.33 to 20.00	Lakshmi (1997)
		28	-	-	-17.61 to 40.88	Patil (1997)
		15	-25.41 to 18.78	-	-20.12 to 27.22	Kulkarni (1999)
		40	-43.40 to 43.10	-	-	Mageswari and Natarajan (1999)
		90	Upto 25.97	Upto 11.93	Upto 19.02	Bhatt <i>et al.</i> (2001)
		24	-25.31 to 24.61	-	-21.44 to 24.04	Sharma <i>et al.</i> (2001)
		15	-1.14 to 26.25	-	3.77 to 25.78	Padma <i>et al.</i> (2002)
		36	-21.32 to 26.40	-	-	Joshi and Thakur (2003)
28	Upto 23.19	Upto 15.93	-	Patagaonkar <i>et al.</i> (2003)		
9	Upto 19.20	-	Upto 35.50	Tiwari and Lal (2004)		

Table 1 Contd.....

Sl. No.	Characters	Hybrids studied	Range of per cent heterosis over			References
			Heterobeltiliosis (%)	Heterosis over best parent (%)	Standard Heterosis (%)	
		45	-45.16 to 37.55	-22.03 to 26.83	-	Prashanth (2004)
		45	102.80	2.87	120.70	Mahendrakar (2004)
		40	-27.66 to 35.69	-36.49 to 33.80	-	Ashwini (2005)
		30	-	-58.77 to 45.98	131.00	Duhan <i>et al.</i> (2005)
		49	-	0.71 to 49.53	-	Singh <i>et al.</i> (2007)
		24	-	-27.14 to 6.93	-27.83 to 9.31	Sharma and Thakur (2008)
		49	-	66.36	-	Singh <i>et al.</i> (2008)
		36	-24.22 to 25.52	-26.51 to 10.98	5.17 to 89.66	Yashavantakumar (2008)
		45	-8.04 to 5.36	-	-	Kumari and Sharma (2011)
		14	3.93 to 31.89	-	-	Ahmad <i>et al.</i> (2011)
		19	-	-29.12 to 13.11	-	Islam <i>et al.</i> (2012)
		30	-29.95 to 27.91	-	-27.50 to 37.50	Sunilet <i>al.</i> (2013)
		49	Upto 11.17	-	-	Brajendra <i>et al.</i> (2013)
		28	Positive	-	-	Gul <i>et al.</i> (2013)
		30	-48.72 to 36.96	-	-31.90 to 32.52	Vinod <i>et al.</i> (2013)
17	pH	16	-	-	9.52 to 11.42	Peter and Rai (1978)
		45	-12.26 to 4.00	-13.81 to 7.89	-11.88 to 8.00	Tendulkar (1994)
		28	-	-2.33 to 8.29	-70.17 to 0.00	Patil (1997)
		36	-17.14 to 25.71	-	-	Gosh <i>et al.</i> (1997)
		36	-13.88 to 9.00	-	-	Srivastava <i>et al.</i> (1998)
		15	-15.48 to 5.89	-	-	Kulkarni (1999)

Table 1 Contd.....

Sl. No.	Characters	Hybrids studied	Range of per cent heterosis over			References
			Heterobeltiliosis (%)	Heterosis over best parent (%)	Standard Heterosis (%)	
		28	Positive	-	-	Gul <i>et al.</i> (2013)
		49	Upto 14.04	-	-	Brajendra <i>et al.</i> (2013)
18	Lycopene	-	High	-	-	Bhutani (1980)
		30	Upto 86.00	-	-	Sathyanarayana and Anand (1992)
		50	-	-	-15.22 to 24.91	Dharmatti (1995)
		31	-29.03 to 46.35	-	-42.86 to 0.38	Vinod <i>et al.</i> (2013)
		49	Upto 15.53	-	-	Brajendra <i>et al.</i> (2013)
19	β -carotene		High	-	-	Bhutani (1980)
20	Number of seeds per fruit	19	Low	-	-	Islam <i>et al.</i> (2012)
		49	-40.44 to 156.93	-17.69 to 163.81	-	Singh <i>et al.</i> (2012)

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

Sl. No.	Characters	Material and method used	Combining ability		Gene action		References
			GCA	SCA	Additive	Non-additive	
1	Plant height	8 x 8 HD	Significant	Significant	-	+	Kaloo <i>et al.</i> (1973)
		7 x 2 L x T	-	Significant	-	+	Mittal <i>et al.</i> (1974)
		12 x 3 L x T	Significant	Significant	+	+	Dudi <i>et al.</i> (1979)
		12 x 2 L x T	Significant	Significant	-	+	Anbu <i>et al.</i> (1980)
		11 x 4 L x T	-	Significant	-	+	Govindarasu <i>et al.</i> (1981)
		7 x 7 HD	Significant	Significant	+	+	Sidhu <i>et al.</i> (1981)
		10 x 4 L x T	Significant	Significant	+	+	Rajadhav and Kale (1987)
		12 x 2 L x T	-	Significant	-	+	Sharma <i>et al.</i> (1996)
		8 x 6 L x T	Significant	Significant	+	-	Kumar <i>et al.</i> (1997)
		4 x 4 L x T	Significant	Significant	+	-	Lakshmi (1997)
		15 x 3 L x T	Significant	Significant	-	+	Srivastava <i>et al.</i> (1998)
		5 x 10 L x T	Significant	Significant	-	+	Dharmatti <i>et al.</i> (1995)
		6 x 6 HD	Significant	Significant	+	+	Kulkarni (1999)
		14 x 14 HD	Significant	Significant	+	+	Bhatt <i>et al.</i> (1999)
		5 x 10 L x T	Significant	Significant	-	+	Dharmatti <i>et al.</i> (2001)
		7 x 3 L x T	Significant	Significant	+	-	Gaikwad <i>et al.</i> (2002)
		6 x 6 HD	Significant	Significant	+	+	Padma <i>et al.</i> (2002)
		10 x 2 L x T	Significant	Significant	-	+	Joshi and Thakur (2003)
		5 x 10 L x T	Significant	Significant	+	-	Kulkarni (2003)
		9 x 3 L x T	Significant	Significant	+	-	Prashanth (2004)
5 x 8 L x T	Significant	Significant	+	-	Ashwini (2005)		
10 x 3 L x T	Significant	Significant	-	+	Pandey <i>et al.</i> (2006)		
4 x 2 L x T	Significant	Significant	-	+	Kamalveer <i>et al.</i> (2006)		
6 x 6 HD	Significant	Significant	-	+	Premalakshmi <i>et al.</i> (2006)		
13x3 L x T	Significant	-	+	-	Singh and Asati (2011)		
4x3 L x T	Significant	Significant	-	+	Izge and Garba(2012)		

Table 2 Contd.....

Sl. No.	Characters	Material and method used	Combining ability		Gene action		References
			GCA	SCA	Additive	Non-additive	
		3x6 H D	Significant	-	+	+	Saleemet <i>et al.</i> (2013)
		9X9 F D	Significant	Significant	-	+	Akramet <i>et al.</i> (2013)
		8X3 L x T	Significant	-	+	-	Adhiet <i>et al.</i> (2013)
		30 L x T	Significant	Significant	-	-	Kumar <i>et al.</i> (2013)
		5X2 H D	Significant	-	+	+	Gabry <i>et al.</i> (2014)
2	Number of branches per Plant	8 x 8 HD	Significant	Significant	-	+	Kaloo <i>et al.</i> (1973)
		7 x 2 L x T	High	-	+	-	Mittal <i>et al.</i> (1974)
		12 x 3 L x T	Significant	Significant	+	+	Dudi <i>et al.</i> (1979)
		11 x 4 L x T	Significant	Significant	-	+	Govindarasu <i>et al.</i> (1981)
		7 x 7 HD	Significant	Significant	+	+	Sidhu <i>et al.</i> (1981)
		-	Significant	Significant	+	+	Dundi (1991)
		5 x 10 L x T	High	-	+	-	Dharmatti (1995)
		4 x 4 L x T	-	Significant	+	-	Lakshmi (1997)
		8 x 8 HD	High	-	+	-	Patil (1997)
		15 x 3 L x T	Significant	Significant	-	+	Srivastava <i>et al.</i> (1998)
		5 x 10 L x T	Significant	Significant	-	+	Dharmatti <i>et al.</i> (1999)
		6 x 6 HD	Significant	Significant	+	+	Kulkarni (1999)
		14 x 14 HD	Significant	Significant	+	+	Bhatt <i>et al.</i> (1999)
		7 x 3 L x T	Significant	Significant	+	-	Gaikwad <i>et al.</i> (2002)
		6 x 6 HD	Significant	Significant	+	+	Padma <i>et al.</i> (2002)
		5 x 10 L x T	Significant	Significant	+	-	Kulkarni (2003)
		5 x 9 L x T	Significant	Significant	+	-	Prashanth (2004)
		5 x 8 L x T	Significant	Significant	+	-	Ashwini (2005)
		4 x 2 L x T	Significant	Significant	+	-	Kamalveer <i>et al.</i> (2006)
		6 x 6 HD	Significant	Significant	+	-	Premalakshmi <i>et al.</i> (2006)
		13x3 L x T	Significant	Significant	+	-	Singh and Asati (2011)

Table 2 Contd.....

Sl. No.	Characters	Material and method used	Combining ability		Gene action		References
			GCA	SCA	Additive	Non-additive	
		4x3 L x T	Significant	Significant	-	+	Izge and Garba(2012)
		30 L x T	Significant	Significant	+	-	Kumar <i>et al.</i> (2013)
		8X3 L x T	Significant	-	+	-	Adhiet <i>et al.</i> (2013)
		5X2 H D	Significant	Significant	+	+	Gabry <i>et al.</i> (2014)
3	Days to first flowering	7x2 LXT	High	-	+	-	Mittal <i>et al.</i> (1974)
		10x2 LXT	Significant	Significant	-	+	Anbu <i>et al.</i> (1980)
		10X3 LXT	Significant	Significant	+	+	Jamwal <i>et al.</i> (1984)
		4X4 LXT	-	Significant	-	+	Laksmi (1997)
		15X3 LXT	Significant	Significant	-	+	Srivathsva <i>et al.</i> (1998)
		3X19 LXT	Significant	Significant	-	+	Dhaliwal <i>et al.</i> (2000)
		18x2 LXT	Significant	Significant	-	+	Thakur and Joshi (2000)
		7x3 LXT	Significant	Significant	-	+	Gaikwad <i>et al.</i> (2002)
		9X9 F D	Significant	Significant	-	+	Akramet <i>et al.</i> (2013)
		30 L x T	Significant	Significant	-	+	Kumar <i>et al.</i> (2013)
4	Days to 50 per cent flowering	7X7 HD	Significant	Significant	-	+	Anbu <i>et al.</i> (1981)
		10X10 HD	-	High	-	+	Patil (1984)
		10X2 LXT	Significant	Significant	-	+	Prabhushankar (1990)
		6X6 HD	-	Significant	-	+	Dundi (1991)
		15X3 LXT	Significant	Significant	+	-	Tendulkar (1994)
		10X10 HD	Significant	Significant	+	-	Patil (1997)
		5X6 LXT	High	-	+	-	Roopa <i>et al.</i> (2001)
		5X3 LXT	Significant	Significant	+	-	Kulkarni (2003)
		15X3 LXT	Significant	Significant	-	+	Mahendrakar (2004)
		15X3 LXT	Significant	Significant	+	-	Singh <i>et al.</i> (2008)
		4x3 L x T	Significant	Significant	-	+	Izge and Garba(2012)
		8X3 L x T	Significant	Significant	+	-	Adhi <i>et al.</i> (2013)

Table 2 Contd.....

Sl. No.	Characters	Material and method used	Combining ability		Gene action		References
			GCA	SCA	Additive	Non-additive	
		30 L x T	Significant	Significant	-	+	Kumar <i>et al.</i> (2013)
5	Days to first fruit set	9x2 L x T	High	-	+	-	Viredelwala <i>et al.</i> (1981)
		10 x 5 L x T	Significant	+	-		Dharmatti (1995)
		3x19 L x T	Significant	Significant	-	+	Dhaliwal <i>et al.</i> (2000)
		5 x 8 L x T	Significant	+	-		Ashwini (2005)
6	Days to first fruit maturity	7 x 2 L x T	High	-	+	-	Mittal <i>et al.</i> (1974)
		9 x 2 L x T	High	-	+	-	Viredelwala <i>et al.</i> (1981)
		3 x 15 L x T	Significant	Significant	+	+	Tendulkar (1994)
		12 x 2 L x T	Significant	-	+	-	Sharma <i>et al.</i> (1996)
		15 x 3 L x t	Significant	Significant	-	+	Srivastava <i>et al.</i> (1998)
		5 x 6 L x T	-	High	-	+	Roopa <i>et al.</i> (2001)
		14 x 14 H D	Significant	Significant	+	+	Bhatt <i>et al.</i> (2004)
		4x3 L x T	-	High	-	+	Izge and Garba(2012)
		3x6 H D	Significant	Significant	+	+	Saleemet <i>et al.</i> (2013)
7	Equatorial diameter of fruit	7x2 L x T	Significant	Significant	+	+	Mittal <i>et al.</i> (1974)
		12x3 L x T	Significant	Significant	+	+	Dudi <i>et al.</i> (1979)
		12x4 L x T	Significant	-	+	-	Raijadhav and Kale (1987)
		12x2 L x T	Significant	Significant	-	+	Sharma (1996)
		4x4 L x T	Significant	Significant	+	+	Laksmi (1997)
		7x7 HD	Significant	Significant	+	+	Rai <i>et al.</i> (1997)
		15x3 L x T	Significant	Significant	-	+	Srivastava <i>et al.</i> (1998)
		5x6 L x T	Significant	Significant	+	+	Roopa <i>et al.</i> (2001)
		3x12 L x T	-	Significant	-	+	Kaur <i>et al.</i> (2002)
		6x6 HD	Significant	Significant	+	+	Padma <i>et al.</i> (2002)
		3X6 LXT	High	-	+	-	Rai <i>et al.</i> (2003)
		15X3 LXT	Significant	Significant	+	+	Mahendrakar (2004)

Table 2 Contd.....

Sl. No.	Characters	Material and method used	Combining ability		Gene action		References
			GCA	SCA	Additive	Non-additive	
		5x3 H D 8X3 L x T	Significant Significant	Significant Significant	+ -	+ -	Saleemet <i>et al.</i> (2013) Adhiet <i>et al.</i> (2013)
8	Polar diameter of fruit	12 x 4 L x T 7 x 7 HD 15 x 3 L x T 12 x 2 L x T 5 x 6 L x T 3 x 12 L x T 3 x 6 HD 7X7 HD 15X3 LXT 5X5 HD 10X3 LXT 8X3 L x T	Significant Significant Significant Significant Significant - Significant Significant Significant Significant Significant Significant	Significant Significant Significan Significant Significant Significant - - Significant - Significant -	+ + - - + - + + - + + -	- - + + + + + - + - - -	Raijadhav and Kale (1987) Rai <i>et al.</i> (1997) Srivastava <i>et al.</i> (1998) Sharma <i>et al.</i> (1999) Roopa <i>et al.</i> (2001) Kaur <i>et al.</i> (2002) Padma <i>et al.</i> (2002) Rai <i>et al.</i> (2003) Mahendrakar (2004) Singh <i>et al.</i> (2005) Pandey <i>et al.</i> (2006) Adhiet <i>et al.</i> (2013)
9	Number of fruits per cluster	12 x 3 L x T 3 x 15 L x T 4 x 4 L x T 8 x 8 HD 5 x 10 L x T 6 x 6 HD 14 x 14 HD 5 x 10 L x T 5 x 6 L x T 5 x 10 L x T 5 x 9 L x T 15X3 LXT	- Significant - - Significant Significant Significant Significant High Significant Significant Significant Significant	Significant Significant Significant High Significant Significant Significant Significant - Significant Significant Significant	+ + - - - + + + - + - - -	+ - + + + + + + - - + + +	Dudi <i>et al.</i> (1979) Tendulkar (1994) Lakshmi (1997) Patil (1997) Dharmatti <i>et al.</i> (1999) Kulkarni (1999) Bhatt <i>et al.</i> (2001) Dharmatti <i>et al.</i> (2001) Roopa <i>et al.</i> (2001) Kulkarni (2003) Prashanth (2004) Mahendrakar (2004)

Table 2 Contd.....

Sl. No.	Characters	Material and method used	Combining ability		Gene action		References
			GCA	SCA	Additive	Non-additive	
		5 x 8 L x T	Significant	Significant	+	-	Ashwini (2005)
		6X6 L x T	Significant	Significant	+	+	Yashavantakumar (2008)
		4x3 L x T	Significant	Significant	-	+	Izge and Garba(2012)
		8X3 L x T	Significant	Significant	-	-	Adhi <i>et al.</i> (2013)
		30 L x T	Significant	Significant	-	+	Kumar <i>et al.</i> (2013)
10	Average fruit weight	7 x 2 L x T	Significant	Significant	+	+	Mittal <i>et al.</i> (1974)
		10 x 2 L x T	Significant	Significant	-	+	Anbu <i>et al.</i> (1980)
		15 x 3 L x T	Significant	Significant	+	-	Dixit <i>et al.</i> (1980)
		7 x 7 HD	Significant	-	+	+	Sidhu <i>et al.</i> (1981)
		9 x 2 L x T	-	High	-	+	Viredelwala <i>et al.</i> (1981)
		6 x 5 L x T	-	High	-	+	Sathyanarayana and Anand (1992)
		3 x 15 L x T	Significant	Significant	-	+	Tendulkar (1994)
		5 x 10 L x T	-	High	-	+	Dharmatti (1995)
		3 x 5 L x T	Significant	Significant	-	+	Kurian and Peter (1995)
		4 x 4 L x T	Significant	Significant	+	-	Lakshmi (1997)
		8 x 8 HD	High	-	+	-	Patil (1997)
		7 x 7 HD	Significant	Significant	+	-	Rai <i>et al.</i> (1997)
		6 x 6 HD	Significant	Significant	+	+	Kulkarni (1999)
		3 x 19 L x T	Significant	Significant	+	-	Dhaliwal <i>et al.</i> (2000)
		5 x 10 L x T	Significant	Significant	-	+	Dharmatti <i>et al.</i> (2001)
		5 x 6 L x T	-	High	-	+	Roopa <i>et al.</i> (2001)
		11 x 3 L x T	Significant	Significant	+	-	Gaikwad <i>et al.</i> (2002)
		6 x 6 HD	Significant	Significant	+	+	Padma <i>et al.</i> (2002)
		5 x 9 L x T	Significant	Significant	-	+	Prashanth (2004)
		5 x 8 L x T	Significant	Significant	-	+	Ashwini (2005)
		6 x 6 HD	Significant	Significant	-	+	Premalakshmi <i>et al.</i> (2006)

Table 2 Contd.....

Sl. No.	Characters	Material and method used	Combining ability		Gene action		References
			GCA	SCA	Additive	Non-additive	
		10 x 3 L x T	Significant	Significant	-	+	Pandey <i>et al.</i> (2006)
		15X3 LXT	Significant	Significant	+	-	Asati <i>et al.</i> (2007)
		10X5 LXT	Significant	Significant	-	+	Kavitha <i>et al.</i> (2007)
		15X3 LXT	Significant	Significant	+	+	Singh <i>et a.</i> (2008)
		6X6 LXT	-	Significant	-	+	Yashavantakumar (2008)
		13x3 L x T	Significant	Significant	+	-	Singh and Asati (2011)
		4x3 L x T	Significant	Significant	+	+	Izge and Garba(2012)
		3x6 H D	-	Significant	-	+	Saleemet <i>et al.</i> (2013)
		8X3 L x T	Significant	Significant	-	-	Adhi <i>et al.</i> (2013)
		30 L x T	Significant	Significant	-	+	Kumar <i>et al.</i> (2013)
		5X2 H D	Significant	Significant	+	+	Gabry <i>et al.</i> (2014)
11	Number of fruits per plant	8 x 8 HD	Significant	Significant	+	-	Kaloo <i>et al.</i> (1973)
		7 x 2 L x T	-	High	-	+	Mittal <i>et al.</i> (1974)
		12 x 3 L x T	Significant	Significant	+	+	Dudi <i>et al.</i> (1979)
		10 x 2 L x T	Significant	Significant	-	+	Anbu <i>et al.</i> (1980)
		15 x 3 L x T	Significant	Significant	+	-	Dixit <i>et al.</i> (1980)
		11 x 4 L x T	-	Significant	-	+	Govindarasu <i>et al.</i> (1981)
		7 x 7 HD	Significant	-	+	-	Sidhu <i>et al.</i> (1981)
		9 x 2 L x T	-	High	-	+	Viredelwala <i>et al.</i> (1981)
		10 x 3 L x T	Significant	Significant	+	+	Jamwal <i>et al.</i> (1984)
		3 x 15 L x T	Significant	Significant	+	-	Tendulkar (1994)
		5 x 10 L x T	-	High	-	+	Dharmatti (1995)
		8 x 6 L x T	-	Significant	-	+	Kumar <i>et al.</i> (1997)
		4 x 4 L x T	-	Significant	-	+	Lakshmi (1997)
		5 x 10 L x T	Significant	Significant	+	-	Kulkarni (2003)

Table 2 Contd.....

Sl. No.	Characters	Material and method used	Combining ability		Gene action		References
			GCA	SCA	Additive	Non-additive	
		5 x 9 L x T	Significant	Significant	+	-	Prashanth (2004)
		5 x 8 L x T	Significant	Significant	+	-	Ashwini (2005)
		6 x 6 HD	Significant	Significant	+	-	Premalakshmi <i>et al.</i> (2006)
		10 x 3 L x T	Significant	Significant	+	-	Pandey <i>et al.</i> (2006)
		15X3 L x T	Significant	-	+	-	Asati <i>et al.</i> (2007)
		10X5 L x T	-	High	-	+	Kavitha <i>et al.</i> (2007)
		15X3 LXT	Significant	Significant	+	+	Singh <i>et al.</i> (2008)
		4x3 L x T	Significant	Significant	-	+	Izge and Garba(2012)
		30 L x T	Significant	-	+	-	Kumar <i>et al.</i> (2013)
		3x6 H D	Significant	High	-	+	Saleemet <i>et al.</i> (2013)
		5X2 H D	Significant	Significant	+	+	Gabry <i>et al.</i> (2014)
12	Yield per plant	8 x 8 HD	Significant	Significant	+	-	Kaloo <i>et al.</i> (1973)
		7 x 2 L x T	Significant	Significant	-	+	Mittal <i>et al.</i> (1974)
		12 x 3 L x T	Significant	Significant	+	-	Dudi <i>et al.</i> (1979)
		10 x 2 L x T	Significant	Significant	-	+	Anbu <i>et al.</i> (1980)
		15 x 3 L x T	Significant	Significant	+	-	Dixit <i>et al.</i> (1980)
		11 x 4 L x T	Significant	Significant	-	+	Govindarasu <i>et al.</i> (1981)
		7 x 7 HD	Significant	Significant	+	-	Sidhu <i>et al.</i> (1981)
		10 x 3 L x T	Significant	Significant	+	-	Jamwal <i>et al.</i> (1984)
		10 x 4 L x T	Significant	Significant	+	-	Rajadhav and Kale (1987)
		3 x 15 L x T	Significant	Significant	-	+	Tendulkar (1994)
		5 x 10 L x T	Significant	Significant	-	+	Dharmatti (1995)
		6 x 6 HD	Significant	Significant	-	+	Kulkarni (1999)
		12 x 2 L x T	Significant	Significant	+	-	Sharma <i>et al.</i> (1999)
		3 x 19 L x T	Significant	Significant	-	+	Dhaliwal <i>et al.</i> (2000)

Table 2 Contd.....

Sl. No.	Characters	Material and method used	Combining ability		Gene action		References
			GCA	SCA	Additive	Non-additive	
		14 x 14 HD	Significant	Significant	-	+	Bhatt <i>et al.</i> (2001)
		5 x 10 L x T	Significant	Significant	-	+	Dharmatti <i>et al.</i> (2001)
		5 x 6 L x T	Significant	Significant	+	-	Roopa <i>et al.</i> (2001)
		7 x 3 L x T	Significant	Significant	-	+	Gaikwad <i>et al.</i> (2002)
		6 x 6 HD	Significant	Significant	-	+	Padma <i>et al.</i> (2002)
		5 x 10 L x T	Significant	Significant	+	-	Kulkarni (2003)
		5 x 9 L x T	Significant	Significant	+	-	Prashanth (2004)
		5 x 8 L x T	Significant	Significant	+	-	Ashwini (2005)
		6 x 6 HD	Significant	Significant	-	+	Premalakshmi <i>et al.</i> (2006)
		10x5 L x T	Significant	Significant	+	-	Kavitha <i>et al.</i> (2007)
		8 x 6 L x T	Significant	Significant	+	-	Kumar <i>et al.</i> (1997)
		10X5 L x T	Significant	Significant	-	+	Singh <i>et al.</i> (2008)
		6X6 LXT	Significant	Significant	-	+	Yashavantakumar (2008)
		13x3 L x T	Significant	Significant	+	-	Singh and Asati (2011)
		4x3 L x T	Significant	Significant	-	+	Izge and Garba(2012)
		30 L x T	Significant	-	+	-	Kumar <i>et al.</i> (2013)
		3x6 H D	Significant	Significant	+	+	Saleemet <i>et al.</i> (2013)
		5X2 H D	Significant	Significant	+	+	Gabry <i>et al.</i> (2014)
13	Number of locules per fruit	8 x 8 HD	Significant	Significant	+	-	Kaloo <i>et al.</i> (1973)
		7 x 2 L x T	-	High	-	+	Mittal <i>et al.</i> (1974)
		10 x 2 L x T	Significant	Significant	-	+	Govindarasu <i>et al.</i> (1981)
		7 x 7 HD	Significant	Significant	+	+	Patil (1985)
		3 x15 L x T	Significant	Significant	-	+	Rai <i>et al.</i> (1996)
		3 x 5 L x T	Significant	Significant	+	+	Kumar <i>et al.</i> (1997)

Table 2 Contd.....

Sl. No.	Characters	Material and method used	Combining ability		Gene action		References
			GCA	SCA	Additive	Non-additive	
		7 x 7 HD	-	Significant	-	+	Patil (1997)
		8 x 6 L x T	Significant	Significant	+	+	Srivastava <i>et al.</i> (1998)
		15 x 3 L x T	Significant	Significant	+	+	Kulkarni (1999)
		12 x 12 HD	Significant	Significant	+	+	Dhaliwal <i>et al.</i> (2000)
		6 x 6 HD	Significant	Significant	+	+	Roopa <i>et al.</i> (2001)
		3 x 19 L x T	Significant	Significant	-	-	Chadha <i>et al.</i> (2002)
		5 x 6 L x T	-	High	+	+	Gaikwad <i>et al.</i> (2002)
		5X10 L x T	Significant	Significant	+	-	Kulkarni (2003)
		15X3 L x T	Significant	Significant	+	+	Mahendrakar (2004)
		7X7 HD	-	Significant	-	+	Joshi andThakur (2003)
		6X6 LXT	Significant	Significant	-	+	Yashavantakumar (2008)
		3x6 H D	Significant	-	+	+	Saleemet <i>et al.</i> (2013)
		30X3 L x T	Significant	Significant	+	+	Kumar <i>et al.</i> (2013)
		5X2 H D	Significant	Significant	+	+	Gabry <i>et al.</i> (2014)
14	Rind thickness	10X10 HD	Significant	Significant	+	+	Patil (1985)
		15X3 L x T	-	High	-	+	Tendulkar (1994)
		7X7 HD	Significant	Significant	+	-	Patil (1997)
		5X6 L x T	Significant	Significant	-	+	Roopa <i>et al.</i> (2001)
		15X3 L x T	Significant	Significant	+	-	Sajjan (2002)
		8X3 L x T	-	Significant	-	+	Chadha <i>et al.</i> (2002)
		5X9 L x T	Significant	Significant	+	+	Prashanth (2004)
		15X3 L x T	Significant	Significant	-	+	Mahendrakar (2004)
		5X8 L x T	Significant	Significant	+	+	Joshi and Thakur (2003)
		18X2 L x T	Significant	Significant	+	+	Thakur and Kohli (2005)
		15X3 L x T	Significant	Significant	+	+	Singh <i>et al.</i> (2008)
		5X2 H D	Significant	Significant	+	+	Gabry <i>et al.</i> (2014)

Table 2 Contd.....

Sl. No.	Characters	Material and method used	Combining ability		Gene action		References
			GCA	SCA	Additive	Non-additive	
		30 L x T	Significant	Significant	+	+	Kumar <i>et al.</i> (2013)
15	TSS	8 x 8 HD	Significant	Significant	-	+	Kaloo <i>et al.</i> (1973)
		11 x 4 L x T	Significant	Significant	-	+	Govindarasu <i>et al.</i> (1981)
		7 x 7 HD	-	High	-	+	Sidhu <i>et al.</i> (1981)
		10 x 10 HD	Significant	Significant	+	+	Patil and Bojappa (1988)
		10 x 4 L x T	-	Significant	-	+	Raijadhav and Kale (1987)
		6 x 5 L x T	-	High	-	+	Sathyanarayana and Anand (1992)
		3 x 15 L x T	-	Significant	-	+	Tendulkar (1994)
		5 x 10 L x T	-	High	-	+	Dharmatti (1995)
		3 x 5 L x T	Significant	Significant	-	+	Kurian and Peter (1995)
		8 x 6 L x T	-	Significant	-	+	Kumar <i>et al.</i> (1997)
		4 x 4 L x T	-	Significant	-	+	Lakshmi (1997)
		8 x 8 HD	High	-	+	-	Patil (1997)
		12 x 2 L x T	Significant	Significant	+	-	Sharma <i>et al.</i> (1999)
		3 x 19 L x T	Significant	Significant	-	+	Dhaliwal <i>et al.</i> (2000)
		5 x 6 L x T	-	High	-	+	Roopa <i>et al.</i> (2001)
		5 x 10 L x T	Significant	Significant	+	-	Kulkarni (2003)
5 x 9 L x T	Significant	Significant	-	+	Prashanth (2004)		
5 x 8 L x T	Significant	Significant	+	-	Ashwini (2005)		
		30 L x T	Significant	-	-	+	Kumar <i>et al.</i> (2013)
16	pH	10X10 HD	Significant	Significant	+	+	Rajput (1987)
		15x3 LXT	Significant	+	+	+	Tendulkar (1994)
		8X8 HD	Significant	Significant	+	+	Patil (1997)

Table 2 Contd.....

Sl. No.	Characters	Material and method used	Combining ability		Gene action		References
			GCA	SCA	Additive	Non-additive	
		5X10 LXT 9X3 LXT 15X3 LXT	- Significant Significant	Significant Significant Significant	- + -	+ + +	Kulkarni (2003) Prashanth (2004) Mahendrakar (2004)
17	Lycopene	- - 12x4 L x T 6x5 L x T	- - - -	- - Significant High	- - - -	Over dominance Over dominance + +	Bhutani (1980) Bhutani and Kalloo (1989) Raijadhav and Kale (1987) Sathyanarayana and Anand (1992)
18	β -carotene	- -	- -	- -	- -	Over dominance Over dominance	Bhutani (1980) Bhutani and Kalloo (1989)

L x T= Line x Tester, HD= Half diallel, FD= Full diallel, GCA= General combining ability and SCA= Specific combining ability.

2.3 Correlation studies

Association of economically important quantitative characters which is statistically determined by correlation coefficient has been quite useful as a basis of selection. Correlation studies provide information that the selection for one character will result in progress for all correlated characters. Review of literature on correlation studies are summarised as follows.

Several workers have reported a strong association of characters in tomato. In a study with 21 genotypes, the trait yield per plant was positively correlated with fruit weight and number of fruits per plant and negatively correlated with days to 50 per cent flowering (Padma *et al.*, 2002). Aravindakumar (2001) studied the association of characters in tomato over three different sets of environment (all, rich and poor environment). Number of fruits per plant was positively correlated with plant height and number of primary branches and negatively correlated with days to 50 per cent flowering. Total yield per plot was positively correlated with plant height and number of primary branches, average fruit weight, number of fruits per plant and yield per plant in all the three environments.

Harer *et al.* (2002) study the association of the characters in 37 genotypes. The number of fruits per cluster and number of fruits per plant had positive and significant correlation with yield per plant. Number of primary branches, fruit weight and ascorbic acid content showed negative association with yield.

Ninety-two genotypes of tomato were evaluated for correlation studies (Singh *et al.*, 2004). The number of fruits per plant and number of fruits per cluster was positively correlated with yield per plant. Number of fruits per plant and number of fruits per cluster were negatively correlated with average fruit weight. Plant height showed positive correlation with days to 50 per cent flowering, days to first fruit set, number of fruits per plant and TSS. Days to 50 per cent flowering were positively associated with days to first fruit set and TSS.

Joshi *et al.* (2004) revealed the association of the characters in 37 genotypes of tomato. Yield per plant was positively correlated with average fruit weight, fruit length and plant height. The average fruit weight was positively correlated with fruit length, fruit breadth and pericarp thickness. However, fruit weight was negatively correlated with number of fruits per plant, number of fruits per cluster and ascorbic acid content of the fruit.

Manna and Paul (2012) studied the association between fruit yield and some yield components in 15 tomato genotypes. The plant height, fruit length, fruit bearing length and pericarp thickness had positively correlated with fruit yield per plant. Whereas fruit yield per plant was positively and significantly correlated with pericarp thickness, fruit length, fruit weight and number of fruits per plant, while other traits like fruit yield per plant had negatively and significantly association with days to 50 per cent flowering, plant height and number of primary branches per plant.

Buckseth *et al.* (2012) studied the association of the characters in 40 genotypes of tomato. Yield per plant expressed a highly significant positive correlation with pericarp thickness, shelf life, TSS, fruit shape index and number of fruits per plant was positively and significantly correlated with yield per plant, whereas it had negatively correlated with average fruit weight.

Shashikanth *et al.* (2012) studies on correlation and path analysis were carried out by using thirty tomato genotypes. Fruit yield had a positive and highly significant association with number of fruits per plant and number of branches per plant.

Ahirwar *et al.* (2013) reported the genetic variability, heritability and correlation in 19 tomato genotypes. Traits like plant height and number of branches at 120 DAT, number of fruits per plant, average fruit weight, number of cluster per plant, fruit set, radial diameter and polar diameter, ascorbic acid and TSS showed positive correlation with fruit yield per hectare, whereas days to 50 per cent flowering, leaf curl incidence and intensity showed negative correlation with fruit yield per hectare.

Manish and Leena (2014) conducted for the estimation of variability in six parents and their 15 F₁s. Study revealed that fruit length and fruit width and pericarp thickness was directly correlated with the shelf life of the fruit.

2.4 Pest and disease incidence studies

Tomato leaf curl virus (ToLCV) disease

Tomato leaf curl virus was reported to be a serious disease in tomato throughout India. The disease may cause upto 75 per cent or more reduction in fruit yield and due to its devastating nature it has become a national problem (Sastry and Singh, 1973). In tomato, the first resistance was found in *Lycopersicon pimpinellifolium* and *Lycopersicon esculentum* (Holmes, 1948).

Sixty-three tomato entries consisting of 20 cultivars, 36 genotypes and seven wild species were screened for resistance to TLCV under field conditions. The test entries under field conditions were grouped into six distinct categories, based on final percent disease incidence at 75 days after transplanting only one entry, EC 5888 showed a highly resistant reaction. While, EC 8630 and EC 26512 were resistant. Pusa Uphar, EC 251709, EC 35446, EC 165700, LE 23, IIHR 2187, IIHR 2272, IIHR 2273 and IIHR 2274 were moderately resistant. These fields promising genotypes were further tested by mechanical sap inoculation for confirmation of resistance, two genotypes *viz.* EC 8630 and EC 5888 were highly resistant, LE 23 and EC 52652 were resistant and EC 165700 displayed a moderately resistant reaction was studied by Venkata Raman *et al.* (2006).

In this study, 134 accessions of *Solanum lycopersicum* and six accessions of *Solanum peruvianum* were assessed for resistance to an Iranian isolate of TLCV. Plants were inoculated using whiteflies (*Bemisia tabaci*) and the reaction of plants was evaluated based on disease symptoms. All accessions of *Solanum lycopersicum* had demonstrated various degrees of disease symptoms. However, all six accessions of *Solanum peruvianum* were resistant and remained symptomless. The high level of resistance noted in whitefly inoculated accessions of *Solanum peruvianum* was not observed in graft inoculated plants of these accessions (Azizi *et al.*, 2008).

Singh (2014) studied the evaluation of tomato genotypes and its reaction against ToLCV causing leaf curl disease in 32 tomato genotypes. Among the screened genotypes, one wild accession, H-88-78-1 showed immune reaction against ToLCV without producing any symptoms of leaf curl disease. Three genotypes *viz.*, Hissar Lalima, TLBRH-6 and NS-515 showed resistant reaction and eight genotypes *viz.*, Hissar Anmol, Kashi Vishesh, Kashi Amrit, Kashi Sharad, KS-17, KS-118, Avinash-2 and US-1008 found moderately resistant reaction to ToLCV.

Tomato fruit borer (TFB) pest

Tomato fruit borer has been found to cause a yield loss of up to 35 per cent in tomato and up to 37.79 per cent in Karnataka, India (Dhandapani *et al.*, 2003). In USA alone, *Helicoverpa* spp. causes a loss of more than one billion dollars to various crops, despite insecticide applications, worth another \$250 million per year (Anonymous, 1976 and Johnson *et al.*, 1986). Control of the insect pests through the application of insecticides cause ill effects like development of insecticide resistance in the pests, pest resurgence, environmental pollution and health hazards. Host plant or varietal resistance constitutes an important tool for the integrated management of the pest insect. There are many reported studies, where the populations of *Heliothis* spp. were managed, using host-plant resistance, alone or in conjunction with other methods (Lukefahr, 1982). The development and cultivation of *Helicoverpa armigera* resistant tomato cultivars is very limited in the India due to the lack of information about resistant tomato cultivars. Therefore, there is a need for borer resistant tomato varieties to minimize the use of insecticides.

Sharma *et al.* (2006) found that out of 11 entries of tomato screened against *Helicoverpa armigera* among the different cultivars, the cultivar Rodade-1 showed negligible infestation at both the locations while BL-333-3, BT-18, PTOM-9802-3 and Palam Pink recorded comparatively low flower and fruit damage.

Considering the field screening of different tomato varieties for resistance against tomato fruit borer, among nine tomato varieties evaluated against tomato fruit borer, the varieties BARI-2 (Ratan) and BARI-8 were the susceptible variety to tomato

fruitborer and the varieties BARI-3, BARI-7, BARI-9, BINA-3 and BINA-4 were themoderately resistant, whereas BINA-1 and BINA-2 were the highly resistant (Monowara, 2007).

Mohammad *et al.* (2011) studied the screening of tomato genotypes for resistance to tomato fruit borer. Study revealed that the genotypes *viz.*, Roma VF, NARC-1 and FS-8002 were categorized as susceptible genotypes with fruit infestation (37.69%, 37.08% and 36.41%, respectively) and larval population per plant (1.02%, 1.02% and 0.84%, respectively). Whereas, the genotypes *viz.*, Sahil, Pakit and Nova Mecb had fruit infestation (12.30%, 13.14% and 13.96%, respectively) and larval population per plant (0.42%, 0.42% and 0.43%, respectively) and declared as resistant genotypes to tomato fruit borer.

Singh *et al.* (2013) studied theperformance of 13 tomato hybrid varieties against the fruit borer, *Helicoverpa armigera* (Hubner) infestation. None of the varieties was found to be highly resistant. Two varieties, *viz.*, NS-538 (Namdhari seed) and Shaktiman were least infested and classified as resistant varieties. Nine varieties *viz.*, NS-501 (Namdhari seed), Lakshmi, Shahenshah, NS-815 (Namdhari seed), All rounder, Manithoibi, Manileima, Ms (Marglobe supreme) and American Apple were graded as moderately resistant. Two varieties *viz.*, Dev and Manikhumnu were rated as moderately susceptible.

3. MATERIAL AND METHODS

Study on “Heterosis and combining ability studies in tomato (*Solanum lycopersicum* L.)” was undertaken during the year 2013-14 at Vegetable Science fields of Kittur Rani Channamma College of Horticulture, Arabhavi. The details of the material used for the investigation, development of F₁'s and their evaluation, experimental designs adopted and statistical procedures followed are outlined in this chapter.

3.1 Experimental site

The investigation on heterosis and combining ability studies in tomato is conducted at the Department of Vegetable Science of Kittur Rani Channamma College of Horticulture, Arabhavi, Gokak taluk, Belgaum district, Karnataka. The soil of research field is comprised of medium red sandy loam.

3.2 Location and climate

Arabhavi is situated in Northern dry zone of Karnataka State at 16° 12' North latitude, 74° 54' East longitude and an altitude of 640 meters above the mean sea level. Arabhavi, which comes under the Zone-3 of Region-2 among the agro-climatic zones of Karnataka, has benefits of both the South-West and North-East monsoons. It is situated in command areas which receives water from Ghataprabha Left Bank Canal from mid-July to mid-March. The meteorological data recorded during the period of experimentation is given in Appendix-I.

3.3 Experimental material

3.3.1 Selection of parents

The parents used in the study were selected based on their disease resistant and yield. There are 15 lines and 3 testers used for investigation and these were developed at Department of Vegetable Science, Kittur Rani Channamma College of Horticulture, Arabhavi. Testers used were quite consistent for yield and had acceptable quality traits in earlier trials carried out. The descriptions of lines and testers are described in Table 3.

Table 3. Salient features of parents used in line × tester study in tomato

Sl. No.	Lines	Source	Features
1	T-26	KRCCH, Arabhavi	Medium sized round fruits, determinate and weighing about 57.52 g.
2	T-36	KRCCH, Arabhavi	Medium sized round fruits, determinate with TSS 5.44 °brix, weighing about 63.03 g.
3	S-22	KRCCH, Arabhavi	Determinate growth habit, fruit is flat round shape, fruit colour is dark red.
4	K-3	KRCCH, Arabhavi	Medium sized, round fruits determinate having TSS 4.46°brix.
5	T-57	KRCCH, Arabhavi	Determinate medium sized pear shaped fruits having TSS 4.14°brix.
6	TB-1	KRCCH, Arabhavi	Medium sized round shape fruits weighing about 58.46 g with TSS 4.52 °brix.
7	Hub-18	KRCCH, Arabhavi	Medium sized round to oval shape fruits with prominent beak having TSS 4.96°brix.
8	DMT-1	UAS, Dharwad	Medium sized round fruits, determinate with TSS 5.44 °brix, weighing about 55.56 g.
9	DMT-3	UAS, Dharwad	Produces medium sized round fruits with prominent beak and pH is 3.96.
10	DMT-5	UAS, Dharwad	Medium sized round fruits having TSS 4.12 °brix and pH 3.9
11	Megha/ L-15	UAS, Dharwad	Indeterminate, round and medium sized fruits, jointed pedicel, yields 25-30t/ha, tolerant to high temperature resistant to bacterial wilt.
12	Arka Meghali	IIHR, Bengaluru	Plants semi-determinate, fruits medium (65 g), oblate with light green shoulder. Deep red fruits. Suitable for fresh market. Suitable for <i>kharif</i> season. Duration 125 days.
13	Arka Vikas	IIHR, Bengaluru	Plants semi-determinate, fruits medium large (80-90 g) oblate with light green shoulder which develop deep red on ripening. Suitable for both <i>kharif</i> and rabi seasons, duration 140 days.
14	Vaibhav	UAS, Bengaluru	Determinate, the attractive smooth oval shaped fruits, red having excellent firmness.
15	Swarna Naveen	HARP, Ranchi	Determinate growth habit, produces medium sized, oblong, deep red fruits, total soluble solids : 5.0-6.0 °brix

Table 3 Contd.....

Sl. No.	Testers	Source	Features
16	Arka Abha	IIHR, Bengaluru	Plants semi determinate. Fruits oblate with light green shoulder. Fruits have stylar end scar. Develops deep red color on ripening. Resistant to bacterial wilt caused by <i>Ralstonia solanacearum</i> . Bred for fresh market. Suitable for both <i>kharif</i> and rabi.
17	Arka Alok	IIHR, Bengaluru	Medium sized oblong shaped fruit and shape is flat suitable for table purpose or salad preparation, fruit weight is 60.00 g. Resistant to bacterial wilt caused by <i>Ralstonia solanacearum</i> .
18	DMT-2	UAS, Dharwad	Fruits are medium size, compressed round with ridgy in shape and having dark green shoulder. Fruit weighing about 53.45 g, determinant. Resistant to bacterial wilt caused by <i>Ralstonia solanacearum</i> .
19	JK Deshi (F ₁) (CC)	JK private seed company	Determinate, flattish round and small-medium sized fruits, jointed pedicel, excellent yielder, having green shoulders, resistant to blight disease, TMV, wilt and nematode.

KRCCH: Kittur Rani Channamma College of Horticulture

IIHR: Indian Institute of Horticultural Research, Hessaraghatta

UAS: University of Agricultural Sciences

HARP: Horticulture and Agroforestry Research Programme



Plate 1: General view of crossing block

3.3.2 Crossing programme

The parental seeds were sown on 9th May, 2013 in the pro-trays. Four week old seedlings were transplanted in crossing block at spacing of 60 cm × 45 cm on 6th June, 2013. Healthy flower buds in a cyme preferably of the first flush (expected to open in the next day) were selected for emasculation and pollination. The selected buds were emasculated by hand using forceps in the evening hours between 4.00 pm to 6.00 pm. The emasculated flowers (1 to 2 per cyme) were covered with butter paper bags to avoid contamination. The pollination of emasculated flowers was done next day morning during anthesis time (7.00 am to 10.30 am). Well opened flowers with dehisced anthers were collected from the male parents, the butter paper bag was removed carefully and stigma was brought in contact with dehisced anthers of male flowers. The female flower was covered with butter paper bag immediately for easy identification and further avoiding the contamination from other pollen. The pedicel of each pollinated flowers was tied with label bearing information of female and male parents and date of crossing for identification. The riped fruits were harvested and the seeds were extracted by fermentation method. Simultaneously, some flowers in each of these genotypes were selfed by covering the flowers with butter paper bags. The selfed fruits were collected and seeds were extracted.

3.3.3 Evaluation of parents and hybrids

The seeds were sown on 24th September, 2013 in the pro-trays. Twenty six days old seedlings were transplanted in the experimental block *i.e.* Randomized block design with two replications with the spacing of 60 cm x 45 cm. Each entry was represented by a single row of 16 plants spaced at 60 cm apart in a row which were kept apart at 45 cm. The commercial hybrid JK Desi (F₁) was used as commercial check. The plants were fertilized with 115 kg of N, 100 kg of P₂O₅ and 60 kg of K₂O per hectare and were grown under irrigation (Anonymous, 2007).

3.4 Observations recorded

3.4.1 Growth characteristics

The following observations were recorded on five randomly selected plants from each entry and the average of these five plants was worked out for the purpose of statistical computation. The details of observations recorded in each experiment and techniques adopted for recording the observations were as follows.

3.4.1.1 Plant height

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

3.4.1.2 Number of primary and secondary branches per plant

Number of primary and secondary branches per plant was counted at 60 and 90 day after transplanting.

3.4.2 Flowering and earliness parameters

3.4.2.1 Days to first flowering

Number of days taken from the date of transplanting to first flower opening was counted and recorded.



Plate 2: General view of experimental plot

3.4.2.2 Days to 50 per cent flowering

Number of days from transplanting to first flower appearance in 50 per cent of the plants in each row was recorded and the average was computed.

3.4.2.3 Days to first fruit set

Number of days taken from the date of transplanting to first fruit set (pea nut stage) was recorded.

3.4.2.4 Days to first fruit maturity

Number of days taken from the date of transplanting to first fruit attaining physiological maturity (colour break stage) was recorded.

3.4.3 Yield parameters

3.4.3.1 Polar diameter of fruit

Polar diameter was measured from stalk end to blossom end of fruit at third harvest by using digital calipers and average of 25 fruits was computed and expressed in centimeters.

3.4.3.2 Equatorial diameter of fruit

Equatorial diameter of fruit at the highest bulged portion was measured at third harvest by using digital calipers and average of 25 fruits was worked out and expressed in centimeters.

3.4.3.3 Number of fruits per cluster

Number of fruits per cluster was noted from randomly selected five clusters in each of five tagged plants and average was worked out.

3.4.3.4 Average fruit weight

Average fruit weight in grams was computed by using formula

$$\text{Average fruit weight (g)} = \frac{\text{Total fruit weight from all the pickings}}{\text{Total number of fruits from all the pickings}}$$

3.4.3.5 Number of fruits per plant

Number of fruits harvested from five tagged plants at each picking was counted and total number of fruits per plant was computed by adding number of all harvests and dividing it by number of plants.

3.4.3.6 Fruit yield per plant

Fruit yield was determined by adding the total fruit weight all the pickings from each tagged plant and expressed in kilograms (kg).

3.4.3.7 Yield per plot

Fruit yield was calculated by adding the total yield of all plants present in the respective plot.

3.4.3.8 Yield per hectare

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

$$\text{Yield per hectare} = \frac{\text{Yield per plot (kg)} \times 10,000\text{m}^2}{\text{Plot area} \times 1,000\text{m}^2}$$

3.4.4 Seed parameters

3.4.4. 1 Number of seeds per fruit

In each treatment, five fruits from tagged plants were collected randomly and seeds of each crossed fruit were extracted separately by fermentation method. Number of seeds per fruit was counted manually and added, the mean number of seeds per fruit was worked out.

3.4.4. 2 Seed weight per fruit (g)

In each treatment five fruits from tagged plants were selected randomly and seeds were extracted by fermentation method, dried to seven per cent seed moisture and seed weight of five fruits was recorded in grams and mean seed weight per fruit was calculated.

3.4.4. 3 Thousand seed weight (g)

Count the thousand seeds of two replication from each treatment and recorded the weight in grams.

3.4.4. 4 Seed yield per plant

The seeds were extracted from riped crossed fruits harvested from five tagged plants by following fermentation method and dried under shade for six to eight days till it reached to constant seed moisture (7.00%). The total seed weight was recorded, mean was worked out and later seed weight per plant in grams was recorded.

3.4.5 Quality parameters

3.4.5.1 Fruit color (market appeal)

Market appeal of tomato fruits judged based on fruit color, shape and overall acceptability. The fruits are evaluated by assigning different numerical as the score value based on their quality. The scale adopted by Ranganna (1986) for fruit color was used for grouping the genotypes in the different categories.

Score card

Hedonic scale	Colour & appearance	Shape	Overall acceptability
Highly acceptable	5	5	5
Acceptable	4	4	4
Fairly acceptable	3	3	3
Poorly acceptable	2	2	2
Not acceptable	1	1	1

3.4.5.2 Number of locules per fruit

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

3.4.5.3 Rind thickness

The rind thickness was measured in millimeter with the help of digital calipers and the mean was computed.

3.4.5.4 Total soluble solids (TSS)

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

3.4.5.5 pH of fruit juice

Tomato juice from each entry was extracted in a beaker and pH was measured using pH meter.

3.4.5.6 Lycopene (mg/100g)

Lycopene content of fruits was estimated through the procedure given by Sadashiam and Manickam (1992). Three to four tomato fruits were pulped well and 5 g of this pulp was taken. This pulp repeatedly extracted with acetone using pestle and mortar. Pooled acetone extract transferred to a separating funnel consisting of 20 ml petroleum ether and mixed gently. Then 20 ml of 5 per cent sodium sulphate was added in separating funnel and again 20 ml of petroleum ether was added for clear separation of layers. The two phases were separated and the lower aqueous layer re-extracted with additional 20 ml petroleum ether until the aqueous phase became colourless. Petroleum ether extract was washed with distilled water and poured into brown bottle containing 10 g anhydrous sodium sulphate. After 30 minutes petroleum extract decanted into 100 ml conical flask through cotton wool. Final volume made upto known volume by adding petroleum ether and the absorbance was measured in a spectrophotometer at 503 nm using petroleum ether as blank. Lycopene content was estimated by using following formula.

$$\text{Absorbance (1 unit)} = 3.1206 \mu\text{g lycopene/ml}$$
$$31.206 \times \text{Absorbance}$$
$$\text{Lycopene (mg) in 100 g sample} = \frac{\text{-----}}{\text{Weight of sample (g)}}$$

3.4.5.7 β-carotene (μg/100g)

β-carotene content of fruits was estimated through the procedure given by Sadashiam and Manickam (1992). Sample of 10 g is dispersed in 50 ml water-saturated n-butanol to make a homogenous suspension. It is shaken gently and allowed to stand overnight (16 h) at room temperature in complete dark. The suspension is again shaken and filtered through the whatman filter paper no.1 and the volume of filtrate is made to 100 ml. The absorbance (A) of the clear filtrate is measured at wavelength of 440 nm in spectronic 20 using saturated n-butanol as a blank. The amount of β-carotene is calculated from the slandered cure (20-200 micro gram/ml) using the following equation.

$$\beta\text{-carotene content (ppm)} = 0.0105 + 23.5366XA$$

3.4.6 Disease incidence

3.4.6.1 Tomato leaf curl virus incidence

Observations recorded at 60 days after transplanting. The total number of plants affected by ToLCV disease are recorded and expressed as per cent. The per cent disease incidence was calculated using the formula (Muniyappa *et al.*, 1991).

$$\text{Per cent disease incidence} = \frac{\text{Number of infected plants}}{\text{Total number of plants}} \times 100$$

Sl. No.	Reaction	Percent
1.	Resistant	5-9
2.	Moderately resistant	10-19
3.	Moderately Susceptible	20-39
4.	Susceptible	40-69
5.	Highly susceptible	70-100

3.4.6.2 Fruit borer incidence

The ratio of number of fruits damaged by fruit borer (*Helicoverpa armigera*) larvae as identified by the hole on upper surface or shoulder of fruit and subsequent whitening and dropping to that of total number of fruits in each genotypes in each replication was done. The scale adopted by Kashyap and Verma (1986) for fruit borer was used for grouping the genotypes in the different categories are as under.

Sl. No.	Reaction	Percent
1.	Highly resistant	0-5
2.	Resistant	5-10
3.	Moderately susceptible	10-20
4.	Susceptible	> 20

$$\text{Fruit borer incidence (\%)} = \frac{\text{Average number of damaged fruits per plant}}{\text{Total number of fruits per plant}} \times 100$$

3.6 Statistical analysis

Replication means for various characters of parents and hybrids were subjected to line x tester analysis (Kempthorne, 1957).

3.6.1 Heterosis

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

$$1) \text{ Heterosis over the better parent (\%)} = \frac{F_1 - BP}{BP} \times 100$$

(Heterobeltiosis)

Where

BP is the mean of superior parent involved in development of respective F₁ and F₁ is mean of F₁ hybrid.

$$2) \text{ Heterosis over the best parent (\%)} = \frac{F_1 - BTP}{BTP} \times 100$$

Where, BTP is the mean of the best parent among parents involved in development of F₁'s for each character.

$$3) \text{ Heterosis over the commercial checks (\%)} = \frac{F_1 - CC}{CC} \times 100$$

(Standard Heterosis)

Where, CC is the mean of commercial check JK-Desi.

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

Critical differences (CD) were calculate by multiplying the SE with table 't' value at 5 per cent and 1 per cent of probabilities for error degrees of freedom.

3. 6.2 Combining ability

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

ANOVA for combining ability

Sources	Degrees of freedom	Mean sum of squares	Expected mean sum of squares
Replication	(r - 1)		
Genotype	(l + t + lt - 1)	Mg	
Parents	(l + t - 1)	Mp	
Parents Vs crosses	1	Mpc	
Crosses	(lt - 1)	Mc	
Lines	(l - 1)	M ₁	$\sigma^2 + r\text{Cov (F.S)} - 2\text{Cov (F.S.)} + l\text{rCov (H.S.)}$
Testers	(t - 1)	M ₂	$\sigma^2 + r\text{Cov (F.S)} - 2\text{Cov (F.S.)} + t\text{rCov (H.S.)}$
Line x tester	(l - 1) x (t - 1)	M ₃	$\sigma^2 + r\text{Cov (F.S)} - 2\text{Cov (H.S.)}$
Error	(l + t + lt - 1) (r - 1)	M ₄	$\sigma\epsilon^2$
Total	(ltr-1)		

Where r = number of replications

l = Number of lines

t = Number of testers

r = Number of replication

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

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

$$\sigma_{sca}^2 = CovHS - 2CovFS$$

Estimation of combining ability effects

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

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

Where μ = population mean

g_i = gca effects of i^{th} line

g_j = gca effects of j^{th} tester

S_{ij} = sca effects of $i \times j^{\text{th}}$ cross

e_{ijk} = error associated with observation ijk

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

General combining ability effects

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

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

Specific combining ability effects

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

Where

l = number of lines

t = number of testers

r = number of replications

g_i = gca of i^{th} line

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

$x_{...}$ = total of all the crosses

g_j = gca of j^{th} testers

$x_{.j.}$ = total of cross $i \times j^{\text{th}}$ testers over all replications

S_{ij} = sca effects of $i \times j$ crosses

$x_{ij.}$ = total of ij^{th} cross

Standard errors of gca and sca effects

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

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

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

Critical difference (CD) were calculated by multiplying the SE with table 't' value at 5 per cent and 1 per cent of probabilities for error degrees of freedom.

4. EXPERIMENTAL RESULTS

Studies on heterosis and combining ability were carried out in tomato. Forty five crosses were developed by crossing each of the fifteen lines with three testers. All the crosses were evaluated along with parents and commercial check for assessing magnitude and direction of heterosis and identifying good combiners for various characters. The results obtained in the present investigation are presented with following sub headings.

- 4.1 Analysis of variance
- 4.2 *Per se* performance, magnitude and direction of heterosis
- 4.3 Combining ability effects and variance
- 4.4 Correlation studies

4.1 Analysis of variance

The results of analysis of variance for 28 characters under study are summarized and presented below (Table 4).

4.1.1 Genotypes

The variance due to genotypes (crosses and parents) was significant (at $p=0.01$) for all the growth, earliness, yield and quality parameters, viz., plant height at 60 and 90 days after transplanting (DAT), number of primary and secondary branches at 60 and 90 DAT, days to first flowering, days to 50 per cent flowering, days to first fruit set, days to first fruit maturity, equatorial and polar diameter of fruit, number of fruits per cluster, average fruit weight, number of fruits per plant, yield per plant, yield per plot, yield per hectare, number of seeds per fruit, seed weight per fruit, 1000 seed weight, seed yield per plant, number of locules per fruit, rind thickness, total soluble solids, pH, lycopene and β -carotene.

4.1.2 Parents

Parents differed significantly (at $p=0.01$) among themselves for all the growth, earliness, yield and quality parameters studied except days to first flowering, days to first fruit set varied significantly at $p=0.05$ only and days to 50 per cent flowering, days to first fruit maturity, number of fruits per cluster and lycopene did not vary significantly.

Table 4. Analysis of variance (mean sum of squares) of line x tester analysis for growth, flowering, earliness, fruit yield, seed yield and quality parameters in tomato

Sl. No.	Characters	Replications	Genotypes	Parents	Parents Vs Crosses	Crosses	Lines	Testers	Line x Tester	Error
	Degrees of freedom	1	62	17	1	44	14	2	28	62
1	Plant height at 60 DAT (cm)	66.59	131.53**	130.71**	13.27 **	134.54**	144.18**	41.86 **	119.72*	18.63
2	Plant height at 90 DAT (cm)	4.17	156.80**	108.43**	15.72 **	178.69**	121.52**	1.92 NS	138.21**	8.37
3	Number of primary branches at 60 DAT	0.76	4.07**	4.76**	13.14**	3.60**	3.58**	68 NS	19.27**	0.50
4	Number of primary branches at 90 DAT	0.002	3.15**	3.66**	7.74**	2.85**	2.40**	1.68 NS	17.86**	0.55
5	Number of secondary branches at 60 DAT	0.65	4.87**	2.23**	4.60**	5.80**	2.14**	5.82 NS	4.60**	0.54
6	Number of secondary branches at 90 DAT	1.17	6.76**	2.93**	28.56**	7.74**	2.87**	2.37 NS	2.37**	0.52
7	Days to first flowering	4.96	10.64**	11.38*	1.40 **	10.57**	11.89*	8.16 NS	10.75 **	5.37
8	Days to 50 per cent flowering	14.67	4.19**	2.19 NS	0.13 **	5.06 NS	2.58 NS	0.50 NS	0.05 **	3.48
9	Days to first fruit set	14.67	4.19 **	5.32*	0.76 **	3.83 NS	5.60 *	6.00 NS	0.005**	2.61
10	Days to first fruit maturity	6.22	11.91*	10.56 NS	1.02 **	12.68**	10.77 NS	11.16**	6.42 **	6.62
11	Equatorial diameter of fruit (mm)	12.66	61.32**	76.53**	17.37 **	56.45**	84.39**	59.37**	0.82 **	4.94
12	Polar diameter of fruit (mm)	113.12	69.02**	16.30**	208.33 **	86.22**	17.64**	3.91 NS	22.28*	3.24

Table 4 Contd...

Sl. No.	Characters	Replications	Genotypes	Parents	Parents Vs Crosses	Crosses	Lines	Testers	Line x Tester	Error
		1	62	17	1	44	14	2	28	62
13	Number of fruits per cluster	3.94	0.59**	0.69 NS	0.03 **	0.56 **	0.71 NS	0.74 NS	0.37 **	0.40
14	Average fruit weight (g)	9849.17	7914.22**	746.00**	5494.41**	8219.26**	8327.97*	2894.16**	420.13**	192.40
15	Number of fruits per plant	30.80	362.12**	332.31**	24.25*	381.31**	376.05**	108.88**	166.73**	3.91
16	Yield per plant (kg)	0.46	0.75**	0.69**	1.10**	0.76**	0.77**	0.32**	0.34**	0.01
17	Yield per plot (kg)	115.62	170.21**	156.39**	248.06**	173.77**	174.18**	71.94**	76.27**	4.51
18	Yield per hectare (t)	166.75	392.00**	350.10**	338.18**	409.42**	387.39**	165.17**	197.88**	7.69
19	Number of seeds per fruit	8.44	1884.73**	276.08**	2961.35**	1520.13**	3020.31*	353.97*	4014.07**	108.71
20	Seed weight per fruit (g)	1.91	2.73**	3.45**	0.09 **	2.52**	3.79**	2.71**	0.05**	0.07
21	1000 seed weight (g)	0.001	0.008**	0.014**	0.006**	0.005**	0.014**	0.005**	0.022**	0.003
22	Seed yield per plant (g)	0.28	25.85**	27.58**	1.35*	25.74**	31.14**	1.60**	29.73**	0.21
23	Number of locules per fruit	0.02	1.15**	1.28 **	0.16 **	1.130**	1.47**	0.61**	0.0005	0.09
24	Rind thickness (mm)	0.02	0.08**	0.09**	0.005 NS	0.09**	0.09**	0.07**	0.01*	0.004
25	Total soluble solids (^o Brix)	0.62	0.71**	1.06**	0.25 NS	0.59**	1.04**	0.98**	1.38**	0.13
26	pH	0.24	0.20**	0.20**	0.06 NS	0.20**	0.18**	0.43**	0.07**	0.07
27	Lycopene (mg/100g)	652.72	582.67**	4.86 NS	133.05 **	816.13 **	5.50 *	2.79 NS	0.031NS	58.01
28	β-carotene (mg/100g)	0.33	19.92**	10.87**	0.48 NS	23.86 **	11.40**	9.13**	6.98*	1.10

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

4.1.3 Parents Vs Crosses

The variance due to parents vs crosses was found significant (at $p=0.01$) among themselves for growth, earliness, yield and quality parameters studied except rind thickness, total soluble solids, pH and β -carotene did not vary significantly.

4.1.4 Crosses

There was significant (at $p=0.01$) difference among the crosses for all the growth, earliness, yield and quality parameters studied except for days to 50 per cent flowering and days to first fruit set did not vary significantly.

4.1.5 Lines

Lines differed significantly (at $p=0.01$) among themselves for all the growth, earliness, yield and quality parameters studied except days to first flowering and days to first fruit set varied significantly at $p=0.05$ only and days to 50 per cent flowering, days to first fruit maturity and number of fruits per cluster did not vary significantly.

4.1.6 Testers

Testers differed significantly (at $p=0.01$) among themselves for all the growth, earliness, yield and quality parameters studied except number of seeds per fruit varied significantly at $p=0.05$ only and plant height at 90 DAT, number of primary and secondary branches at 60 and 90 DAT, days to first flowering, days to 50 per cent flowering, days to first fruit set, polar diameter of fruit, number of fruits per cluster and lycopene did not vary significantly.

4.1.7 Line x Tester

Variance due to line x tester interaction was significant (at $p=0.01$) for all the growth, earliness, yield and quality parameters except rind thickness varied significantly at $p=0.05$ only.

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

The *per se* performance of crosses, parents and the commercial check are presented here under. Heterosis can be defined as superiority of F_1 over the parents. Heterosis worked out over better parent, the best parent and the commercial check (JK Desi F_1) are presented for growth, earliness, yield and quality parameters. The hybrid (JK Desi F_1) was selected as the commercial check, since it is the commercially popular widely grown F_1 hybrid.

4.2.1 Plant height (Table 5 and 6)

Genotypes varied significantly among themselves for plant height at 60 and 90 DAT. Plant height at 60 DAT ranged from 49.20 (K-3) to 81.65 cm (T-26) among lines, 52.70 (Arka Alok) to 66.46 cm (DMT-2) among testers and 41.70 (Arka Vikas x Arka Alok) to 84.20 cm (Arka Meghali x DMT-2) among crosses. Magnitude of heterosis over better parent and the commercial check was significant in both the directions. Maximum heterosis over better parent (34.54 %) was observed in the cross K-3 x Arka Alok. None of the crosses recorded positive and significant heterosis over the best parent and the cross Arka Meghali x DMT-2 recorded maximum heterosis over commercial check (30.54%). Out of 45 crosses studied, 16 crosses over better parent and eight crosses over the commercial check exhibited positive and significant heterosis.

Table 5. Per se performance of parents, crosses and commercial check for growth, flowering and earliness parameters in tomato

Sl. No.	Genotypes	Plant height (cm)		Number of primary branches		Number of secondary branches		Days to first flowering	Days to 50 per cent flowering	Days to first fruit set	Days to first fruit maturity
		60 DAT	90 DAT	60 DAT	90 DAT	60 DAT	90 DAT				
Lines											
1	T-26	81.65	94.95	7.50	8.10	5.50	7.00	29.50	35.00	37.50	82.00
2	T-36	66.10	71.95	7.05	7.20	4.20	4.60	31.50	36.00	43.00	81.50
3	Arka Vikas	55.50	63.15	7.30	8.00	5.70	6.60	35.50	38.50	42.00	80.00
4	Swarna Naveen	68.70	73.90	5.40	6.40	4.40	5.40	34.00	37.50	43.00	82.00
5	Vaibhav	55.85	66.30	7.50	8.30	6.80	8.20	28.00	33.00	37.00	78.50
6	DMT-1	50.20	60.10	5.70	6.30	5.90	7.90	28.50	36.50	37.50	82.00
7	DMT-3	53.30	56.10	6.60	6.70	4.50	5.00	36.00	36.50	42.50	81.50
8	DMT-5	56.60	61.20	7.60	8.10	4.70	5.20	32.00	36.00	40.50	82.00
9	S-22	58.50	70.30	5.50	6.70	3.80	5.40	28.50	35.50	36.50	80.50
10	Arka Meghali	53.00	59.10	9.00	9.60	7.50	7.80	28.50	37.50	37.00	78.00
11	Megha	62.63	70.30	8.90	9.70	7.20	8.70	30.50	39.50	38.00	80.50
12	K-3	49.20	54.43	5.98	6.50	4.70	6.00	31.00	40.00	39.00	84.50
13	T-57	56.00	67.87	4.90	8.10	6.90	7.50	35.00	38.50	42.00	83.00
14	TB-1	57.40	66.40	6.90	7.60	4.00	5.30	32.50	39.50	41.00	78.50
15	HUB-18	70.40	78.70	7.30	7.80	6.00	6.30	28.50	38.00	36.00	77.50
Testers											
16	Arka Abha	57.90	64.85	8.20	9.95	7.10	8.30	34.50	36.50	43.00	81.00
17	Arka Alok	52.70	59.10	10.00	11.80	7.85	8.20	33.50	36.00	40.00	76.00
18	DMT-2	66.46	80.89	9.35	9.38	4.37	6.40	32.00	34.50	39.50	83.00

Table 5 contd.....

Sl. No.	Genotypes	Plant height (cm)		Number of primary branches		Number of secondary branches		Days to first flowering	Days to 50 per cent flowering	Days to first fruit set	Days to first fruit maturity
		60 DAT	90 DAT	60 DAT	90 DAT	60 DAT	90 DAT				
	Crosses										
19	T-26 X Arka Abha	69.00	73.50	9.10	10.35	4.80	6.30	28.50	35.50	37.50	78.00
20	T-26 X Arka Alok	71.50	78.50	8.70	9.40	7.30	8.30	29.00	33.00	38.00	75.50
21	T-26 X DMT-2	68.10	74.70	10.00	11.70	7.90	8.40	29.00	33.50	36.00	75.50
22	T-36 X Arka Abha	55.60	60.80	11.00	11.20	7.90	8.20	29.50	35.50	38.50	80.50
23	T-36 X Arka Alok	59.20	64.80	10.00	10.50	5.95	6.40	32.50	36.50	40.50	78.00
24	T-36 X DMT-2	73.50	78.60	9.65	10.30	5.40	7.80	28.50	35.00	37.50	78.00
25	Arka VikasX Arka Abha	61.10	68.80	8.90	9.25	5.80	7.35	29.50	36.00	39.00	77.00
26	Arka Vikas X Arka Alok	41.70	56.70	8.10	8.85	7.80	8.60	30.00	35.50	39.50	77.50
27	Arka Vikas X DMT-2	66.50	70.55	8.30	8.40	6.00	6.50	28.00	35.00	36.50	80.00
28	Swarna Naveen X Arka Abha	69.30	75.00	8.90	10.05	6.50	6.80	27.50	35.50	37.00	75.00
29	Swarna Naveen X Arka Alok	50.80	60.25	8.30	8.40	5.60	7.20	32.00	38.50	40.50	76.50
30	Swarna Naveen X DMT-2	80.60	84.65	9.20	9.80	4.90	5.50	31.50	34.50	38.50	83.50
31	Vaibhav X Arka Abha	65.90	77.55	7.90	8.10	5.20	6.65	28.50	34.00	37.00	78.00
32	Vaibhav X Arka Alok	57.60	70.20	7.55	8.40	6.50	8.80	35.50	38.50	44.00	79.50
33	Vaibhav X DMT-2	63.90	77.60	5.70	6.20	6.80	7.50	31.50	35.50	38.00	79.00
34	DMT -1 X Arka Abha	60.10	73.40	8.01	9.30	7.01	8.82	30.50	35.50	38.00	80.00

Table 5 contd.....

Sl. No.	Genotypes	Plant height (cm)		Number of primary branches		Number of secondary branches		Days to first flowering	Days to 50 per cent flowering	Days to first fruit set	Days to first fruit maturity
		60 DAT	90 DAT	60 DAT	90 DAT	60 DAT	90 DAT				
35	DMT -1 X Arka Alok	57.75	60.20	7.40	7.80	7.15	8.80	32.00	36.50	39.50	76.00
36	DMT -1 X DMT-2	63.50	77.30	8.30	8.50	7.40	8.05	31.50	36.50	41.50	80.00
37	DMT-5 X Arka Abha	70.85	81.15	8.00	9.10	7.10	8.50	32.00	33.50	39.50	79.50
38	DMT-5 X Arka Alok	71.80	80.45	8.90	9.30	7.30	8.75	27.00	33.50	38.50	76.50
39	DMT-5 X DMT-2	75.80	83.24	5.80	7.50	4.30	6.60	30.00	35.50	38.00	76.50
40	S-22 X Arka Abha	73.60	84.70	6.75	7.40	7.20	8.50	32.00	36.50	40.50	78.50
41	S-22 X Arka Alok	60.40	76.65	6.40	7.02	5.25	5.60	31.00	36.50	39.50	76.50
42	S-22 X DMT-2	80.60	91.60	9.30	9.70	8.70	8.95	27.50	32.50	37.50	74.50
43	Arka Meghali X Arka Abha	62.10	69.80	7.30	8.60	5.30	7.75	30.50	34.00	38.00	75.00
44	Arka Meghali X Arka Alok	59.10	65.80	9.00	9.75	8.60	8.59	29.00	36.50	36.50	76.50
45	Arka Meghali X DMT-2	84.20	89.80	8.00	8.30	6.20	6.80	28.00	32.50	36.50	77.50
46	Megha X Arka Abha	78.15	83.50	5.00	5.70	4.20	4.60	33.00	35.00	41.00	78.50
47	Megha X Arka Alok	68.80	75.20	7.60	7.90	6.10	6.70	31.00	35.50	40.50	79.50
48	Megha X DMT-2	52.10	58.50	5.70	6.40	4.70	5.90	27.00	34.00	36.00	76.00
49	K-3 X Arka Abha	70.60	76.85	7.15	7.50	6.70	7.00	30.00	35.50	38.50	78.50
50	K-3 X Arka Alok	70.90	76.75	8.20	8.90	5.80	7.80	31.50	34.00	38.50	79.50
51	K-3 X DMT-2	70.10	80.10	8.90	9.70	7.90	8.30	31.00	36.00	38.50	80.50

Table 5 contd.....

Sl. No.	Genotypes	Plant height (cm)		Number of primary branches		Number of secondary branches		Days to first flowering	Days to 50 per cent flowering	Days to first fruit set	Days to first fruit maturity
		60 DAT	90 DAT	60 DAT	90 DAT	60 DAT	90 DAT				
52	T-57 X Arka Abha	66.70	69.45	10.00	10.10	9.70	10.60	31.00	36.50	40.50	80.00
53	T-57 X Arka Alok	71.55	82.80	8.80	9.02	8.01	7.30	28.50	35.50	40.00	83.00
54	T-57 X DMT-2	66.10	81.70	9.10	9.40	7.00	7.70	27.50	35.00	37.50	82.00
55	TB-1 X Arka Abha	57.15	68.20	9.70	10.60	8.70	9.35	27.50	33.00	37.00	78.00
56	TB-1 X Arka Alok	71.00	86.35	8.60	9.80	7.40	8.01	30.50	34.00	38.50	82.00
57	TB-1 X DMT-2	74.50	76.20	9.00	9.30	8.00	8.35	31.50	36.50	40.00	82.00
58	HUB-18X Arka Abha	59.70	64.30	8.20	8.70	7.20	7.90	30.00	36.50	39.50	80.50
59	HUB-18X Arka Alok	62.00	73.10	9.10	9.50	6.10	6.50	28.00	35.00	39.00	81.00
60	HUB-18X DMT-2	61.65	72.85	8.80	9.20	4.90	5.30	30.00	34.00	40.00	81.50
61	DMT-3 X Arka Abha	55.80	65.30	8.50	9.10	7.90	8.50	31.00	37.50	42.00	81.00
62	DMT-3 X Arka Alok	63.80	70.35	7.10	8.50	6.00	6.20	28.00	34.00	36.50	78.00
63	DMT-3 X DMT-2	61.65	72.60	8.30	8.55	6.00	6.75	32.00	36.50	39.00	79.00
Commercial check											
64	JK-Desi (F ₁)	64.5	78.85	7.06	7.75	5.50	6.80	32.00	36.00	41.00	81.50
	S.Em±	7.28	7.71	0.93	0.78	0.86	0.63	1.83	1.38	1.72	0.89
	C.D. at 5%	16.82	18.44	2.01	1.66	1.78	1.61	4.69	2.89	4.22	2.52
	C.D.at 1%	22.36	24.52	2.68	2.21	2.36	2.14	6.24	3.85	5.61	3.36

DAT: Days after transplanting

Table 6. Heterosis (%) over better parent, best parent and commercial check for plant height (60 and 90) and number of primary branches at 60 DAT n tomato

Sl. No.	Crosses	Plant height at 60 DAT			Plant height at 90 DAT			Number of primary branches at 60 DAT		
		BP	BTP	CC	BP	BTP	CC	BP	BTP	CC
1	T-26 x Arka Abha	-15.49**	-15.49**	6.98	-22.59**	-22.59**	-6.79*	10.98**	-9.00**	28.90**
2	T-26 x Arka Alok	-12.43**	-12.43**	10.85*	-17.32**	-17.32**	-0.44	-13.00**	-13.00**	23.23**
3	T-26 x DMT-2	-16.60**	-16.60**	5.58	-21.33**	-21.33**	-5.26	6.95**	0.00	41.64**
4	T-36 x Arka Abha	-15.89**	-31.90**	-13.80**	-15.50**	-35.97**	-22.89**	34.15**	10.00**	55.81**
5	T-36 x Arka Alok	-10.44*	-27.50**	-8.22	-9.94**	-31.75**	-17.82**	0.00	0.00	41.64**
6	T-36 x DMT-2	10.59*	-9.98*	13.95**	-2.83	-17.22**	-0.32	3.21**	-3.50**	36.69**
7	Arka Vikas x Arka Abha	5.53	-25.17**	-5.27	6.09*	-27.54**	-12.75**	8.54**	-11.00**	26.06**
8	Arka Vikas x Arka Alok	-24.86**	-48.93**	-35.35**	-10.21**	-40.28**	-28.09**	-19.00**	-19.00**	14.73**
9	Arka Vikas x DMT-2	0.06	-18.55**	3.10	-12.78**	-25.70**	-10.53**	-11.23**	-17.00**	17.56**
10	Swarna Naveen x Arka Abha	0.87	-15.13**	7.44	1.49	-21.01**	-4.88	8.54**	-11.00**	26.06**
11	Swarna Naveen x Arka Alok	-26.06**	-37.78**	-21.24**	-18.47**	-36.55**	-23.59**	-17.00**	-17.00**	17.56**
12	Swarna Naveen x DMT-2	17.32**	-1.29	24.96**	4.65	-10.85**	7.36*	-1.60*	-8.00**	30.31**
13	Vaibhav x Arka Abha	13.82**	-19.29**	2.17	16.97**	-18.33**	-1.65	-3.66**	-21.00**	11.90**
14	Vaibhav x Arka Alok	3.13	-29.45**	-10.70*	5.88*	-26.07**	-10.97**	-24.50**	-24.50**	6.94**
15	Vaibhav x DMT-2	-3.85	-21.74**	-0.93	-4.07	-18.27**	-1.59	-39.04**	-43.00**	-19.26**
16	DMT -1 x Arka Abha	3.80	-26.39**	-6.82	13.11**	-22.70**	-6.91*	-2.32**	-19.90**	13.46**
17	DMT -1 x Arka Alok	9.58*	-29.27**	-10.47*	0.17	-36.60**	-23.65**	-26.00**	-26.00**	4.82**

Table 6 contd.....

Sl. No.	Crosses	Plant height at 60 DAT			Plant height at 90 DAT			Number of primary branches at 60 DAT		
		BP	BTP	CC	BP	BTP	CC	BP	BTP	CC
18	DMT -1 x DMT-2	-4.45	-22.23**	-1.55	-4.44	-18.59**	-1.97	-11.23**	-17.00**	17.56**
19	DMT-5 x Arka Abha	22.37**	-13.23**	9.84*	25.13**	-14.53**	2.92	-2.44**	-20.00**	13.31**
20	DMT-5 x Arka Alok	26.86**	-12.06**	11.32*	31.45**	-15.27**	2.03	-11.00**	-11.00**	26.06**
21	DMT-5 x DMT-2	14.05**	-7.16	17.52**	2.91	-12.33**	5.57	-37.97**	-42.00**	-17.85**
22	S-22 x Arka Abha	25.81**	-9.86*	14.11**	20.48**	-10.80**	7.42*	-17.68**	-32.50**	-4.39**
23	S-22 x Arka Alok	3.25	-26.03**	-6.36	9.03**	-19.27**	-2.79	-36.00**	-36.00**	-9.35**
24	S-22 x DMT-2	21.28**	-1.29	24.96**	13.24**	-3.53	16.17**	-0.53	-7.00**	31.73**
25	Arka Meghali x Arka Abha	7.25	-23.94**	-3.72	7.63*	-26.49**	-11.48**	-29.13**	-27.00**	3.40**
26	Arka Meghali x Arka Alok	11.51*	-27.62**	-8.37	11.34**	-30.70**	-16.55**	-3.74**	-10.00**	27.48**
27	Arka Meghali x DMT-2	34.44**	3.12	30.54**	11.01**	-5.42	13.89**	-14.43**	-20.00**	13.31**
28	Megha x Arka Abha	24.78**	-4.29	21.16**	18.78**	-12.06**	5.90*	-43.82**	-50.00**	-29.18**
29	Megha x Arka Alok	9.85*	-15.74**	6.67	6.97*	-20.80**	-4.63	-24**	-24.00**	7.65**
30	Megha x DMT-2	-21.61**	-36.19**	-19.22**	-27.68**	-38.39**	-25.81**	-39.04**	-43.00**	-19.26**
31	K-3 x Arka Abha	21.93**	-13.53**	9.46*	18.50**	-19.06**	-2.54	-12.80**	-28.50**	1.27
32	K-3 x Arka Alok	34.54**	-13.17**	9.92*	29.86**	-19.17**	-2.66	-18**	-18.00**	16.15**
33	K-3 x DMT-2	5.48	-14.15**	8.68	-0.98	-15.64**	1.59	-4.81**	-11.00**	26.06**
34	T-57 x Arka Abha	15.20**	-18.31**	3.41	2.30	-26.86**	-11.92**	21.95**	0.00	41.64**
35	T-57 x Arka Alok	27.77**	-12.37**	10.93*	21.96**	-12.80**	5.01	-12**	-12.00**	24.65**

Table 6 contd.....

Sl. No.	Crosses	Plant height at 60 DAT			Plant height at 90 DAT			Number of primary branches at 60 DAT		
		BP	BTP	CC	BP	BTP	CC	BP	BTP	CC
36	T-57 x DMT-2	-0.54	-19.04**	2.48	1.00	-13.95**	3.61	-2.67**	-9.00**	28.90**
37	TB-1 x Arka Abha	-0.44	-30.01**	-11.40*	2.71	-28.17**	-13.51**	18.29**	-3.00**	37.39**
38	TB-1 x Arka Alok	23.69**	-13.04**	10.08*	30.05**	-9.06**	9.51**	-14**	-14.00**	21.81**
39	TB-1 x DMT-2	12.10**	-8.76*	15.50**	-5.80	-19.75**	-3.36	-3.74**	-10.00**	27.48**
40	HUB-18X Arka Abha	-15.20**	-26.88**	-7.44	-18.30**	-32.28**	-18.45**	0	-18.00**	16.15**
41	HUB-18X Arka Alok	-11.93**	-24.07**	-3.88	-7.12*	-23.01**	-7.29*	-9**	-9.00**	28.90**
42	HUB-18X DMT-2	-12.43**	-24.49**	-4.42	-9.94**	-23.28**	-7.61*	-5.88**	-12.00**	24.65**
43	DMT-3 x Arka Abha	-3.63	-31.66**	-13.49**	0.69	-31.23**	-17.18**	3.66**	-15.00**	20.40**
44	DMT-3 x Arka Alok	19.70**	-21.86**	-1.09	19.04**	-25.91**	-10.78**	-29**	-29.00**	0.57
45	DMT-3 x DMT-2	-7.24	-24.49**	-4.42	-10.25**	-23.54**	-7.93**	-11.23**	-17.00**	17.56**
	S.Em±	4.31	4.31	4.31	2.89	2.89	2.89	0.71	0.71	0.71
	C.D. at 5%	8.70	8.70	8.70	5.83	5.83	5.83	1.43	1.43	1.43
	C.D. at 1%	11.62	11.62	11.62	7.79	7.79	7.79	1.91	1.91	1.91

*and ** indicate significance of values at $p=0.05$ and 0.01 , respectively. BP- Heterosis over better parent, BTP- Heterosis over the best parent, CC- Heterosis over the commercial check (JK-Desi F_1), DAT- Days after transplanting.

Plant height at 90 DAT varied from 54.43 (K-3) to 94.95 cm (T-26) among lines, 59.10 (Arka Alok) to 80.89 cm (DMT-2) among testers and 56.70 (Arka Vikas x Arka Alok) to 91.60 cm (S-22 x DMT-2) among crosses. Magnitude of heterosis over better parent and the commercial check was significant in both the directions. Maximum heterosis over better parent (31.45%) was observed in the cross DMT-5 x Arka Alok. None of the crosses recorded positive and significant heterosis over the best parent and the cross S-22 x DMT-2 recorded maximum heterosis over commercial check (16.17%). Among 45 crosses studied, 15 crosses over better parent and three crosses over the commercial check exhibited positive and significant heterosis.

4.2.2 Number of primary branches (Table 5 and 6)

Genotypes varied significantly among themselves for number of primary branches at 60 and 90 DAT. Number of primary branches per plant at 60 DAT ranged from 4.90 (T-57) to 9.00 (Arka Meghali) among lines, 8.20 (Arka Abha) to 10.00 (Arka Alok) among testers and 5.0 (Megha x Arka Abha) to 11.00 (T-36 x Arka Abha) among crosses. Magnitude of heterosis over better parent, the best parent and the commercial check was significant in both the directions. Maximum heterosis over better parent (34.15%) was observed in the cross T-36 x Arka Abha. The cross T-36 x Arka Abha exhibited maximum heterosis over the best parent (10.00%) and heterosis over commercial check (55.81%). Among 45 crosses studied, 9 crosses over better parent, one crosses over best parent and 37 crosses over the commercial check exhibited positive and significant heterosis for number of primary branches at 60 DAT

Number of primary branches per plant at 90 DAT ranged from 6.30 (DMT-1) to 9.70 (Megha) among lines, 9.38 (DMT-2) to 11.80 (Arka Alok) among testers and 5.70 (Megha x Arka Abha) to 10.60 (TB-1 x Arka Abha) among crosses. Magnitude of heterosis over better parent, the best parent and the commercial check was significant in both the directions. Maximum heterosis over better parent (24.73%) was observed in the cross T-26 x DMT-2 and the commercial check (50.97%). Among 45 crosses studied, eight crosses over better parent, and 36 crosses over the commercial check exhibited positive and significant heterosis.

4.2.3 Number of secondary branches (Table 5 and 7)

Genotypes varied significantly among themselves for number secondary branches 60 and 90 DAT. Number of secondary branches at 60 DAT ranged from 3.80 (S-22) to 7.50 (Arka Meghali) among lines, 4.37 (DMT-2) to 7.85 (Arka Alok) among testers and 4.20 (Megha x Arka Abha) to 9.70 (T-57 x Arka Abha) among crosses. Magnitude of heterosis over better parent, the best parent and the commercial check was significant in both the directions. Maximum heterosis over better parent (99.08%) was observed in the cross S-22 x DMT-2 and maximum heterosis over the best parent (23.57%) and the commercial check (76.36%). Among 45 crosses studied, 15 crosses over better parent, five crosses over the best parent and 34 crosses over the commercial check exhibited positive and significant heterosis for number of secondary branches at 60 DAT.

Number of secondary branches 90 DAT ranged from 4.60 (T-36) to 8.70 (Megha) among lines, 6.40 (DMT-2) to 8.30 (Arka Abha) among testers and 4.60 (Megha x Arka Abha) to 10.60 (T-57 x Arka Abha) among crosses. Magnitude of heterosis over better parent, the best parent and the commercial check was significant in both the directions. Maximum heterosis over better parent (39.84%) was observed in the cross S-22 x DMT-2 and the cross T-57 x Arka Abha exhibited maximum heterosis over the best parent (21.84%) and the commercial check (55.88%). Among 45 crosses studied, 19 crosses over better parent, two crosses over the best parent and 28 crosses over the commercial check exhibited positive and significant heterosis.

Table 7. Heterosis (%) over better parent, best parent and commercial check for number of primary and secondary branches in tomato

Sl. No.	Crosses	Number of primary branches at 90 DAT			Number of secondary branches at 60 DAT			Number of secondary branches at 90 DAT		
		BP	BTP	CC	BP	BTP	CC	BP	BTP	CC
1	T-26 x Arka Abha	4.02**	-12.29**	33.55**	-32.39**	-38.85**	-12.73**	-24.10**	-27.59**	-7.35**
2	T-26 x Arka Alok	-20.34**	-20.34**	21.29**	-7.01**	-7.01**	32.73**	1.22	-4.60**	22.06**
3	T-26 x DMT-2	24.73**	-0.85	50.97**	43.64**	0.64	43.64**	20.00**	-3.45**	23.53**
4	T-36 x Arka Abha	12.56**	-5.08**	44.52**	11.27**	0.64	43.64**	-1.20	-5.75**	20.59**
5	T-36 x Arka Alok	-11.02**	-11.02**	35.48**	-24.20**	-24.20**	8.18**	-21.95**	-26.44**	-5.88**
6	T-36 x DMT-2	9.81**	-12.71**	32.90**	23.57**	-31.21**	-1.82*	21.88**	-10.34**	14.71**
7	Arka Vikas x Arka Abha	-7.04**	-21.61**	19.35**	-18.31**	-26.11**	5.45**	-11.45**	-15.52**	8.09**
8	Arka Vikas x Arka Alok	-25.00**	-25.00**	14.19**	-0.64	-0.64	41.82**	4.88**	-1.15	26.47**
9	Arka Vikas x DMT-2	-10.45**	-28.81**	8.39**	37.30**	-23.57**	9.09**	-1.52*	-25.29**	-4.41**
10	Swarna Naveen x Arka Abha	1.01	-14.83**	29.68**	-8.45**	-17.20**	18.18**	-18.07**	-21.84**	0.00
11	Swarna Naveen x Arka Alok	-28.81**	-28.81**	8.39**	-28.66**	-28.66**	1.82*	-12.20**	-17.24**	5.88**
12	Swarna Naveen x DMT-2	4.48**	-16.95**	26.45**	11.36**	-37.58**	-10.91**	-14.06**	-36.78**	-19.12**
13	Vaibhav x Arka Abha	-18.59**	-31.36**	4.52**	-26.76**	-33.76**	-5.45**	-19.88**	-23.56**	-2.21**
14	Vaibhav x Arka Alok	-28.81**	-28.81**	8.39**	-17.20**	-17.20**	18.18**	7.32**	1.15	29.41**
15	Vaibhav x DMT-2	-33.90**	-47.46**	-20.00**	0.00	-13.38**	23.64**	-8.54**	-13.79**	10.29**
16	DMT -1 x Arka Abha	-6.53**	-21.19**	20.00**	-1.27	-10.70**	27.45**	6.27**	1.38	29.71**
17	DMT -1 x Arka Alok	-33.90**	-33.90**	0.65	-8.92**	-8.92**	30.00**	7.32**	1.15	29.41**

Table 7 contd.....

Sl. No.	Crosses	Number of primary branches at 90 DAT			Number of secondary branches at 60 DAT			Number of secondary branches at 90 DAT		
		BP	BTP	CC	BP	BTP	CC	BP	BTP	CC
18	DMT -1 x DMT-2	-9.38**	-27.97**	9.68**	25.42**	-5.73**	34.55**	1.90*	-7.47**	18.38**
19	DMT-5 x Arka Abha	-8.54**	-22.88**	17.42**	0.00	-9.55**	29.09**	2.41**	-2.30**	25.00**
20	DMT-5 x Arka Alok	-21.19**	-21.19**	20.00**	-7.01**	-7.01**	32.73**	6.71**	0.57	28.68**
21	DMT-5 x DMT-2	-20.04**	-36.44**	-3.23**	-8.51**	-45.22**	-21.82**	3.12**	-24.14**	-2.94**
22	S-22 x Arka Abha	-25.63**	-37.29**	-4.52**	1.41	-8.28**	30.91**	2.41**	-2.30**	25.00**
23	S-22 x Arka Alok	-40.51**	-40.51**	-9.42**	-33.12**	-33.12**	-4.55**	-31.71**	-35.63**	-17.65**
24	S-22 x DMT-2	3.41**	-17.80**	25.16**	99.08**	10.83**	58.18**	39.84**	2.87**	31.62**
25	Arka Meghali x Arka Abha	-13.57**	-27.12**	10.97**	-29.33**	-32.48**	-3.64**	-6.63**	-10.92**	13.97**
26	Arka Meghali x Arka Alok	-17.37**	-17.37**	25.81**	9.55**	9.55**	56.36**	4.76**	-1.26	26.32**
27	Arka Meghali x DMT-2	-13.54**	-29.66**	7.10**	-17.33**	-21.02**	12.73**	-12.82**	-21.84**	0.00
28	Megha x Arka Abha	-42.71**	-51.69**	-26.45**	-41.67**	-46.50**	-23.64**	-47.13**	-47.13**	-32.35**
29	Megha x Arka Alok	-33.05**	-33.05**	1.94*	-19.53**	-22.29**	10.91**	-22.99**	-22.99**	-1.47**
30	Megha x DMT-2	-34.02**	-45.76**	-17.42**	-34.72**	-40.13**	-14.55**	-32.18**	-32.18**	-13.24**
31	K-3 x Arka Abha	-24.62**	-36.44**	-3.23**	-5.63**	-14.65**	21.82**	-15.66**	-19.54**	2.94**
32	K-3 x Arka Alok	-24.58**	-24.58**	14.84**	-26.11**	-26.11**	5.45**	-4.88**	-10.34**	14.71**
33	K-3 x DMT-2	3.41**	-17.80**	25.16**	68.09**	0.64	43.64**	29.69**	-4.60**	22.06**
34	T-57 x Arka Abha	1.51*	-14.41**	30.32**	36.62**	23.57**	76.36**	27.71**	21.84**	55.88**
35	T-57 x Arka Alok	-23.56**	-23.56**	16.39**	2.04**	2.04**	45.64**	-10.98**	-16.09**	7.35**

Table 7 contd.....

Sl. No.	Crosses	Number of primary branches at 90 DAT			Number of secondary branches at 60 DAT			Number of secondary branches at 90 DAT		
		BP	BTP	CC	BP	BTP	CC	BP	BTP	CC
36	T-57 x DMT-2	0.21	-20.34**	21.29**	1.45	-10.83**	27.27**	2.67**	-11.49**	13.24**
37	TB-1 x Arka Abha	6.53**	-10.17**	36.77**	22.54**	10.83**	58.18**	12.65**	7.47**	37.50**
38	TB-1 x Arka Alok	-16.95**	-16.95**	26.45**	-5.73**	-5.73**	34.55**	-2.32**	-7.93**	17.79**
39	TB-1 x DMT-2	-0.85	-21.19**	20.00**	83.07**	1.91*	45.45**	30.47**	-4.02**	22.79**
40	HUB-18X Arka Abha	-12.56**	-26.27**	12.26**	1.41	-8.28**	30.91**	-4.82**	-9.20**	16.18**
41	HUB-18X Arka Alok	-19.49**	-19.49**	22.58**	-22.29**	-22.29**	10.91**	-20.73**	-25.29**	-4.41**
42	HUB-18X DMT-2	-1.92*	-22.03**	18.71**	-18.33**	-37.58**	-10.91**	-17.19**	-39.08**	-22.06**
43	DMT-3 x Arka Abha	-8.54**	-22.88**	17.42**	11.27**	0.64	43.64**	2.41**	-2.30**	25.00**
44	DMT-3 x Arka Alok	-27.97**	-27.97**	9.68**	-23.57**	-23.57**	9.09**	-24.39**	-28.74**	-8.82**
45	DMT-3 x DMT-2	-8.85**	-27.54**	10.32**	33.33**	-23.57**	9.09**	5.47**	-22.41**	-0.74
	S.Em±	0.74	0.74	0.74	0.73	0.73	0.73	0.72	0.72	0.72
	C.D. at 5%	1.49	1.49	1.49	1.48	1.48	1.48	1.46	1.46	1.46
	C.D.at 1%	2.00	2.00	2.00	1.98	1.98	1.98	1.95	1.95	1.95

*and ** indicate significance of values at $p=0.05$ and 0.01 , respectively. BP- Heterosis over better parent, BTP- Heterosis over the best parent, CC- Heterosis over the commercial check (JK-Desi F_1), DAT- Days after transplanting.

4.2.4 Days to first flowering (Table 5 and 8)

Genotypes varied significantly among themselves for days to first flowering varied from 28.00 (Vaibhav) to 36.00 (DMT-3) among lines, 32.00 (DMT-2) to 34.50 (Arka Abha) among testers and 27.50 (Swarna Naveen x Arka Abha) to 35.50 (Vaibhav x Arka Alok) among crosses. Magnitude of heterosis over better parent, the best parent and the commercial check was significant in both directions. Negative heterosis for this trait indicates earliness and is desirable. Maximum heterosis over better parent (-19.12%) was observed in the cross Swarna Naveen x Arka Abha and none of the crosses were showed heterosis over the best parent and the cross DMT-5 x Arka Alok exhibited maximum heterosis over the commercial check (-15.63%). Among 45 crosses studied, 15 crosses over better parent and 9 crosses over the commercial check exhibited negative and significant heterosis.

4.2.5 Days to 50 per cent flowering (Table 5 and 8)

Genotypes varied significantly among themselves for days to 50 per cent flowering varied from 33.00 (Vaibhav) to 40.00 (K-3) among lines, 34.50 (DMT-2) to 36.50 (Arka Abha) among testers and 32.50 (S-22 x DMT-2) to 38.50 (Swarna Naveen x Arka Alok) among crosses. Magnitude of heterosis over better parent, the best parent and the commercial check was significant in both directions. Negative heterosis for this trait indicates earliness and is desirable. Maximum heterosis over best parent (-9.59%) was observed in the cross TB-1 x Arka Abha and None of the crosses recorded negative and significant heterosis over the best parent and the cross S-22 x DMT-2 was recorded maximum heterosis over commercial check (-9.72%). Among 45 crosses studied, 14 crosses over better parent and 14 crosses over the commercial check exhibited positive and significant heterosis.

Table 8. Heterosis (%) over better parent, best parent and commercial check for days to first flowering, days to 50 per cent flowering and days to first fruit set in tomato

Sl. No.	Crosses	Days to first flowering			Days to 50 per cent flowering			Days to first fruit set		
		BP	BTP	CC	BP	BTP	CC	BP	BTP	CC
1	T-26 x Arka Abha	-3.39	1.79	-10.94**	1.43	7.58	-1.39	0	4.17*	-8.54**
2	T-26 x Arka Alok	-1.69	3.57	-9.38**	-5.71**	0.00	-8.33**	1.33	5.56**	-7.32**
3	T-26 x DMT-2	-1.69	3.57	-9.38**	-2.90	1.52	-6.94**	-4.00*	0.00	-12.20**
4	T-36 x Arka Abha	-6.35**	5.36*	-7.81**	-1.39	7.58	-1.39	-10.47**	6.94**	-6.10**
5	T-36 x Arka Alok	3.17	16.07**	1.56	1.39	10.61	1.39	1.25	12.50**	-1.22
6	T-36 x DMT-2	-9.52**	1.79	-10.94**	1.45	6.06	-2.78	-5.06**	4.17*	-8.54**
7	Arka Vikas x Arka Abha	-7.81**	5.36*	-7.81**	-1.37	9.09	0.00	-7.14**	8.33**	-4.88**
8	Arka Vikas x Arka Alok	-6.25**	7.14**	-6.25**	-1.39	7.58	-1.39	-1.25	9.72**	-3.66*
9	Arka Vikas x DMT-2	-12.50**	0.00	-12.50**	1.45	6.06	-2.78	-7.59**	1.39	-10.98**
10	Swarna Naveen x Arka Abha	-19.12**	-1.79	-14.06**	-2.74	7.58	-1.39	-13.95**	2.78	-9.76**
11	Swarna Naveen x Arka Alok	-4.48	14.29**	0.00	6.94**	16.67	6.94**	1.25	12.50**	-1.22
12	Swarna Naveen x DMT-2	-1.56	12.50**	-1.56	0.00	4.55	-4.17*	-2.53	6.94**	-6.10**
13	Vaibhav x Arka Abha	1.79	1.79	-10.94**	3.03	3.03	-5.56**	0.00	2.78	-9.76**
14	Vaibhav x Arka Alok	26.79**	26.79**	10.94**	16.67**	16.67	6.94**	18.92**	22.22**	7.32**
15	Vaibhav x DMT-2	12.50**	12.50**	-1.56	7.58**	7.58	-1.39	2.70	5.56**	-7.32**
16	DMT -1 x Arka Abha	7.02**	8.93**	-4.69	-2.74	7.58	-1.39	1.33	5.56**	-7.32**
17	DMT -1 x Arka Alok	12.28**	14.29**	0.00	1.39	10.61	1.39	5.33**	9.72**	-3.66*

Table 8 contd.....

Sl. No.	Crosses	Days to first flowering			Days to 50 per cent flowering			Days to first fruit set		
		BP	BTP	CC	BP	BTP	CC	BP	BTP	CC
18	DMT -1 x DMT-2	10.53**	12.50**	-1.56	5.80**	10.61	1.39	10.67**	15.28**	1.22
19	DMT-5 x Arka Abha	0.00	14.29**	0.00	-6.94**	1.52	-6.94**	-2.47	9.72**	-3.66*
20	DMT-5 x Arka Alok	-15.63**	-3.57	-15.63**	-6.94**	1.52	-6.94**	-3.75*	6.94**	-6.10**
21	DMT-5 x DMT-2	-6.25**	7.14**	-6.25**	2.90	7.58	-1.39	-3.80*	5.56**	-7.32**
22	S-22 x Arka Abha	12.28**	14.29**	0.00	2.82	10.61	1.39	10.96**	12.50**	-1.22
23	S-22 x Arka Alok	8.77**	10.71**	-3.13	2.82	10.61	1.39	8.22**	9.72**	-3.66*
24	S-22 x DMT-2	-3.51	-1.79	-14.06**	-5.80**	-1.52	-9.72**	2.74	4.17**	-8.54**
25	Arka Meghali x Arka Abha	7.02**	8.93**	-4.69	-6.85**	3.03	-5.56**	2.70	5.56**	-7.32**
26	Arka Meghali x Arka Alok	1.75	3.57	-9.38**	1.39	10.61	1.39	-1.35	1.39	-10.98**
27	Arka Meghali x DMT-2	-1.75	0.00	-12.50**	-5.80**	-1.52	-9.72**	-1.35	1.39	-10.98**
28	Megha x Arka Abha	8.20**	17.86**	3.13	-4.11	6.06	-2.78	7.89**	13.89**	0.00
29	Megha x Arka Alok	1.64	10.71**	-3.13	-1.39	7.58	-1.39	6.58**	12.50**	-1.22
30	Megha x DMT-2	-11.48**	-3.57	-15.63**	-1.45	3.03	-5.56**	-5.26**	0.00	-12.20**
31	K-3 x Arka Abha	-3.23	7.14**	-6.25**	-2.74	7.58	-1.39	-1.28	6.94**	-6.10**
32	K-3 x Arka Alok	1.61	12.50**	-1.56	-5.56**	3.03	-5.56**	-1.28	6.94**	-6.10**
33	K-3 x DMT-2	0.00	10.71**	-3.13	4.35*	9.09	0.00	-1.28	6.94**	-6.10**
34	T-57 x Arka Abha	-10.14**	10.71**	-3.13	0.00	10.61	1.39	-3.57*	12.50**	-1.22
35	T-57 x Arka Alok	-14.93**	1.79	-10.94**	-1.39	7.58	-1.39	0.00	11.11**	-2.44

Table 8 contd.....

Sl. No.	Crosses	Days to first flowering			Days to 50 per cent flowering			Days to first fruit set		
		BP	BTP	CC	BP	BTP	CC	BP	BTP	CC
36	T-57 x DMT-2	-14.06**	-1.79	-14.06**	1.45	6.06	-2.78	-5.06**	4.17*	-8.54**
37	TB-1 x Arka Abha	-15.38**	-1.79	-14.06**	-9.59**	0.00	-8.33**	-9.76**	2.78	-9.76**
38	TB-1 x Arka Alok	-6.15*	8.93**	-4.69	-5.56**	3.03	-5.56**	-3.75*	6.94**	-6.10**
39	TB-1 x DMT-2	-1.56	12.50**	-1.56	5.80**	10.61	1.39	1.27	11.11**	-2.44
40	HUB-18X Arka Abha	5.26*	7.14**	-6.25**	0.00	10.61	1.39	9.72**	9.72**	-3.66*
41	HUB-18X Arka Alok	-1.75	0.00	-12.50**	-2.78	6.06	-2.78	8.33**	8.33**	-4.88**
42	HUB-18X DMT-2	5.26*	7.14**	-6.25**	-1.45	3.03	-5.56**	11.11**	11.11**	-2.44
43	DMT-3 x Arka Abha	-10.14**	10.71**	-3.13	2.74	13.64	4.17*	-1.18	16.67**	2.44
44	DMT-3 x Arka Alok	-16.42**	0.00	-12.50**	-5.56**	3.03	-5.56**	-8.75**	1.39	-10.98**
45	DMT-3 x DMT-2	0.00	14.29**	0.00	5.80**	10.61	1.39	-1.27	8.33**	-4.88**
	S.Em±	2.31	2.31	2.31	1.86	1.86	1.86	1.61	1.61	1.61
	C.D. at 5%	4.67	4.67	4.67	3.76	3.76	3.76	3.25	3.25	3.25
	C.D.at 1%	6.24	6.24	6.24	5.02	5.02	5.02	4.34	4.34	4.34

*and ** indicate significance of values at $p=0.05$ and 0.01 , respectively. BP- Heterosis over better parent, BTP- Heterosis over the best parent, CC- Heterosis over the commercial check (JK-Desi F₁).

4.2.6 Days to first fruit set (Table 5 and 8)

Genotypes varied significantly among themselves for days to first fruit set varied from 36.00 (HUB-18) to 43.00 (T-36) among lines, 39.50 (DMT-2) to 43.00 (Arka Abha) among testers and 36.00 (T-26 x DMT-2) to 44.00 (Viabhav x Arka Alok) among crosses. Magnitude of heterosis over better parent, the best parent and the commercial check was significant in both directions. Negative heterosis for this trait indicates earliness and is desirable. Maximum heterosis over better parent (-13.95%) was observed in the cross Swarna Naveen x Arka Abha and None of the crosses recorded negative and significant heterosis over the best parent and the cross Swarna Naveen x Arka Abha exhibited maximum heterosis over the commercial check (-12.20%). Among 45 crosses studied, nine crosses over better parent, and 30 crosses over the commercial check exhibited negative and significant heterosis.

4.2.7 Days to first fruit maturity (Table 5 and 9)

Genotypes varied significantly among themselves for days to first fruit maturity varied from 77.50 (HUB-18) to 84.50 (K-3) among lines, 76.00 (Arka Alok) to 83.00 (DMT-2) among testers and 75.00 (Swarna Naveen x Arka Abha) to 83.50 (Swarna Naveen x DMT-2) among crosses. Magnitude of heterosis over better parent, the best parent and the commercial check was significant in both directions. Negative heterosis for this trait indicates earliness and is desirable. Maximum heterosis over better parent (-7.93%) was observed in the cross T-26 x DMT-2 and None of the crosses recorded negative and significant heterosis over the best parent and the cross S-22 X DMT-2 exhibited maximum heterosis over the commercial check (-8.59%). Among 45 crosses studied, five crosses over better parent and 13 crosses over the commercial check exhibited negative and significant heterosis.

4.2.8 Equatorial diameter of fruit (Table 10 and 9)

Genotypes varied significantly among themselves for equatorial diameter of fruit varied from 34.92 (HUB-18) to 52.00 mm (K-3) among lines, 44.90 (Arka Abha) to 51.17 mm (Arka Alok) among testers and 41.06 (Arka Meghali x DMT-2) to 69.94 mm (Arka Meghali x Arka Abha) among crosses. Magnitude of heterosis over better parent, the best parent and the commercial check was significant in both directions. The maximum positive and significant heterosis over better parent was observed in the cross Arka Meghali x Arka Abha (55.75%), the best parent (34.50%) and the commercial check (60.52%). Among 45 crosses, 17, 10 and 31 crosses shown positive and significant heterosis over better parent, the best parent and the commercial check, respectively for equatorial diameter of fruit.

Table 9. Heterosis (%) over better parent, best parent and commercial check for days to first fruit maturity, equatorial and polar diameter of fruit in tomato

Sl. No.	Crosses	Days to first fruit maturity			Equatorial diameter of fruit			Polar diameter of fruit		
		BP	BTP	CC	BP	BTP	CC	BP	BTP	CC
1	T-26 x Arka Abha	-3.70*	2.63	-4.29*	-0.62	-14.19**	2.41	9.39**	-27.06**	25.48**
2	T-26 x Arka Alok	-0.66	-0.66	-7.36**	7.82**	6.10**	26.62**	1.90	-34.05**	13.45**
3	T-26 x DMT-2	-7.93**	-0.66	-7.36**	9.91**	4.12	24.26**	14.97**	-26.50**	26.43**
4	T-36 x Arka Abha	-0.62	5.92**	-1.23	21.80**	5.17*	25.52**	-34.65**	-34.65**	12.42**
5	T-36 x Arka Alok	2.63	2.63	-4.29*	-3.22	-4.77*	13.66**	-37.78**	-37.78**	7.03**
6	T-36 x DMT-2	-4.29*	2.63	-4.29*	-9.56**	-14.33**	2.25	-35.22**	-35.22**	11.44**
7	Arka Vikas x Arka Abha	-3.75*	1.32	-5.52**	5.88*	-8.58**	9.11**	19.81**	-20.11**	37.43**
8	Arka Vikas x Arka Alok	1.97	1.97	-4.91*	28.14**	26.10**	50.49**	-2.04	-36.60**	9.07**
9	Arka Vikas x DMT-2	-1.84	5.26*	-1.84	-8.04**	-12.88**	3.97	-16.68**	-46.74**	-8.37**
10	Swarna Naveen x Arka Abha	-7.41**	-1.32	-7.98**	4.15	-9.37**	8.17**	-12.58**	-41.70**	0.28
11	Swarna Naveen x Arka Alok	0.66	0.66	-6.13**	-18.55**	-19.85**	-4.34	-20.99**	-48.86**	-12.03**
12	Swarna Naveen x DMT-2	1.83	9.87**	2.45	-14.70**	-19.19**	-3.56	20.73**	-22.82**	32.77**
13	Vaibhav x Arka Abha	-0.64	2.63	-4.29*	11.49**	-3.73	14.90**	-4.36*	-36.22**	9.71**
14	Vaibhav x Arka Alok	4.61*	4.61*	-2.45	12.23**	10.44**	31.81**	3.12	-33.26**	14.81**
15	Vaibhav x DMT-2	0.64	3.95*	-3.07*	-12.20**	-16.83**	-0.73	-1.48	-37.02**	8.35**
16	DMT -1 x Arka Abha	-1.23	5.26*	-1.84	1.96	-4.06	14.51**	-21.27**	-42.30**	-0.75
17	DMT -1 x Arka Alok	0.00	0.00	-6.75**	-17.20**	-18.52**	-2.75	-6.27**	-31.31**	18.16**

Table 9 contd...

Sl. No.	Crosses	Days to first fruit maturity			Equatorial diameter of fruit			Polar diameter of fruit		
		BP	BTP	CC	BP	BTP	CC	BP	BTP	CC
18	DMT -1 x DMT-2	-2.44	5.26*	-1.84	7.43**	1.77	21.46**	-21.62**	-42.56**	-1.18
19	DMT-5 x Arka Abha	-1.85	4.61*	-2.45	16.79**	7.02**	27.73**	-7.63**	-29.50**	21.28**
20	DMT-5 x Arka Alok	0.66	0.66	-6.13**	5.37*	3.69	23.75**	-6.42**	-28.57**	22.87**
21	DMT-5 x DMT-2	-6.71**	0.66	-6.13**	-13.80**	-18.35**	-2.55	-0.84	-24.32**	30.19**
22	S-22 x Arka Abha	-2.48	3.29*	-3.68*	6.42**	3.54	23.57**	7.77**	-28.14**	23.62**
23	S-22 x Arka Alok	0.66	0.66	-6.13**	0.63	-0.98	18.18**	-5.58**	-36.12**	9.89**
24	S-22 x DMT-2	-7.45**	-1.97	-8.59**	14.33**	11.23**	32.75**	5.36**	-28.72**	22.62**
25	Arka Meghali x Arka Abha	-3.85	-1.32	-7.98**	55.77**	34.50**	60.52**	25.26**	-16.47**	43.69**
26	Arka Meghali x Arka Alok	0.66	0.66	-6.13**	-2.85	-4.40	14.09**	17.19**	-24.15**	30.47**
27	Arka Meghali x DMT-2	-0.64	1.97	-4.91*	-16.65**	-21.04**	-5.76*	2.08	-34.74**	12.26**
28	Megha x Arka Abha	-2.48	3.29*	-3.68*	-4.23	-17.31**	-1.31	-11.79**	-41.18**	1.18
29	Megha x Arka Alok	4.61*	4.61*	-2.45	-17.67**	-18.98**	-3.31	12.70**	-27.06**	25.48**
30	Megha x DMT-2	-5.59**	0.00	-6.75**	-13.80**	-18.35**	-2.55	-9.86**	-42.38**	-0.88
31	K-3 x Arka Abha	-3.09*	3.29*	-3.68*	19.88**	19.88**	43.08**	-2.22	-34.80**	12.16**
32	K-3 x Arka Alok	4.61*	4.61*	-2.45	4.87*	4.87*	25.15**	12.40**	-27.25**	25.14**
33	K-3 x DMT-2	-3.01	5.92**	-1.23	-1.06	-1.06	18.09**	5.08**	-32.82**	15.56**
34	T-57 x Arka Abha	-1.23	5.26	-1.84	-7.21**	-16.88**	-0.80	0.54	-32.96**	15.33**
35	T-57 x Arka Alok	9.21**	9.21**	1.84	-1.56	-3.13	15.61**	30.86**	-12.88**	49.87**

Table 9 contd...

Sl. No.	Crosses	Days to first fruit maturity			Equatorial diameter of fruit			Polar diameter of fruit		
		BP	BTP	CC	BP	BTP	CC	BP	BTP	CC
36	T-57 x DMT-2	-1.20	7.89**	0.61	-6.11**	-11.06**	6.15**	10.95**	-26.13**	27.07**
37	TB-1 x Arka Abha	-0.64	2.63	-4.29*	8.66**	-6.17**	11.98**	19.45**	-20.35**	37.02**
38	TB-1 x Arka Alok	7.89**	7.89**	0.61	-16.14**	-17.48**	-1.51	-4.63**	-38.27**	6.18**
39	TB-1 x DMT-2	4.46	7.89**	0.61	33.64**	26.60**	51.09**	-1.24	-36.87**	8.60**
40	HUB-18X Arka Abha	3.87	5.92**	-1.23	16.77**	0.83	20.34**	-7.79**	-36.58**	9.09**
41	HUB-18X Arka Alok	6.58**	6.58**	-0.61	4.73*	3.06	23.00**	-2.05	-32.63**	15.89**
42	HUB-18X DMT-2	5.16*	7.24**	0.00	17.11**	10.94**	32.41**	-7.03**	-36.06**	9.99**
43	DMT-3 x Arka Abha	0.00	6.58**	-0.61	27.17**	9.81**	31.05**	-9.83**	-29.16**	21.87**
44	DMT-3 x Arka Alok	2.63	2.63	-4.29*	5.67*	3.98	24.10**	0.13	-21.32**	35.34**
45	DMT-3 x DMT-2	-2.47	3.95	-3.07*	-1.32	-6.52	11.57**	-18.14**	-35.68**	10.64**
	S.Em±	1.92	1.92	1.92	2.22	2.22	2.22	1.80	1.80	1.80
	C.D. at 5%	3.06	3.06	3.06	4.48	4.48	4.48	3.62	3.62	3.62
	C.D.at 1%	5.47	5.47	5.47	5.98	5.98	5.98	4.84	4.84	4.84

*and ** indicate significance of values at $p=0.05$ and 0.01 , respectively. BP- Heterosis over better parent, BTP- Heterosis over the best parent, CC- Heterosis over the commercial check (JK-Desi F₁).

4.2.9 Polar diameter of fruit (Table 10 and 9)

Genotypes varied significantly among themselves for polar diameter of fruit ranged from 33.19 (Arka Vikas) to 66.78 mm (T-36) among lines, 42.69 (DMT-2) to 44.53 mm (Arka Abha) among testers and 34.15 (Swarna Naveen x Arka Alok) to 58.18 mm (T-57 x Arka Alok) among crosses. Magnitude of heterosis over better parent, the best parent and the commercial check was significant in both directions. The cross T-57 x Arka Alok exhibited maximum heterosis over better parent (30.86%) and none of the crosses recorded positive and significant heterosis over the best parent and the cross T-57 x Arka Alok exhibited maximum heterosis over the commercial check (49.87%). Among 45 crosses, 14 and 38 crosses shown positive and significant heterosis over better parent, the best parent and the commercial check, respectively.

4.2.10 Number of fruits per cluster (Table 10 and 11)

Genotypes varied significantly among themselves for number of fruits per cluster ranged from 3.10 (S-22) to 4.60 (T-26) among lines, 3.00 (Arka Abha) to 5.09 (DMT-2) among testers and 2.90 (Arka Meghali x Arka Alok) to 5.40 (HUB-18 x Arka Alok) among crosses. Magnitude of heterosis over better parent, the best parent and the commercial check was significant in both directions. The maximum positive and significant heterosis over better parent was observed in the cross TB-1 x Arka Abha (41.94%). The cross HUB-18 x Arka Alok expressed maximum heterosis over the best parent (6.09%) and the commercial check (28.57%). Among 45 crosses, 17, two and 17 crosses shown positive and significant heterosis over better parent, the best parent and the commercial check, respectively.

4.2.11 Average fruit weight (Table 10 and 11)

Genotypes varied significantly among themselves for average fruit weight varied from 33.50 (HUB-18) to 75.25 g (S-22) among lines, 69.00 (Arka Abha) to 88.70 g (DMT-2) among testers and 45.30 (Arka Vikas x DMT-2) to 133.75 g (T-57 x DMT-2) among crosses. Magnitude of heterosis over better parent, the best parent and the commercial check was significant in both directions. The maximum positive and significant heterosis over better parent (50.07%), best parent (50.79 %) and commercial check (101.89 %) was observed in the cross T-57 x DMT-2. Among 45 crosses, four, two and five crosses showed positive and significant heterosis over better parent, the best parent and the commercial check, respectively.

Table 10. Per se performance of parents, crosses and commercial check for yield and quality parameters in tomato

Sl. No.	Genotypes	Equatorial diameter of fruit (mm)	Polar diameter of fruit (mm)	Number of fruits per cluster	Average fruit weight (g)	Number of fruits per plant	Yield per plant (kg)	Yield per plot (kg)	Yield per ha (t)	Number of locules per fruit
	Lines									
1	T-26	44.92	41.59	4.60	52.75	40.55	2.01	32.62	45.30	3.42
2	T-36	41.48	66.78	4.20	33.60	30.55	0.97	15.52	21.55	2.45
3	Arka Vikas	41.52	33.19	3.20	34.00	33.22	1.10	17.60	24.44	3.10
4	Swarna Naveen	45.25	40.46	4.30	50.50	30.80	1.33	21.28	29.55	4.10
5	Vaibhav	44.44	54.24	3.70	44.00	33.90	1.39	22.24	30.88	3.10
6	DMT-1	48.93	48.94	3.40	36.00	18.52	0.95	15.20	21.13	2.90
7	DMT-3	42.45	52.47	4.20	64.50	32.00	2.01	32.16	44.66	2.80
8	DMT-5	47.62	50.97	4.20	67.75	35.67	2.37	36.02	49.31	4.10
9	S-22	50.59	45.18	3.10	75.25	30.80	2.09	32.52	45.16	3.65
10	Arka Meghali	44.84	39.67	3.70	54.50	22.35	1.20	19.20	26.66	3.15
11	Megha	39.85	38.33	3.30	56.20	23.67	1.26	20.16	28.00	3.00
12	K-3	52.00	41.08	3.70	51.50	18.87	0.90	14.40	20.00	4.10
13	T-57	46.58	44.46	3.90	49.20	22.37	1.11	17.76	24.66	5.40
14	TB-1	40.74	38.32	3.70	48.20	20.77	1.02	16.32	22.66	4.40
15	HUB-18	34.92	45.93	3.80	33.50	36.44	1.20	19.20	26.66	2.30
	Testers									
16	Arka Abha	44.90	44.53	3.00	69.00	35.00	1.93	30.88	42.88	3.40
17	Arka Alok	51.17	43.22	4.40	78.70	30.20	2.03	32.48	45.11	3.65
18	DMT-2	49.26	42.69	5.09	88.70	37.83	3.25	52.00	72.22	3.70

Table 10 contd...

Sl. No.	Genotypes	Equatorial diameter of fruit (mm)	Polar diameter of fruit (mm)	Number of fruits per cluster	Average fruit weight (g)	Number of fruits per plant	Yield per plant (kg)	Yield per plot (kg)	Yield per ha (t)	Number of locules per fruit
	Crosses									
19	T-26 X Arka Abha	44.62	48.71	4.90	57.50	24.67	1.33	21.28	29.55	2.70
20	T-26 X Arka Alok	55.17	44.04	5.20	61.20	25.42	1.32	21.12	29.33	3.60
21	T-26 X DMT-2	54.14	49.08	4.80	53.50	69.02	3.52	56.32	78.22	2.60
22	T-36 X Arka Abha	54.69	43.64	4.80	89.20	23.37	1.89	30.24	42.00	3.90
23	T-36 X Arka Alok	49.52	41.55	4.87	62.50	24.32	1.20	19.20	26.66	2.80
24	T-36 X DMT-2	44.55	43.26	4.50	63.50	51.47	3.01	48.16	66.88	3.50
25	Arka Vikas X Arka Abha	47.54	53.35	4.20	51.70	24.57	1.20	19.20	26.66	3.25
26	Arka Vikas X Arka Alok	65.57	42.34	4.10	76.20	23.90	1.48	23.68	32.88	5.50
27	Arka Vikas X DMT-2	45.30	35.57	3.60	45.30	21.72	0.98	15.68	21.77	5.40
28	Swarna Naveen X Arka Abha	47.13	38.93	4.20	51.20	33.19	1.47	23.52	32.66	3.90
29	Swarna Naveen X Arka Alok	41.68	34.15	3.20	50.50	20.70	0.97	15.27	21.20	3.80
30	Swarna Naveen X DMT-2	42.02	51.54	3.60	52.00	21.35	1.01	16.16	22.44	4.60
31	Vaibhav X Arka Abha	50.06	42.59	4.20	123.75	19.72	2.18	34.88	48.44	3.20
32	Vaibhav X Arka Alok	57.43	44.57	3.60	64.00	33.62	2.02	32.32	44.88	4.30
33	Vaibhav X DMT-2	43.25	42.06	3.40	73.50	32.57	2.16	34.62	48.08	3.10
34	DMT -1 X Arka Abha	49.89	38.53	4.40	64.50	20.72	1.32	21.12	29.33	3.70
35	DMT -1 X Arka Alok	42.37	45.87	3.30	53.70	18.62	0.99	15.84	22.00	4.30

Table 10 contd...

Sl. No.	Genotypes	Equatorial diameter of fruit (mm)	Polar diameter of fruit (mm)	Number of fruits per cluster	Average fruit weight (g)	Number of fruits per plant	Yield per plant (kg)	Yield per plot (kg)	Yield per ha (t)	Number of locules per fruit
36	DMT -1 X DMT-2	52.92	38.36	3.50	77.70	32.42	2.45	39.20	54.44	3.20
37	DMT-5 X Arka Abha	55.65	47.08	4.20	65.70	58.60	3.60	57.60	80.00	3.50
38	DMT-5 X Arka Alok	53.92	47.70	5.15	62.50	63.43	3.70	59.20	82.22	3.40
39	DMT-5 X DMT-2	42.46	50.54	4.40	57.50	52.40	2.83	45.28	62.88	3.35
40	S-22 X Arka Abha	53.84	47.99	4.00	61.70	63.72	3.80	60.80	84.44	3.47
41	S-22 X Arka Alok	51.49	42.66	3.70	76.20	24.40	1.80	28.80	40.00	4.25
42	S-22 X DMT-2	57.84	47.60	3.10	52.40	52.30	2.40	38.40	53.33	3.65
43	Arka Meghali X Arka Abha	69.94	55.78	4.50	81.50	30.35	2.14	34.24	47.55	4.40
44	Arka Meghali X Arka Alok	49.71	50.65	2.90	62.50	34.77	2.10	33.60	46.66	3.10
45	Arka Meghali X DMT-2	41.06	43.58	4.30	51.25	25.72	1.30	20.80	28.88	3.45
46	Megha X Arka Abha	43.00	39.28	3.65	78.00	30.79	2.03	32.48	45.11	3.45
47	Megha X Arka Alok	42.13	48.71	4.50	78.75	45.54	3.01	48.16	66.88	3.70
48	Megha X DMT-2	42.46	38.48	3.70	81.75	40.23	2.96	47.36	65.77	4.32
49	K-3 X Arka Abha	62.34	43.54	4.60	76.50	38.67	2.56	40.96	56.88	5.25
50	K-3 X Arka Alok	54.53	48.58	3.50	87.75	32.08	2.71	43.36	60.22	5.55
51	K-3 X DMT-2	51.45	44.86	4.10	76.25	35.32	2.40	38.40	53.33	3.45
52	T-57 X Arka Abha	43.22	44.77	3.90	72.50	21.67	1.40	22.14	30.75	3.55
53	T-57 X Arka Alok	50.37	58.18	4.10	81.25	15.90	1.12	17.02	23.63	3.25

Table 10 contd...

Sl. No.	Genotypes	Equatorial diameter of fruit (mm)	Polar diameter of fruit (mm)	Number of fruits per cluster	Average fruit weight (g)	Number of fruits per plant	Yield per plant (kg)	Yield per plot (kg)	Yield per ha (t)	Number of locules per fruit
54	T-57 X DMT-2	46.25	49.33	3.70	133.75	20.45	2.36	37.76	52.44	3.45
55	TB-1 X Arka Abha	48.79	53.19	5.10	81.25	24.52	1.67	26.72	37.11	3.25
56	TB-1 X Arka Alok	42.91	41.22	4.50	67.00	21.75	1.34	21.44	29.77	2.95
57	TB-1 X DMT-2	65.83	42.16	3.80	86.25	18.62	1.59	25.44	35.33	3.70
58	HUB-18X Arka Abha	52.43	42.35	4.40	101.25	31.65	3.02	48.32	67.11	4.30
59	HUB-18X Arka Alok	53.59	44.99	5.40	108.00	29.00	2.92	46.72	64.88	4.17
60	HUB-18X DMT-2	57.69	42.70	3.70	92.50	35.00	2.98	47.68	66.22	3.25
61	DMT-3 X Arka Abha	57.10	47.31	4.10	78.75	29.62	1.98	31.68	44.00	5.00
62	DMT-3 X Arka Alok	54.07	52.54	3.40	69.25	32.19	2.02	32.32	44.88	5.10
63	DMT-3 X DMT-2	48.61	42.95	3.60	69.00	17.20	1.14	18.24	25.33	3.30
	Commercial check									
64	JK-Desi (F ₁)	43.57	38.82	4.20	66.25	53.17	3.50	56.00	77.78	3.80
	S.Em±	4.35	1.83	0.63	13.15	1.77	0.14	1.81	2.96	0.30
	C.D. at 5%	9.28	3.89	1.13	28.23	3.74	0.28	3.93	6.23	0.63
	C.D.at 1%	12.34	5.17	1.54	37.53	4.97	0.38	5.23	8.28	0.84

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

Sl. No.	Crosses	Number of fruits per cluster			Average fruit weight			Number of fruits per plant		
		BP	BTP	CC	BP	BTP	CC	BP	BTP	CC
1	T-26 x Arka Abha	6.52**	-3.73**	16.67**	-16.67	-35.17*	-13.21	-39.16**	-39.16**	-53.60**
2	T-26 x Arka Alok	13.04**	2.16**	23.81**	-22.24	-31.00*	-7.62	-37.31**	-37.31**	-52.19**
3	T-26 x DMT-2	-5.70**	-5.70**	14.29**	-39.68**	-39.68**	-19.25	70.21**	70.21**	29.81**
4	T-36 x Arka Abha	14.29**	-5.70**	14.29**	29.28*	0.56	34.64*	-33.23**	-42.37**	-56.05**
5	T-36 x Arka Alok	10.68**	-4.32**	15.95**	-20.58	-29.54*	-5.66	-20.39**	-40.02**	-54.26**
6	T-36 x DMT-2	-11.59**	-11.59**	7.14**	-28.41*	-28.41*	-4.15	36.06**	26.93**	-3.20
7	Arka Vikas x Arka Abha	31.25**	-17.49**	0.00	-25.07	-41.71**	-21.96	-29.80**	-39.41**	-53.79**
8	Arka Vikas x Arka Alok	-6.82**	-19.45**	-2.38**	-3.18	-14.09	15.02	-28.06**	-41.06**	-55.05**
9	Arka Vikas x DMT-2	-29.27**	-29.27**	-14.29**	-48.93**	-48.93**	-31.62	-42.59**	-46.44**	-59.15**
10	Swarna Naveen x Arka Abha	-2.33**	-17.49**	0.00	-25.80	-42.28**	-22.72	-5.17*	-18.15**	-37.58**
11	Swarna Naveen x Arka Alok	-27.27**	-37.13**	-23.81**	-35.83*	-43.07**	-23.77	-32.79**	-48.95**	-61.07**
12	Swarna Naveen x DMT-2	-29.27**	-29.27**	-14.29**	-41.38**	-41.38**	-21.51	-43.56**	-47.35**	-59.85**
13	Vaibhav x Arka Abha	13.51**	-17.49**	0.00	79.35**	39.52**	86.79**	-43.66**	-51.37**	-62.91**
14	Vaibhav x Arka Alok	-18.18**	-29.27**	-14.29**	-18.68	-27.85*	-3.40	-0.83	-17.09**	-36.77**
15	Vaibhav x DMT-2	-33.20**	-33.20**	-19.05**	-17.14	-17.14	10.94	-13.90**	-19.68**	-38.74**
16	DMT -1 x Arka Abha	41.94**	-13.56**	4.76**	-6.52	-27.28*	-2.64	-40.80**	-48.90**	-61.03**
17	DMT -1 x Arka Alok	-25.00**	-35.17**	-21.43**	-31.77*	-39.46**	-18.94	-38.34**	-54.08**	-64.98**

Table 11 contd.....

Sl. No.	Crosses	Number of fruits per cluster			Average fruit weight			Number of fruits per plant		
		BP	BTP	CC	BP	BTP	CC	BP	BTP	CC
18	DMT -1 x DMT-2	-31.24**	-31.24**	-16.67**	-12.40	-12.40	17.28	-14.30**	-20.05**	-39.03**
19	DMT-5 x Arka Abha	0.00	-17.49**	0.00	-4.78	-25.93	-0.83	64.28**	44.51**	10.21**
20	DMT-5 x Arka Alok	17.05**	1.18*	22.62**	-20.58	-29.54*	-5.66	77.82**	56.42**	19.30**
21	DMT-5 x DMT-2	-13.56**	-13.56**	4.76**	-35.17*	-35.17**	-13.21	38.51**	29.22**	-1.45
22	S-22 x Arka Abha	29.03**	-21.41**	-4.76**	-18.01	-30.44*	-6.87	82.06**	57.14**	19.84**
23	S-22 x Arka Alok	-15.91**	-27.31**	-11.90**	-3.18	-14.09	15.02	-19.21**	-39.83**	-54.11**
24	S-22 x DMT-2	-39.10**	-39.10**	-26.19**	-40.92**	-40.92**	-20.91	38.25**	28.98**	-1.64
25	Arka Meghali x Arka Abha	21.62**	-11.59**	7.14**	18.12	-8.12	23.02	-13.29**	-25.15**	-42.92**
26	Arka Meghali x Arka Alok	-34.09**	-43.03**	-30.95**	-20.58	-29.54*	-5.66	15.13**	-14.25**	-34.61**
27	Arka Meghali x DMT-2	-15.52**	-15.52**	2.38**	-42.22**	-42.22**	-22.64	-32.01**	-36.57**	-51.63**
28	Megha x Arka Abha	10.61**	-28.29**	-13.10**	13.04	-12.06	17.74	-12.03**	-24.07**	-42.09**
29	Megha x Arka Alok	2.27**	-11.59**	7.14**	0.06	-11.22	18.87	50.79**	12.31**	-14.35**
30	Megha x DMT-2	-27.31**	-27.31**	-11.90**	-7.84	-7.84	23.40	6.34**	-0.79	-24.34**
31	K-3 x Arka Abha	24.32**	-9.63**	9.52**	10.87	-13.75	15.47	10.49**	-4.64*	-27.27**
32	K-3 x Arka Alok	-20.45**	-31.24**	-16.67**	11.50	-1.07	32.45*	6.23**	-20.89**	-39.67**
33	K-3 x DMT-2	-19.45**	-19.45**	-2.38**	-14.04	-14.04	15.09	-6.63**	-12.90**	-33.57**
34	T-57 x Arka Abha	0.00	-23.38**	-7.14**	5.07	-18.26	9.43	-38.09**	-46.56**	-59.24**
35	T-57 x Arka Alok	-6.82**	-19.45**	-2.38**	3.24	-8.40	22.64	-47.35**	-60.79**	-70.10**

Table 11 contd.....

Sl. No.	Crosses	Number of fruits per cluster			Average fruit weight			Number of fruits per plant		
		BP	BTP	CC	BP	BTP	CC	BP	BTP	CC
36	T-57 x DMT-2	-27.31**	-27.31**	-11.90**	50.79**	50.79**	101.89**	-45.94**	-49.57**	-61.54**
37	TB-1 x Arka Abha	37.84**	0.20	21.43**	17.75	-8.40	22.64	-29.94**	-39.53**	-53.88**
38	TB-1 x Arka Alok	2.27**	-11.59**	7.14**	-14.87	-24.46	1.13	-27.98**	-46.36**	-59.09**
39	TB-1 x DMT-2	-25.34**	-25.34**	-9.52**	-2.76	-2.76	30.19*	-50.78**	-54.08**	-64.98**
40	HUB-18X Arka Abha	15.79**	-13.56**	4.76**	46.74**	14.15	52.83**	-13.14**	-21.95**	-40.47**
41	HUB-18X Arka Alok	22.73**	6.09**	28.57**	37.23*	21.76	63.02**	-20.42**	-28.48**	-45.46**
42	HUB-18X DMT-2	-27.31**	-27.31**	-11.90**	4.28	4.28	39.62**	-7.48**	-13.69**	-34.17**
43	DMT-3 x Arka Abha	-2.38**	-19.45**	-2.38**	14.13	-11.22	18.87	-15.37**	-26.95**	-44.29**
44	DMT-3 x Arka Alok	-22.73**	-33.20**	-19.05**	-12.01	-21.93	4.53	0.59	-20.62**	-39.46**
45	DMT-3 x DMT-2	-29.27**	-29.27**	-14.29**	-22.21	-22.21	4.15	-54.53**	-57.58**	-67.65**
	S.Em±	0.63	0.63	0.63	13.87	13.87	13.87	1.97	1.97	1.97
	C.D. at 5%	1.27	1.27	1.27	27.95	27.95	27.95	3.98	3.98	3.98
	C.D.at 1%	1.70	1.70	1.70	37.34	37.34	37.34	5.32	5.32	5.32

*and ** indicate significance of values at p=0.05 and 0.01, respectively. BP- Heterosis over better parent, BTP- Heterosis over the best parent, CC- Heterosis over the commercial check (JK-Desi F₁).

4.2.12 Number of fruits per plant (Table 10 and 11)

Genotypes varied significantly among themselves for number of fruits per plant varied from 18.52 (DMT-1) to 40.55 (T-26) among lines, 30.20 (Arka Alok) to 37.83 (DMT-2) among testers and 15.90 (T-57 x Arka Alok) to 69.02 (T-26 x DMT-2) among crosses. Magnitude of heterosis over better parent, the best parent and the commercial check was significant in both directions. The maximum positive and significant heterosis over better parent was observed in the cross S-22 x Arka Abha (82.06%). The cross T-26 x DMT-2 expressed maximum heterosis over the best parent (70.21%) and the commercial check (29.81%). Among 45 crosses, 12, eight and four crosses shown positive and significant heterosis over better parent, the best parent and the commercial check, respectively for number of fruits per plant.

4.2.13 Yield per plant (Table 10 and 12)

Genotypes varied significantly among themselves for yield per plant ranged from 0.90 (K-3) to 2.37 kg (DMT-5) among lines, 1.93 (Arka Abha) to 3.25 kg (DMT-2) among testers and 0.97 (Swarna Naveen x Arka Alok) to 3.80 kg (S-22 x Arka Abha) among crosses. Magnitude of heterosis over better parent, the best parent and the commercial check was significant in both directions. The maximum positive and significant heterosis over better parent (81.82%), best parent (16.92%) and the commercial check (8.57%) was observed in the cross S-22 x Arka Abha. Among 45 crosses, 13, four and four crosses shown positive and significant heterosis over better parent, the best parent and the commercial check, respectively for yield per plant.

4.2.14 Yield per plot (Table 10 and 12)

Genotypes varied significantly among themselves for yield per plot ranged from 14.40 (K-3) to 36.02 kg (DMT-5) among lines, 30.88 (Arka Abha) to 52.00 kg (DMT-2) among testers and 15.27 (Swarna Naveen x Arka Alok) to 60.80 kg (S-22 x Arka Abha) among crosses. Magnitude of heterosis over better parent, the best parent and the commercial check was significant in both directions. The maximum positive and significant heterosis over better parent (86.96%), best parent (16.92%) and the commercial check (8.57%) was observed in the cross S-22 x Arka Abha. Among 45 crosses, 13, four and four crosses shown positive and significant heterosis over better parent, the best parent and the commercial check, respectively.

4.2.15 Yield per hectare (Table 10 and 12)

Genotypes varied significantly among themselves for yield per hectare ranged from 20.00 (K-3) to 44.66 tonnes (DMT-3) among lines, 42.88 (Arka Abha) to 72.22 tonnes (DMT-2) among testers and 21.20 (Swarna Naveen x Arka Alok) to 84.44 tonnes (S-22 x Arka Abha) among crosses. Magnitude of heterosis over better parent, the best parent and the commercial check was significant in both directions. The maximum positive and significant heterosis over better parent (86.98%), best parent (16.92%) and the commercial check (8.56%) was observed in the cross S-22 x Arka Abha. Among 45 crosses, 13, four and four crosses shown positive and significant heterosis over better parent, the best parent and the commercial check, respectively.

Table 12. Heterosis (%) over better parent, best parent and commercial check for yield per plant, yield per plot and yield per hain tomato

Sl. No.	Crosses	Yield per plant			Yield per plot			Yield per ha		
		BP	BTP	CC	BP	BTP	CC	BP	BTP	CC
1	T-26 x Arka Abha	-33.83**	-59.08**	-62.00**	-34.76**	-59.08**	-62.00**	-34.77**	-59.08**	-62.01**
2	T-26 x Arka Alok	-34.98**	-59.38**	-62.29**	-35.25**	-59.38**	-62.29**	-34.98**	-59.39**	-62.29**
3	T-26 x DMT-2	8.31**	8.31**	0.57**	8.31**	8.31**	0.57**	8.31**	8.31**	0.57**
4	T-36 x Arka Abha	-2.07**	-41.85**	-46.00**	-7.30**	-41.85**	-46.00**	-7.28**	-41.84**	-46.00**
5	T-36 x Arka Alok	-40.89**	-63.08**	-65.71**	-41.14**	-63.08**	-65.71**	-40.90**	-63.09**	-65.72**
6	T-36 x DMT-2	-7.38**	-7.38**	-14.00**	-7.38**	-7.38**	-14.00**	-7.39**	-7.39**	-14.01**
7	Arka Vikas x Arka Abha	-37.82**	-63.08**	-65.71**	-41.14**	-63.08**	-65.71**	-41.15**	-63.09**	-65.72**
8	Arka Vikas x Arka Alok	-27.09**	-54.46**	-57.71**	-27.41**	-54.46**	-57.71**	-27.11**	-54.47**	-57.73**
9	Arka Vikas x DMT-2	-69.85**	-69.85**	-72.00**	-69.85**	-69.85**	-72.00**	-69.86**	-69.86**	-72.01**
10	Swarna Naveen x Arka Abha	-23.83**	-54.77**	-58.00**	-27.90**	-54.77**	-58.00**	-27.90**	-54.78**	-58.01**
11	Swarna Naveen x Arka Alok	-52.22**	-70.15**	-72.29**	-53.19**	-70.63**	-72.73**	-53.00**	-70.65**	-72.74**
12	Swarna Naveen x DMT-2	-68.92**	-68.92**	-71.14**	-68.92**	-68.92**	-71.14**	-68.93**	-68.93**	-71.15**
13	Vaibhav x Arka Abha	12.95**	-32.92**	-37.71**	6.93**	-32.92**	-37.71**	6.93**	-32.93**	-37.72**
14	Vaibhav x Arka Alok	-0.49**	-37.85**	-42.29**	-0.92**	-37.85**	-42.29**	-0.51	-37.86**	-42.30**
15	Vaibhav x DMT-2	-33.54**	-33.54**	-38.29**	-33.42**	-33.42**	-38.18**	-33.43**	-33.43**	-38.18**
16	DMT -1 x Arka Abha	-31.61**	-59.38**	-62.29**	-35.25**	-59.38**	-62.29**	-35.25**	-59.39**	-62.29**
17	DMT -1 x Arka Alok	-51.23**	-69.54**	-71.71**	-51.44**	-69.54**	-71.71**	-51.23**	-69.54**	-71.72**

Table 12 contd.....

Sl. No.	Crosses	Yield per plant			Yield per plot			Yield per ha		
		BP	BTP	CC	BP	BTP	CC	BP	BTP	CC
18	DMT -1 x DMT-2	-24.62**	-24.62**	-30.00**	-24.62**	-24.62**	-30.00**	-24.62**	-24.62**	-30.01**
19	DMT-5 x Arka Abha	51.90**	10.77**	2.86**	59.91**	10.77**	2.86**	62.24**	10.77**	2.85**
20	DMT-5 x Arka Alok	56.12**	13.85**	5.71**	64.35**	13.85**	5.74**	66.74**	13.85**	5.71**
21	DMT-5 x DMT-2	-12.92**	-12.92**	-19.14**	-12.92**	-12.92**	-19.14**	-12.93**	-12.93**	-19.16**
22	S-22 x Arka Abha	81.82**	16.92**	8.57**	86.96**	16.92**	8.57**	86.98**	16.92**	8.56**
23	S-22 x Arka Alok	-13.88**	-44.62**	-48.57**	-11.44**	-44.62**	-48.57**	-11.43**	-44.61**	-48.57**
24	S-22 x DMT-2	-26.15**	-26.15**	-31.43**	-26.15**	-26.15**	-31.43**	-26.16**	-26.16**	-31.43**
25	Arka Meghali x Arka Abha	6.47**	-34.15**	-38.86**	4.97**	-34.15**	-38.86**	4.97**	-34.16**	-38.87**
26	Arka Meghali x Arka Alok	3.45**	-35.38**	-40.00**	3.00**	-35.38**	-40.00**	3.44**	-35.39**	-40.01**
27	Arka Meghali x DMT-2	-60.00**	-60.00**	-62.86**	-60.00**	-60.00**	-62.86**	-60.01**	-60.01**	-62.87**
28	Megha x Arka Abha	1.00**	-37.54**	-42.00**	-0.43	-37.54**	-42.00**	-0.42	-37.54**	-42.00**
29	Megha x Arka Alok	48.28**	-7.38**	-14.00**	47.64**	-7.38**	-14.00**	48.26**	-7.39**	-14.01**
30	Megha x DMT-2	-8.92**	-8.92**	-15.43**	-8.92**	-8.92**	-15.43**	-8.93**	-8.93**	-15.44**
31	K-3 x Arka Abha	27.36**	-21.23**	-26.86**	25.57**	-21.23**	-26.86**	25.56**	-21.24**	-26.87**
32	K-3 x Arka Alok	33.50**	-16.62**	-22.57**	32.92**	-16.62**	-22.57**	33.50**	-16.62**	-22.58**
33	K-3 x DMT-2	-26.15**	-26.15**	-31.43**	-26.15**	-26.15**	-31.43**	-26.16**	-26.16**	-31.43**
34	T-57 x Arka Abha	-30.35**	-56.92**	-60.00**	-32.13**	-57.42**	-60.46**	-32.12**	-57.42**	-60.47**
35	T-57 x Arka Alok	-44.83**	-65.54**	-68.00**	-47.82**	-67.27**	-69.61**	-47.62**	-67.28**	-69.62**

Table 12 contd.....

Sl. No.	Crosses	Yield per plant			Yield per plot			Yield per ha		
		BP	BTP	CC	BP	BTP	CC	BP	BTP	CC
36	T-57 x DMT-2	-27.38**	-27.38**	-32.57**	-27.38**	-27.38**	-32.57**	-27.39**	-27.39**	-32.58**
37	TB-1 x Arka Abha	-16.92**	-48.62**	-52.29**	-18.09**	-48.62**	-52.29**	-18.08**	-48.62**	-52.29**
38	TB-1 x Arka Alok	-33.99**	-58.77**	-61.71**	-34.27**	-58.77**	-61.71**	-34.01**	-58.78**	-61.73**
39	TB-1 x DMT-2	-51.08**	-51.08**	-54.57**	-51.08**	-51.08**	-54.57**	-51.08**	-51.08**	-54.58**
40	HUB-18X Arka Abha	50.25**	-7.08**	-13.71**	48.13**	-7.08**	-13.71**	48.15**	-7.08	-13.72**
41	HUB-18X Arka Alok	43.84**	-10.15**	-16.57**	43.23**	-10.15**	-16.57**	43.83**	-10.16**	-16.59**
42	HUB-18X DMT-2	-8.31**	-8.31**	-14.86**	-8.31**	-8.31**	-14.86**	-8.31**	-8.31**	-14.86**
43	DMT-3 x Arka Abha	-1.49**	-39.08**	-43.43**	-1.49**	-39.08**	-43.43**	-1.48**	-39.08**	-43.43**
44	DMT-3 x Arka Alok	-0.49**	-37.85**	-42.29**	-0.43*	-37.85**	-42.29**	0.49	-37.86**	-42.30**
45	DMT-3 x DMT-2	-64.92**	-64.92**	-67.43**	-64.92**	-64.92**	-67.43**	-64.93**	-64.93**	-67.43**
	S.Em±	0.14	0.14	0.14	0.21	0.21	0.21	0.27	0.27	0.27
	C.D. at 5%	0.28	0.28	0.28	0.42	0.42	0.42	0.55	0.55	0.55
	C.D.at 1%	0.37	0.37	0.37	0.57	0.57	0.57	0.74	0.74	0.74

*and ** indicate significance of values at p=0.05 and 0.01, respectively. BP- Heterosis over better parent, BTP- Heterosis over the best parent, CC- Heterosis over the commercial check (JK-Desi F₁).



Plate 3: Fruits of testers and commercial check

4.2.16 Number of locules per fruit (Table 10 and 14)

Genotypes varied significantly among themselves for number of locules per fruit ranged from 2.30 (HUB-18) to 5.40 (T-57) among lines, 3.40 (Arka Abha) to 3.70 (DMT-2) among testers and 2.60 (T-26 x DMT-2) to 5.55 (K-3 x Arka Alok) among crosses. Magnitude of heterosis over better parent, the best parent and the commercial check was significant in both directions. Negative heterosis for this trait and is desirable. Maximum heterosis over better parent (-23.98%) was observed in the cross T-26 x DMT-2 and none of the crosses recorded positive and significant heterosis over the best parent and the cross T-26 x DMT-2 exhibited maximum heterosis over the commercial check (-31.58%). Among 45 crosses studied, 10 crosses over better parent and 28 crosses over the commercial check exhibited positive and significant heterosis.

4.2.17 Rind thickness (Table 13 and 14)

Genotypes varied significantly among themselves for rind thickness ranged from 0.30 (T-36) to 0.90 mm (T-57) among lines, 0.27 (Arka Alok) to 0.47 mm (Arka Abha) among testers and 0.14 (T-57 x DMT-2) to 0.92 mm (Swarna Naveen x Arka Abha) among crosses. Magnitude of heterosis over better parent, the best parent and the commercial check was significant in both directions. The maximum positive and significant heterosis over better parent was observed in the cross HUB-18 x Arka Abha (126.47%). The cross Swarna Naveen x Arka Abha expressed maximum heterosis over the best parent (2.22%) and heterosis over the commercial check (100.00%). Among 45 crosses, 18, seven and 17 crosses shown positive and significant heterosis over better parent, the best parent and the commercial check, respectively heterosis for rind thickness.

4.2.18 Total soluble solids (Table 13 and 14)

Genotypes varied significantly among themselves for total soluble solids and it ranged from 4.40 (T-36) to 5.80 °Brix (S-22) among lines, 4.10 (DMT-2) to 5.05°Brix (Arka Abha) among testers and 3.70 (DMT-1 x Arka Abha) to 6.30°Brix (Swarna Naveen x Arka Alok) among crosses studied. Magnitude of heterosis over better parent, the best parent and the commercial check was significant in both the directions. The maximum positive and significant heterosis over better parent (31.25 %), best parent (8.65%) and commercial check (17.76 %) was observed in the cross Swarna Naveen x Arka Alok. Among 45 crosses, 17, five and 10 crosses shown positive and significant heterosis over better parent, the best parent and the commercial check, respectively.

4.2.19 pH (Table 13 and 15)

Genotypes varied significantly among themselves for pH and it ranged from 4.03 (TB-1) to 4.86 (Vaibhav) among lines, 4.13 (Arka Alok) to 4.86 (Arka Abha) among testers and 4.09 (Vaibhav x Arka Abha) to 5.15 (Swarna Naveen x DMT-2) among crosses studied. Magnitude of heterosis over better parent, the best parent and the commercial check was significant in both the directions. Negative heterosis for this trait indicates pH and is desirable. Maximum heterosis over better parent (-15.84%) was observed in the cross Vaibhav x Arka Abha and the cross DMT-1 x Arka Alok exhibited maximum heterosis over the best parent (-1.94%) and heterosis over the commercial check (-13.09%). Among 45 crosses studied, 13 crosses over better parent, 2 crosses over the best parent and 25 crosses over the commercial check exhibited positive and significant heterosis.

Table 13. Per se performance of parents, crosses and commercial check for quality and seed parameters in tomato

Sl. No.	Genotypes	Rind thickness (mm)	TSS (°Brix)	pH	Lycopene (mg/100g)	β-carotene (mg/100g)	Number of seeds per fruit	1000 seed weight (g)	Seed weight per fruit (g)	Seed yield per plant (g)
	Lines									
1	T-26	0.66	5.13	4.30	5.45	8.37	84.85	2.40	0.20	4.82
2	T-36	0.30	4.40	4.41	2.93	7.91	96.07	1.90	0.18	4.59
3	Arka Vikas	0.78	5.10	4.45	3.18	8.93	58.87	3.42	0.20	5.58
4	Swarna Naveen	0.31	4.80	4.25	3.07	12.35	66.17	2.31	0.13	3.42
5	Vaibhav	0.45	5.45	4.86	4.11	9.15	42.50	5.29	0.20	6.19
6	DMT-1	0.40	5.10	4.15	4.48	11.03	86.45	3.28	0.25	4.04
7	DMT-3	0.42	4.65	4.30	3.40	7.98	72.63	3.36	0.22	5.12
8	DMT-5	0.67	5.40	4.51	6.08	10.78	48.44	5.04	0.23	5.04
9	S-22	0.47	5.80	4.40	4.15	7.38	55.12	4.04	0.20	2.71
10	Arka Meghali	0.35	4.70	4.81	4.31	13.98	46.15	3.43	0.15	2.76
11	Megha	0.54	5.65	4.56	3.34	18.42	61.13	1.86	0.10	2.17
12	K-3	0.75	4.65	4.70	5.63	8.65	54.50	4.69	0.19	1.94
13	T-57	0.90	5.35	4.85	3.10	9.68	69.41	1.77	0.11	1.32
14	TB-1	0.65	4.95	4.03	5.59	12.75	67.07	2.50	0.16	1.54
15	HUB-18	0.34	5.10	4.80	3.16	16.72	70.35	3.40	0.26	7.08
	Testers									
16	Arka Abha	0.47	5.05	4.86	5.65	11.99	94.10	3.33	0.34	5.50
17	Arka Alok	0.27	4.45	4.13	4.98	16.25	145.35	1.44	0.20	3.45
18	DMT-2	0.30	4.10	4.79	4.59	17.43	79.17	3.95	0.30	8.74

Table 13 contd....

Sl. No.	Genotypes	Rind thickness (mm)	TSS (°Brix)	pH	Lycopene (mg/100g)	β-carotene (mg/100g)	Number of seeds per fruit	1000 seed weight (g)	Seed weight per fruit (g)	Seed yield per plant (g)
	Crosses									
19	T-26 X Arka Abha	0.50	5.90	5.01	5.30	10.73	73.88	1.85	0.12	3.52
20	T-26 X Arka Alok	0.21	4.85	4.85	5.79	13.95	33.70	5.59	0.16	4.45
21	T-26 X DMT-2	0.37	5.15	4.90	5.47	10.50	94.03	2.81	0.24	14.95
22	T-36 X Arka Abha	0.77	4.05	4.30	6.03	16.46	127.35	2.71	0.33	5.46
23	T-36 X Arka Alok	0.42	5.50	4.37	3.05	12.33	110.79	1.90	0.19	4.62
24	T-36 X DMT-2	0.23	5.10	4.90	5.97	11.91	68.87	4.67	0.32	15.25
25	Arka VikasX Arka Abha	0.66	5.45	4.36	6.84	14.54	128.12	1.95	0.22	5.55
26	Arka Vikas X Arka Alok	0.69	4.45	4.55	2.88	12.50	52.99	2.52	0.12	4.95
27	Arka Vikas X DMT-2	0.29	4.60	4.80	3.22	9.75	44.17	5.66	0.23	5.65
28	Swarna Naveen X Arka Abha	0.92	5.10	4.36	3.73	14.55	102.50	2.03	0.19	7.14
29	Swarna Naveen X Arka Alok	0.53	6.30	4.50	2.99	9.10	43.00	3.38	0.14	2.43
30	Swarna Naveen X DMT-2	0.28	5.50	5.15	2.36	16.01	97.50	4.08	0.37	7.75
31	Vaibhav X Arka Abha	0.45	4.50	4.09	2.27	11.70	118.14	1.73	0.18	4.51
32	Vaibhav X Arka Alok	0.60	3.75	4.36	2.65	13.46	148.35	2.58	0.38	11.80
33	Vaibhav X DMT-2	0.43	5.20	4.67	5.20	15.79	153.45	1.66	0.20	8.05
34	DMT -1 X Arka Abha	0.50	3.70	4.95	5.37	12.65	64.32	3.43	0.20	5.66

Table 13 contd....

Sl. No.	Genotypes	Rind thickness (mm)	TSS (°Brix)	pH	Lycopene (mg/100g)	β-carotene (mg/100g)	Number of seeds per fruit	1000 seed weight (g)	Seed weight per fruit (g)	Seed yield per plant (g)
35	DMT -1 X Arka Alok	0.57	4.45	4.05	4.76	11.05	51.73	3.69	0.17	4.01
36	DMT -1 X DMT-2	0.53	5.10	4.30	3.98	13.70	78.32	1.56	0.15	4.23
37	DMT-5 X Arka Abha	0.55	5.70	4.21	2.76	9.91	83.37	3.69	0.31	16.65
38	DMT-5 X Arka Alok	0.56	4.30	5.21	4.33	12.99	116.35	2.33	0.25	15.85
39	DMT-5 X ODMT-2	0.77	4.50	4.38	3.53	10.05	82.40	2.62	0.20	10.86
40	S-22 X Arka Abha	0.42	5.05	4.47	2.36	12.20	169.87	1.95	0.18	12.05
41	S-22 X Arka Alok	0.37	4.50	5.11	5.22	13.42	95.37	1.67	0.19	3.96
42	S-22 X DMT-2	0.57	6.00	4.66	7.02	9.66	72.84	4.45	0.30	15.72
43	Arka Meghali X Arka Abha	0.58	4.50	4.43	3.70	11.38	58.35	2.01	0.12	5.95
44	Arka Meghali X Arka Alok	0.57	5.00	4.30	3.76	20.73	93.62	2.17	0.19	7.62
45	Arka Meghali X DMT-2	0.52	4.00	4.26	4.32	13.52	87.50	1.94	0.15	4.04
46	Megha X Arka Abha	0.38	5.55	4.16	4.52	16.35	76.12	3.20	0.24	7.71
47	Megha X Arka Alok	0.31	5.00	5.18	2.29	10.72	67.00	2.71	0.17	8.18
48	Megha X DMT-2	0.39	4.70	4.43	5.86	17.49	88.25	3.09	0.26	13.15
49	K-3 X Arka Abha	0.34	5.25	4.76	5.37	22.88	65.62	2.99	0.18	6.95
50	K-3 X Arka Alok	0.56	4.90	5.03	6.72	12.46	86.72	2.21	0.18	5.40
51	K-3 X DMT-2	0.58	5.90	4.84	5.49	22.89	82.38	2.71	0.19	8.05

Table 13 contd....

Sl. No.	Genotypes	Rind thickness (mm)	TSS (°Brix)	pH	Lycopene (mg/100g)	β-carotene (mg/100g)	Number of seeds per fruit	1000 seed weight (g)	Seed weight per fruit (g)	Seed yield per plant (g)
52	T-57 X Arka Abha	0.31	5.10	5.17	4.65	15.02	63.10	2.60	0.15	5.71
53	T-57 X Arka Alok	0.61	5.30	4.51	3.76	15.01	68.10	3.41	0.24	6.21
54	T-57 X DMT-2	0.14	4.90	4.42	3.08	13.50	60.64	4.73	0.26	5.15
55	TB-1 X Arka Abha	0.53	5.90	4.40	4.50	17.52	63.50	2.63	0.15	4.63
56	TB-1 X Arka Alok	0.35	5.15	4.90	2.55	12.81	156.37	1.71	0.28	6.47
57	TB-1 X DMT-2	0.53	3.95	5.03	2.30	12.11	67.57	2.45	0.16	4.99
58	HUB-18X Arka Abha	0.86	5.10	4.59	3.77	10.02	90.75	2.09	0.17	6.63
59	HUB-18X Arka Alok	0.77	5.15	4.15	4.70	15.90	76.27	1.87	0.15	6.49
60	HUB-18X DMT-2	0.49	4.10	4.83	3.54	17.00	18.50	6.66	0.14	7.36
61	DMT-3 X Arka Abha	0.51	5.15	4.51	2.35	14.17	74.57	2.88	0.20	6.85
62	DMT-3 X Arka Alok	0.33	4.85	4.15	4.63	19.06	48.87	3.62	0.17	6.05
63	DMT-3 X DMT-2	0.50	4.60	5.01	2.68	15.30	86.85	2.77	0.22	5.01
	Commercial check									
64	JK-Desi (F ₁)	0.46	5.35	4.66	4.84	18.94	94.75	2.31	0.23	11.35
	S.Em±	2.54	0.36	0.20	0.36	0.86	8.39	0.17	1.79	0.51
	C.D. at 5%	5.06	0.94	0.53	0.82	2.18	19.84	0.40	5.03	0.92
	C.D.at 1%	6.71	1.25	0.71	1.09	2.90	26.38	0.59	6.68	1.23

Table 14. Heterosis (%) over better parent, best parent and commercial check for quality parameters in tomato

Sl. No.	Crosses	Number of locules per fruit			Rind thickness			TSS		
		BP	BTP	CC	BP	BTP	CC	BP	BTP	CC
1	T-26 x Arka Abha	-20.59**	17.39**	-28.95**	-24.24**	-44.44**	8.70**	15.01**	1.72**	10.28**
2	T-26 x Arka Alok	5.26**	56.52**	-5.26**	-68.18**	-76.67**	-54.35**	-5.46**	-16.38**	-9.35**
3	T-26 x DMT-2	-23.98**	13.04**	-31.58**	-43.94**	-58.89**	-19.57**	0.39	-11.21**	-3.74**
4	T-36 x Arka Abha	59.18**	69.57**	2.63**	63.83**	-14.44**	67.39**	-19.80**	-30.17**	-24.30**
5	T-36 x Arka Alok	14.29**	21.74**	-26.32**	55.56**	-53.33**	-8.70**	23.60**	-5.17**	2.80**
6	T-36 x DMT-2	42.86**	52.17**	-7.89**	-23.33**	-74.44**	-50.00**	15.91**	-12.07**	-4.67**
7	Arka Vikas x Arka Abha	4.84**	41.30**	-14.47**	-15.38**	-26.67**	43.48**	6.86**	-6.03**	1.87**
8	Arka Vikas x Arka Alok	77.42**	139.13**	44.74**	-11.54**	-23.33**	50.00**	-12.75**	-23.28**	-16.82**
9	Arka Vikas x DMT-2	74.19**	134.78**	42.11**	-62.82**	-67.78**	-36.96**	-9.80**	-20.69**	-14.02**
10	Swarna Naveen x Arka Abha	14.71**	69.57**	2.63**	95.74**	2.22**	100.00**	0.99**	-12.07**	-4.67**
11	Swarna Naveen x Arka Alok	4.11**	65.22**	0.00	70.97**	-41.11**	15.22**	31.25**	8.62**	17.76**
12	Swarna Naveen x DMT-2	24.32**	100.00**	21.05**	-9.68**	-68.89**	-39.13**	14.58**	-5.17**	2.80**
13	Vaibhav x Arka Abha	3.23**	39.13**	-15.79**	-4.26**	-50.00**	-2.17**	-17.43**	-22.41**	-15.89**
14	Vaibhav x Arka Alok	38.71**	86.96**	13.16**	50.00**	-33.33**	30.43**	-31.19**	-35.34**	-29.91**
15	Vaibhav x DMT-2	0.00	34.78**	-18.42**	-4.44**	-52.22**	-6.52**	-4.59**	-10.34**	-2.80**
16	DMT -1 x Arka Abha	27.59**	60.87**	-2.63**	6.38**	-44.44**	8.70**	-27.45**	-36.21**	-30.84**
17	DMT -1 x Arka Alok	48.28**	86.96**	13.16**	42.50**	-36.67**	23.91**	-12.75**	-23.28**	-16.82**

Table 14 contd.....

Sl. No.	Crosses	Number of locules per fruit			Rind thickness			TSS		
		BP	BTP	CC	BP	BTP	CC	BP	BTP	CC
18	DMT -1 x DMT-2	10.34**	39.13**	-15.79**	76.67**	-41.11**	15.22**	0.00	-12.07**	-4.67**
19	DMT-5 x Arka Abha	2.94**	52.17**	-7.89**	-17.91**	-38.89**	19.57**	5.56**	-1.72**	6.54**
20	DMT-5 x Arka Alok	-6.85**	47.83**	-10.53**	-16.42**	-37.78**	21.74**	-20.37**	-25.86**	-19.63**
21	DMT-5 x DMT-2	-9.46**	45.65**	-11.84**	14.93**	-14.44**	67.39**	-16.67**	-22.41**	-15.89**
22	S-22 x Arka Abha	2.06**	50.87**	-8.68**	-10.64**	-53.33**	-8.70**	-12.93**	-12.93**	-5.61**
23	S-22 x Arka Alok	16.44**	84.78**	11.84**	-21.28**	-58.89**	-19.57**	-22.41**	-22.41**	-15.89**
24	S-22 x DMT-2	0.00	58.70**	-3.95**	21.28**	-36.67**	23.91**	3.45**	3.45**	12.15**
25	Arka Meghali x Arka Abha	39.68**	91.30**	15.79**	23.40**	-35.56**	26.09**	-10.89**	-22.41**	-15.89**
26	Arka Meghali x Arka Alok	-1.59**	34.78**	-18.42**	62.86**	-36.67**	23.91**	6.38**	-13.79**	-6.54**
27	Arka Meghali x DMT-2	9.52**	50.00**	-9.21**	48.57**	-42.22**	13.04**	-14.89**	-31.03**	-25.23**
28	Megha x Arka Abha	15.00**	50.00**	-9.21**	-29.63**	-57.78**	-17.39**	-1.77**	-4.31**	3.74**
29	Megha x Arka Alok	23.33**	60.87**	-2.63**	-42.59**	-65.56**	-32.61**	-11.50**	-13.79**	-6.54**
30	Megha x DMT-2	44.00**	87.83**	13.68**	-27.78**	-56.67**	-15.22**	-16.81**	-18.97**	-12.15**
31	K-3 x Arka Abha	54.41**	128.26**	38.16**	-54.67**	-62.22**	-26.09**	3.96**	-9.48**	-1.87**
32	K-3 x Arka Alok	52.05**	141.30**	46.05**	-25.33**	-37.78**	21.74**	5.38**	-15.52**	-8.41**
33	K-3 x DMT-2	-6.76**	50.00**	-9.21**	-22.67**	-35.56**	26.09**	26.88**	1.72**	10.28**
34	T-57 x Arka Abha	4.41**	54.35**	-6.58**	-65.56**	-65.56**	-32.61**	-4.67**	-12.07**	-4.67**
35	T-57 x Arka Alok	-10.96**	41.30**	-14.47**	-32.22**	-32.22**	32.61**	-0.93	-8.62**	-0.93

Table 14 contd.....

Sl. No.	Crosses	Number of locules per fruit			Rind thickness			TSS		
		BP	BTP	CC	BP	BTP	CC	BP	BTP	CC
36	T-57 x DMT-2	-6.76**	50.00**	-9.21**	-84.44**	-84.44**	-69.57**	-8.41**	-15.52**	-8.41**
37	TB-1 x Arka Abha	-4.41**	41.30**	-14.47**	-18.46**	-41.11**	15.22**	16.83**	1.72**	10.28**
38	TB-1 x Arka Alok	-19.18**	28.26**	-22.37**	-46.15**	-61.11**	-23.91**	4.04**	-11.21**	-3.74**
39	TB-1 x DMT-2	0.00	60.87**	-2.63**	-18.46**	-41.11**	15.22**	-20.20**	-31.90**	-26.17**
40	HUB-18X Arka Abha	86.96**	86.96**	13.16**	82.98**	-4.44**	86.96**	0.00	-12.07**	-4.67**
41	HUB-18X Arka Alok	81.30**	81.30**	9.74**	126.47**	-14.44**	67.39**	0.98**	-11.21**	-3.74**
42	HUB-18X DMT-2	41.30**	41.30**	-14.47**	44.12**	-45.56**	6.52**	-19.61**	-29.31**	-23.36**
43	DMT-3 x Arka Abha	78.57**	117.39**	31.58**	8.51**	-43.33**	10.87**	1.98**	-11.21**	-3.74**
44	DMT-3 x Arka Alok	82.14**	121.74**	34.21**	-21.43**	-63.33**	-28.26**	4.30**	-16.38**	-9.35**
45	DMT-3 x DMT-2	17.86**	43.48**	-13.16**	19.05**	-44.44**	8.70**	-1.08**	-20.69**	-14.02**
	S.Em±	0.30	0.30	0.30	0.07	0.07	0.07	0.36	0.36	0.36
	C.D. at 5%	0.60	0.60	0.60	0.14	0.14	0.14	0.74	0.74	0.74
	C.D.at 1%	0.81	0.81	0.81	0.18	0.18	0.18	0.98	0.98	0.98

*and ** indicate significance of values at $p=0.05$ and 0.01 , respectively. BP- Heterosis over better parent, BTP- Heterosis over the best parent, CC- Heterosis over the commercial check (JK-Desi F_1).

4.2.20 Lycopene (Table 13 and 15)

Genotypes varied significantly among themselves for lycopene and it ranged from 2.93 (T-36) to 6.08 mg/100 g (DMT-5) among lines, 4.59 (DMT-2) to 5.65 mg/100 g (Arka Abha) among testers and 2.27 (Vaibhav x Arka Abha) to 7.02 mg/100 g (S-22 x DMT-2) among crosses studied. Magnitude of heterosis over better parent, the best parent and the commercial check was significant in both the directions. The maximum positive and significant heterosis over better parent was observed in the cross S-22 x DMT-2 (52.94%) and none of the crosses recorded positive and significant heterosis over the best parent and commercial check. Among 45 crosses, only one cross shown positive and significant heterosis over better parent.

4.2.21 β -carotene (Table 13 and 15)

Genotypes varied significantly among themselves for β -carotene and it ranged from 7.38 (S-22) to 16.72 mg/100 g (HUB-18) among lines, 11.99 (Arka Abha) to 17.43 mg/100 g (DMT-2) among testers and 9.10 (Swarna Naveen x Arka Alok) to 22.89 mg/100 g (K-3 x DMT-2) among crosses studied. Magnitude of heterosis over better parent, the best parent and the commercial check was significant in both the directions. The maximum positive and significant heterosis over better parent (90.83%), best parent (24.21%) and commercial check (20.80%) was observed in the cross K-3 x Arka Abha. Among 45 crosses, 16, five and five crosses shown positive and significant heterosis over better parent, the best parent and the commercial check, respectively.

4.2.22 Number of seeds per fruit (Table 13 and 16)

Genotypes varied significantly among themselves for number of seeds per fruit and it ranged from 42.50 (Vaibhav) to 96.07 (T-36) among lines, 79.17 (DMT-2) to 145.35 (Arka Alok) among testers and 18.50 (HUB-18 x DMT-2) to 169.87 (S-22 x Arka Abha) among crosses studied. Magnitude of heterosis over better parent, the best parent and the commercial check was significant in both the directions. The maximum positive and significant heterosis over better parent was observed in the cross Vaibhav x DMT-2 (93.82%). None of the crosses recorded positive and significant heterosis over the best parent and the cross S-22 x Arka Abha recorded maximum heterosis over commercial check (79.28%). Among 45 crosses, six and six crosses shown positive and significant heterosis over better parent and the commercial check, respectively.

Table 15. Heterosis (%) over better parent, best parent and commercial check for quality parameters in tomato

Sl. No.	Crosses	pH			Lycopene			β-carotene		
		BP	BTP	CC	BP	BTP	CC	BP	BTP	CC
1	T-26 x Arka Abha	16.51**	21.31**	7.51**	-2.75	-12.83	9.50	-10.51**	-41.75**	-43.35**
2	T-26 x Arka Alok	17.43**	17.43**	4.08**	6.24	-4.77	19.63	-14.15**	-24.27**	-26.35**
3	T-26 x DMT-2	13.95**	18.64**	5.15**	0.37	-10.03	13.02	-39.76**	-43.00**	-44.56**
4	T-36 x Arka Abha	-2.49**	4.12**	-7.73**	6.73	-0.82	24.59	37.28**	-10.64**	-13.09**
5	T-36 x Arka Alok	5.81**	5.81**	-6.22**	-38.76	-49.84*	-36.98	-24.12**	-33.06**	-34.90**
6	T-36 x DMT-2	11.11**	18.64**	5.15**	30.07	-1.81	23.35	-31.67**	-35.34**	-37.12**
7	Arka Vikas x Arka Abha	-2.02**	5.57**	-6.44**	21.06	12.50	41.32	21.27**	-21.06**	-23.23**
8	Arka Vikas x Arka Alok	10.17**	10.17**	-2.36**	-42.17	-52.63*	-40.50	-23.08**	-32.14**	-34.00**
9	Arka Vikas x DMT-2	7.87**	16.22**	3.00**	-29.85	-47.04	-33.47	-44.06**	-47.07**	-48.52**
10	Swarna Naveen x Arka Abha	2.59**	5.57**	-6.44**	-33.98	-38.65	-22.93	17.81**	-21.01**	-23.18**
11	Swarna Naveen x Arka Alok	8.96**	8.96**	-3.43**	-39.96	-50.82*	-38.22	-44.00**	-50.60**	-51.95**
12	Swarna Naveen x DMT-2	21.18**	24.70**	10.52**	-48.58	-61.18*	-51.24*	-8.15**	-13.08**	-15.47**
13	Vaibhav x Arka Abha	-15.84**	-0.97**	-12.23**	-59.82*	-62.66*	-53.10*	-2.42*	-36.48**	-38.23**
14	Vaibhav x Arka Alok	5.57**	5.57**	-6.44**	-46.79	-56.41*	-45.25	-17.17**	-26.93**	-28.93**
15	Vaibhav x DMT-2	-40.05**	13.08**	0.21	13.29	-14.47	7.44	-9.41**	-14.28**	-16.63**
16	DMT -1 x Arka Abha	19.28**	19.85**	6.22**	-4.96	-11.68	10.95	5.50**	-31.32**	-33.21**
17	DMT -1 x Arka Alok	-1.94**	-1.94**	-13.09**	-4.42	-21.71	-1.65	-32.00**	-40.01**	-41.66**

Table 15 contd.....

Sl. No.	Crosses	pH			Lycopene			β-carotene		
		BP	BTP	CC	BP	BTP	CC	BP	BTP	CC
18	DMT -1 x DMT-2	3.61**	4.12**	-7.73**	-13.29	-34.54	-17.77	-21.40**	-25.62**	-27.67**
19	DMT-5 x Arka Abha	-6.65**	1.94**	-9.66**	-54.61*	-54.61*	-42.98	-17.35**	-46.20**	-47.68**
20	DMT-5 x Arka Alok	26.15**	26.15**	11.80**	-28.78	-28.78	-10.54	-20.06**	-29.48**	-31.41**
21	DMT-5 x DMT-2	-2.88**	6.05**	-6.01**	-41.94	-41.94	-27.07	-42.34**	-45.44**	-46.94**
22	S-22 x Arka Abha	1.59**	8.23**	-4.08**	-58.23*	-61.18*	-51.24*	1.75	-33.77**	-35.59**
23	S-22 x Arka Alok	23.73**	23.73**	9.66**	4.82	-14.14	7.85	-17.42**	-27.14**	-29.14**
24	S-22 x DMT-2	4.95**	12.83**	0.00	52.94*	15.46	45.04	-44.58**	-47.56**	-49.00**
25	Arka Meghali x Arka Abha	-7.90**	7.26**	-4.94**	-34.51	-39.14	-23.55	-18.60**	-38.22**	-39.92**
26	Arka Meghali x Arka Alok	4.12**	4.12**	-7.73**	-24.50	-38.16	-22.31	27.57**	12.54**	9.45**
27	Arka Meghali x DMT-2	-11.43**	3.15**	-8.58**	-5.88	-28.95	-10.74	-22.43**	-26.60**	-28.62**
28	Megha x Arka Abha	-8.77**	0.73**	-10.73**	-20.00	-25.66	-6.61	-11.24**	-11.24**	-13.67**
29	Megha x Arka Alok	25.42**	25.42**	11.16**	-54.02*	-62.34*	-52.69*	-41.80**	-41.80**	-43.40**
30	Megha x DMT-2	-2.85**	7.26**	-4.94**	27.67	-3.62	21.07	-5.05**	-5.05**	-7.66**
31	K-3 x Arka Abha	1.28**	15.25**	2.15**	-4.62	-11.68	10.95	90.83**	24.21**	20.80**
32	K-3 x Arka Alok	21.79**	21.79**	7.94**	19.36	10.53	38.84	-23.32**	-32.36**	-34.21**
33	K-3 x DMT-2	2.98**	17.19**	3.86**	-2.49	-9.70	13.43	31.33**	24.27**	20.86**
34	T-57 x Arka Abha	6.60**	25.18**	10.94**	-17.70	-23.52	-3.93	25.27**	-18.46**	-20.70**
35	T-57 x Arka Alok	9.20**	9.20**	-3.22**	-24.50	-38.16	-22.31	-7.63**	-18.51**	-20.75**

Table 15 contd.....

Sl. No.	Crosses	pH			Lycopene			β-carotene		
		BP	BTP	CC	BP	BTP	CC	BP	BTP	CC
36	T-57 x DMT-2	-7.72**	7.02**	-5.15**	-32.90	-49.34*	-36.36	-22.55**	-26.71**	-28.72**
37	TB-1 x Arka Abha	9.18**	6.54**	-5.58**	-20.35	-25.99	-7.02	37.41**	-4.89**	-7.50**
38	TB-1 x Arka Alok	21.59**	18.64**	5.15**	-54.38*	-58.06*	-47.31	-21.17**	-30.46**	-32.37**
39	TB-1 x DMT-2	24.81**	21.79**	7.94**	-58.86*	-62.17*	-52.48*	-30.52**	-34.26**	-36.06**
40	HUB-18X Arka Abha	-4.38**	11.14**	-1.50**	-33.27	-37.99	-22.11	-40.07**	-45.60**	-47.10**
41	HUB-18X Arka Alok	0.48**	0.48	-10.94**	-5.62	-22.70	-2.89	-4.90**	-13.68**	-16.05**
42	HUB-18X DMT-2	0.84**	16.95**	3.65**	-22.88	-41.78	-26.86	-2.47*	-7.71**	-10.24**
43	DMT-3 x Arka Abha	4.88**	9.20**	-3.22**	-58.41*	-61.35*	-51.45*	18.18**	-23.07**	-25.18**
44	DMT-3 x Arka Alok	0.48	0.48	-10.94**	-7.03	-23.85	-4.34	17.29**	3.47**	0.63
45	DMT-3 x DMT-2	16.51**	21.31**	7.51**	-41.61	-55.92*	-44.63	-12.22**	-16.94**	-19.22**
	S.Em±	0.27	0.27	0.27	24.24	24.24	24.24	1.05	1.05	1.05
	C.D. at 5%	0.55	0.55	0.55	48.87	48.87	48.87	2.12	2.12	2.12
	C.D.at 1%	0.74	0.74	0.74	65.28	65.28	65.28	2.83	2.83	2.83

*and ** indicate significance of values at p=0.05 and 0.01, respectively. BP- Heterosis over better parent, BTP- Heterosis over the best parent, CC- Heterosis over the commercial check (JK-Desi F₁).

Table 16. Heterosis (%) over better parent, best parent and commercial check for seed parameters in tomato

Sl. No.	Crosses	Number of seeds per fruit			1000 seed weight			Seed weight per fruit		
		BP	BTP	CC	BP	BTP	CC	BP	BTP	CC
1	T-26 x Arka Abha	-21.49*	-49.17**	-22.03*	-44.44**	-65.03**	-19.91**	-64.71**	-64.71**	-47.83**
2	T-26 x Arka Alok	-76.81**	-76.81**	-64.43**	132.92**	5.67**	141.99**	-20.00**	-52.94**	-30.43**
3	T-26 x DMT-2	10.82	-35.31**	-0.76	-28.86**	-46.88**	21.65**	-20.00**	-29.41**	4.35**
4	T-36 x Arka Abha	32.56**	-12.38	34.41**	-18.62**	-48.77**	17.32**	-2.94**	-2.94**	43.48**
5	T-36 x Arka Alok	-23.78*	-23.78*	16.93	0.00	-64.08**	-17.75**	-5.00**	-44.12**	-17.39**
6	T-36 x DMT-2	-28.31*	-52.62**	-27.31*	18.23**	-11.72**	102.16**	6.67**	-5.88**	39.13**
7	Arka Vikas x Arka Abha	36.15**	-11.85	35.22**	-42.98**	-63.14**	-15.58**	-35.29**	-35.29**	-4.35**
8	Arka Vikas x Arka Alok	-63.54**	-63.54**	-44.07**	-26.32**	-52.36**	9.09**	-40.00**	-64.71**	-47.83**
9	Arka Vikas x DMT-2	-44.21**	-69.61**	-53.38**	43.29**	6.99**	145.02**	-23.33**	-32.35**	0.00
10	Swarna Naveen x Arka Abha	8.93	-29.48**	8.18	-38.48**	-61.63**	-12.12**	-44.12**	-44.12**	-17.39**
11	Swarna Naveen x Arka Alok	-70.42**	-70.42**	-54.62**	46.32**	-36.11**	46.32**	-30.00**	-58.82**	-39.13**
12	Swarna Naveen x DMT-2	23.15*	-32.92**	2.90	329.47**	-22.87**	76.62**	23.33**	8.82**	60.87**
13	Vaibhav x Arka Abha	25.55*	-18.72	24.69*	-67.30**	-67.30**	-25.11**	-47.06**	-47.06**	-21.74**
14	Vaibhav x Arka Alok	2.06	2.06	56.57**	-51.23**	-51.23**	11.69**	90.00**	11.76**	65.22**
15	Vaibhav x DMT-2	93.82**	5.57	61.95**	-68.62**	-68.62**	-28.14**	-33.33**	-41.18**	-13.04**
16	DMT -1 x Arka Abha	-31.65**	-55.75**	-32.12**	3.00**	-35.16**	48.48**	-41.18**	-41.18**	-13.04**
17	DMT -1 x Arka Alok	-64.41**	-64.41**	-45.40**	12.50**	-30.25**	59.74**	-32.00**	-50.00**	-26.09**

Table 16 contd.....

Sl. No.	Crosses	Number of seeds per fruit			1000 seed weight			Seed weight per fruit		
		BP	BTP	CC	BP	BTP	CC	BP	BTP	CC
18	DMT -1 x DMT-2	-9.40	-46.12**	-17.34	-60.51**	-70.51**	-32.47**	-50.00**	-55.88**	-34.78**
19	DMT-5 x Arka Abha	-11.40	-42.64**	-12.01	-26.79**	-30.25**	59.74**	-8.82**	-8.82**	34.78**
20	DMT-5 x Arka Alok	-19.95	-19.95	22.80*	-53.77**	-55.95**	0.87**	8.70**	-26.47**	8.70**
21	DMT-5 x DMT-2	-2.89	-43.31**	-13.03	-48.02**	-50.47**	13.42**	-13.04**	-41.18**	-13.04**
22	S-22 x Arka Abha	80.52**	16.87	79.28**	-51.73**	-63.14**	-15.58**	-47.06**	-47.06**	-21.74**
23	S-22 x Arka Alok	-34.39**	-34.39**	0.65	-58.66**	-68.43**	-27.71**	-5.00**	-44.12**	-17.39**
24	S-22 x DMT-2	-14.15	-49.89**	-23.12*	10.15**	-15.88**	92.64**	0.00	-11.76**	30.43**
25	Arka Meghali x Arka Abha	-37.99**	-59.86**	-38.42**	-41.40**	-62.00**	-12.99**	-64.71**	-64.71**	-47.83**
26	Arka Meghali x Arka Alok	-35.59**	-35.59**	-1.19	-36.73**	-58.98**	-6.06**	-5.00**	-44.12**	-17.39**
27	Arka Meghali x DMT-2	3.12	-39.80**	-7.65	-43.44**	-63.33**	-16.02**	-50.00**	-55.88**	-34.78**
28	Megha x Arka Abha	-19.11	-47.63**	-19.66	140.60**	-39.51**	38.53**	-29.41**	-29.41**	4.35**
29	Megha x Arka Alok	-53.90**	-53.90**	-29.29**	45.70**	-48.77**	17.32**	-15.00**	-50.00**	-26.09**
30	Megha x DMT-2	4.01	-39.28**	-6.86	-21.77**	-41.59**	33.77**	-13.33**	-23.53**	13.04**
31	K-3 x Arka Abha	-30.27**	-54.85**	-30.74**	-36.25**	-43.48**	29.44**	-47.06**	-47.06**	-21.74**
32	K-3 x Arka Alok	-40.34**	-40.34**	-8.47	-52.88**	-58.22**	-4.33**	-10.00**	-47.06**	-21.74**
33	K-3 x DMT-2	-2.91	-43.32**	-13.06	-42.22**	-48.77**	17.32**	-36.67**	-44.12**	-17.39**
34	T-57 x Arka Abha	-32.94**	-56.59**	-33.40**	-21.92**	-50.85**	12.55**	-55.88**	-55.88**	-34.78**
35	T-57 x Arka Alok	-53.15**	-53.15**	-28.13**	136.81**	-35.54**	47.62**	20.00**	-29.41**	4.35**

Table 16 contd.....

Sl. No.	Crosses	Number of seeds per fruit			1000 seed weight			Seed weight per fruit		
		BP	BTP	CC	BP	BTP	CC	BP	BTP	CC
36	T-57 x DMT-2	-28.53**	-58.28**	-36.00**	19.75**	-10.59**	104.76**	-13.33**	-23.53**	13.04**
37	TB-1 x Arka Abha	-32.52**	-56.31**	-32.98**	-21.02**	-50.28**	13.85**	-55.88**	-55.88**	-34.78**
38	TB-1 x Arka Alok	7.58	7.58	65.03**	-31.60**	-67.67**	-25.97**	40.00**	-17.65**	21.74**
39	TB-1 x DMT-2	-20.37	-53.51**	-28.69**	-37.97**	-53.69**	6.06**	-46.67**	-52.94**	-30.43**
40	HUB-18X Arka Abha	-3.56	-37.56**	-4.22	-38.53**	-60.49**	-9.52**	-50.00**	-50.00**	-26.09**
41	HUB-18X Arka Alok	-47.53**	-47.53**	-19.50	-45.00**	-64.65**	-19.05**	-42.31**	-55.88**	-34.78**
42	HUB-18X DMT-2	-78.20**	-87.27**	-80.47**	68.61**	25.90**	188.31**	-53.33**	-58.82**	-39.13**
43	DMT-3 x Arka Abha	-20.75	-48.70**	-21.30*	-14.29**	-45.56**	24.68**	-41.18**	-41.18**	-13.04**
44	DMT-3 x Arka Alok	-66.38**	-66.38**	-48.42**	7.74**	-31.57**	56.71**	-34.62**	-50.00**	-26.09**
45	DMT-3 x DMT-2	2.36	-40.25**	-8.34	-29.87**	-47.64**	19.91**	-26.67**	-35.29**	-4.35**
	S.Em±	10.42	10.42	10.42	0.28	0.28	0.28	0.05	0.05	0.05
	C.D. at 5%	21.01	21.01	21.01	0.56	0.56	0.56	0.01	0.01	0.01
	C.D.at 1%	28.07	28.07	28.07	0.76	0.76	0.76	0.14	0.14	0.14

*and ** indicate significance of values at p=0.05 and 0.01, respectively. BP- Heterosis over better parent, BTP- Heterosis over the best parent, CC- Heterosis over the commercial check (JK-Desi F₁).

4.2.23 Thousand seed weight (Table 13 and 16)

Genotypes varied significantly among themselves for thousand seed weight and it ranged from 1.77 (T-57) to 5.29 g (Vaibhav) among lines, 1.44 (Arka Alok) to 3.95 g (DMT-2) among testers and 1.56 (DMT-1 x DMT-2) to 6.66 g (HUB-18 x DMT-2) among crosses studied. Magnitude of heterosis over better parent, the best parent and the commercial check was significant in both the directions. The maximum positive and significant heterosis over better parent was observed in the cross Swarna Naveen x DMT-2 (329.47%). The cross HUB-18 x DMT-2 expressed maximum heterosis over the best parent (25.90%) and the commercial check (188.31%). Among 45 crosses, 10, two and 13 crosses shown positive and significant heterosis over better parent, the best parent and the commercial check, respectively.

4.2.24 Seed weight per fruit (Table 13 and 16)

Genotypes varied significantly among themselves for seed weight per fruit and it ranged from 0.10 (Megha) to 0.25 g (DMT-1) among lines, 0.20 (Arka Alok) to 0.34 g (Arka Abha) among testers and 0.12 (T-26 x Arka Abha, Arka Meghali x Arka Abha and Arka Vikas x Arka Alok) to 0.38 g (Vaibhav x Arka Alok) among crosses studied. Magnitude of heterosis over better parent, the best parent and the commercial check was significant in both the directions. The maximum positive and significant heterosis over better parent (90.00%), best parent (11.76 %) and commercial check (65.22 %) was observed in the cross Vaibhav x Arka Abha (90.00%). Among 45 crosses, 13, three and 13 crosses shown positive and significant heterosis over better parent, the best parent and the commercial check, respectively.

4.2.25 Seed yield per plant (Table 13 and 17)

Genotypes varied significantly among themselves for seed yield per plantit ranged from 1.32 (T-57) to 7.08 g (HUB-18) among lines, 3.45 (Arka Alok) to 8.74 g (DMT-2) among testers and 2.43 (Swarna Naveen x Arka Alok) to 16.65 g (DMT-5 x Arka Abha) among crosses studied. Magnitude of heterosis over better parent, the best parent and the commercial check was significant in both the directions. The maximum positive and significant heterosis over better parent was observed in the cross DMT-5 x Arka Alok (214.48%). The cross DMT-5 x Arka Abha expressed maximum heterosis over the best parent (90.50%) and the commercial check (46.70%). Among 45 crosses, 19, nine and seven crosses shown positive and significant heterosis over better parent, the best parent and the commercial check

Table 17. Heterosis (%) over better parent, best parent and commercial check for seed yield per plant in tomato

Sl. No.	Crosses	Seed yield per plant		
		BP	BTP	CC
1	T-26 x Arka Abha	-36.00**	-59.73**	-68.99**
2	T-26 x Arka Alok	-8.25**	-49.08**	-60.79**
3	T-26 x DMT-2	71.05**	71.05**	31.72**
4	T-36 x Arka Abha	-0.73	-37.53**	-51.89**
5	T-36 x Arka Alok	0.65	-47.14**	-59.30**
6	T-36 x DMT-2	74.49**	74.49**	34.36**
7	Arka Vikas x Arka Abha	-0.54**	-36.50**	-51.10**
8	Arka Vikas x Arka Alok	-11.29**	-43.36**	-56.39**
9	Arka Vikas x DMT-2	-35.35**	-35.35**	-50.22**
10	Swarna Naveen x Arka Abha	29.82**	-18.31**	-37.09**
11	Swarna Naveen x Arka Alok	-29.57**	-72.20**	-78.59**
12	Swarna Naveen x DMT-2	-11.33**	-11.33**	-31.72**
13	Vaibhav x Arka Abha	-27.14**	-48.40**	-60.26**
14	Vaibhav x Arka Alok	90.63**	35.01**	3.96**
15	Vaibhav x DMT-2	-7.89**	-7.89**	-29.07**
16	DMT -1 x Arka Abha	2.91**	-35.24**	-50.13**
17	DMT -1 x Arka Alok	-0.74	-54.12**	-64.67**
18	DMT -1 x DMT-2	-51.60**	-51.60**	-62.73**
19	DMT-5 x Arka Abha	202.73**	90.50**	46.70**
20	DMT-5 x Arka Alok	214.48**	81.35**	39.65**
21	DMT-5 x DMT-2	24.26**	24.26**	-4.32**
22	S-22 x Arka Abha	119.09**	37.87**	6.17**
23	S-22 x Arka Alok	14.78**	-54.69**	-65.11**
24	S-22 x DMT-2	79.86**	79.86**	38.50**
25	Arka Meghali x Arka Abha	8.18**	-31.92**	-47.58**
26	Arka Meghali x Arka Alok	120.87**	-12.81**	-32.86**
27	Arka Meghali x DMT-2	-53.78**	-53.78**	-64.41**
28	Megha x Arka Abha	40.18**	-11.78**	-32.07**

Table 17 contd.....

Sl. No.	Crosses	Seed yield per plant		
		BP	BTP	CC
29	Megha x Arka Alok	137.10**	-6.41**	-27.93**
30	Megha x DMT-2	50.46**	50.46**	15.86**
31	K-3 x Arka Abha	26.36**	-20.48**	-38.77**
32	K-3 x Arka Alok	56.52**	-38.22**	-52.42**
33	K-3 x DMT-2	-7.89**	-7.89**	-29.07**
34	T-57 x Arka Abha	3.82**	-34.67**	-49.69**
35	T-57 x Arka Alok	80.00**	-28.95**	-45.29**
36	T-57 x DMT-2	-41.08**	-41.08**	-54.63**
37	TB-1 x Arka Abha	-15.82**	-47.03**	-59.21**
38	TB-1 x Arka Alok	87.54**	-25.97**	-43.00**
39	TB-1 x DMT-2	-42.91**	-42.91**	-56.04**
40	HUB-18X Arka Abha	-6.36**	-24.14**	-41.59**
41	HUB-18X Arka Alok	-8.33**	-25.74**	-42.82**
42	HUB-18X DMT-2	-15.79**	-15.79**	-35.15**
43	DMT-3 x Arka Abha	24.55**	-21.62**	-39.65**
44	DMT-3 x Arka Alok	18.16**	-30.78**	-46.70**
45	DMT-3 x DMT-2	-42.68**	-42.68**	-55.86**
	S.Em±	0.45	0.45	0.45
	C.D. at 5%	0.92	0.92	0.92
	C.D.at 1%	1.23	1.23	1.23

*and ** indicate significance of values at $p=0.05$ and 0.01 , respectively. BP- Heterosis over better parent, BTP- Heterosis over the best parent, CC- Heterosis over the commercial check (JK-Desi F₁).

4.3 Combining ability effects and variance (Table 18)

The variance due to general combining ability (GCA), specific combining ability (SCA) and GCA to SCA ratio for various characters are presented in Table-18. Moderate to low GCA to SCA ratio was observed for number of primary branches at 90 DAT (0.15). Low GCA to SCA ratio was observed for plant height at 60 DAT (0.006), plant height at 90 DAT (0.005), number of primary branches at 60 DAT (0.009), number of secondary branches at 60 DAT (0.002), number of secondary branches at 90 DAT (0.005), days to first flowering (0.004), days to 50 per cent flowering (0.002), days to first fruit set (0.004), days to first fruit maturity (0.009), equatorial diameter of fruit (0.001), polar diameter of the fruit (0.006), number of fruits per cluster (0.001), average fruit weight (0.003), number of fruits per plant (0.002), yield per plant (0.002), yield per plot (0.003), yield per hectare (0.001), number of seeds per fruit (0.006), seed weight per fruit (0.010), 1000 seed weight (0.016), seed yield per plant (0.004), number of locules per fruit (0.008), rind thickness (0.003), total soluble solids (0.002), pH (0.001), lycopene (0.004) and β -carotene (0.005).

4.3.1 Plant height (Table 19 and 20)

For plant height at 60 DAT, four lines exhibited positive and significant gca effects. The maximum positive and significant gca effects was observed in the line Arka Meghali (9.07). Among testers, they did not vary significantly. Out of 45 crosses, seven crosses showed positive and significant sca effects and maximum sca effects was observed in the cross Megha x Arka Alok (14.43).

With respect to plant height at 90 DAT, five lines expressed significant positive gca effects and the line T-36 (11.56) exhibited maximum positive gca effects. Among testers, they did not vary significantly and nine crosses shown significant positive sca effects and maximum sca effects was observed in the cross S-22 x DMT-2 (17.43).

4.3.2 Number of primary branches (Table 19 and 20)

With respect to number of primary branches at 60 DAT, four lines out of 15 had significant gca effects. The line HUB-18 had maximum and significant positive gca effects (1.59). Out of three testers only Arka Alok had significant positive gca effects (0.38). Among hybrids, seven exhibited significant sca effects in positive direction and the maximum sca effects was expressed by T-26 x Arka Abha (2.35) hybrid.

With respect to number of primary branches at 90 DAT, seven lines out of 15 had significant gca effects. The line T-36 had maximum and significant positive gca effects (11.56). The tester DMT-2 had significant gca effects in positive direction (1.09) among testers. Four hybrids exhibited positive and significant sca effects. The cross T-26 x DMT-2 (2.34) expressed maximum positive and significant sca effects.

Table 18. Variance due to general combining ability and specific combining ability for different parameters in tomato

Sl. No.	Characters	GCA	SCA	GCA:SCA
1	Plant height at 60 DAT	1.650	298.77	0.006
2	Plant height at 90 DAT	2.76	592.29	0.005
3	Number of primary at 60 DAT	0.091	10.43	0.009
4	Number of primary at 90 DAT	0.112	7.37	0.15
5	Number of secondary branches at 60 DAT	0.042	24.27	0.002
6	Number of secondary branches at 90 DAT	0.12	23.79	0.005
7	Days to first flowering	0.14	33.02	0.004
8	Days to 50 percent flowering	0.024	13.415	0.002
9	Days to first fruit set	0.003	14.315	0.004
10	Days to first fruit maturity	0.38	43.35	0.009
11	Equatorial diameter of fruit	0.058	102.01	0.001
12	Polar diameter of fruit	4.30	749.22	0.006
13	Number of fruits per cluster	0.003	2.59	0.001
14	Average fruit weight	169.86	53421.40	0.003
15	Number of fruits per plant	1.83	777.65	0.002
16	Yield per plant	0.002	0.880	0.002
17	Yield per plot	0.48	187.46	0.003
18	Yield per hectare	0.005	407.64	0.001
19	Number of seeds per fruit	48.230	7689.27	0.006
20	Seed weight per fruit	0.12	11.99	0.010
21	1000 seed weight	0.000	0.022	0.016
22	Seed yield per plant	0.24	63.54	0.004
23	Number locules per fruit	0.050	6.31	0.008
24	Rind thickness	0.001	0.52	0.003
25	Total soluble solids	0.003	1.732	0.002
26	pH	0.001	0.713	0.001
27	Lycopene	7.383	1972.51	0.004
28	β -carotene	0.445	92.45	0.005

GCA- Variance due to General combining ability, SCA- Variance due to Specific combining ability, DAT: Days after transplanting.

Table 19. General combining ability effects for growth,flowering and earliness parameters in tomato

Sl. No.	Genotypes	Plant height		Number of primary branches		Number of secondary branches		Days to first flowering	Days to 50 per cent flowering	Days to first fruit set
	Lines	60 DAT	90 DAT	60 DAT	90 DAT	60 DAT	90 DAT			
1	T-26	8.43**	4.81 **	-0.25	-4.81 **	0.36	-0.02	-0.43	-1.21	-1.82
2	T-36	8.35**	11.56 **	0.35	11.56 **	1.85 **	-0.19	1.34	-0.54	0.34
3	Arka Vikas	5.66**	6.14 **	0.51	-6.14 **	1.15 **	0.72 **	1.72	-2.71**	-1.98 **
4	Swarna Naveen	-6.22 **	-5.12 **	-1.72 **	-5.12 **	-1.13 **	-1.49 **	-1.25 **	-0.71	-0.15
5	Vaibhav	2.20	3.46**	0.07	3.46**	-0.23	-0.01	2.07 *	0.28	0.01
6	DMT-1	0.37	3.03*	1.14 **	3.03**	1.96 **	1.00 **	2.18 *	0.45	-0.32
7	DMT-3	2.50	10.83 **	1.27 **	10.83 **	1.50 **	1.07 **	1.91 *	-1.04	-1.65 *
8	DMT-5	-0.57	0.77	0.87 **	0.77*	0.20	0.94 **	-0.12	0.45	0.17
9	S-22	-4.94 **	0.08	0.41 *	0.08	-0.66 *	0.97 **	-1.55	-0.54	0.17
10	Arka Meghali	9.07**	2.84*	-0.53	2.84**	-1.49 **	-0.52	-1.45	1.28	0.34
11	Megha	-0.80	-1.41	-1.65 **	-1.41 **	-0.89 **	-1.49 **	-0.47	-0.87	-0.48
12	K-3	-6.75 **	-4.31 **	-1.25 **	-4.38 **	-2.13 **	-1.22 **	-2.65 **	1.45	0.01
13	T-57	-10.02 **	-13.27 **	0.64 *	-13.27 **	0.56 *	0.44	-0.02	-0.87	2.34**
14	TB-1	-1.90	1.11	0.62 *	1.11**	-0.89 **	-0.69 *	-1.07	1.12	2.51 **
15	HUB-18	-5.37 **	1.38	1.59 **	1.38**	-0.15	1.21 **	-0.20	2.45**	2.51 **
	S.Em±	1.76	1.18	0.29	0.30	0.30	0.29	0.94	0.76	0.65
	C.D. at 5%	3.55	2.38	0.58	0.61	0.60	0.59	1.90	1.53	1.32
	C.D.at 1%	4.74	3.18	0.78	0.81	0.81	0.79	2.54	2.05	1.77

Table 19 contd....

Sl. No.	Genotypes	Plant height		Number of primary branches		Number of secondary branches		Days to first flowering	Days to 50 per cent flowering	Days to first fruit set
	Lines	60 DAT	90 DAT	60 DAT	90 DAT	60 DAT	90 DAT			
	Testers									
16	Arka Abha	0.68	0.56	-0.02	0.56**	0.38**	-0.04	0.25	-0.92 **	-0.22
17	Arka Alok	-1.28	-1.66 **	0.38 **	-1.66 **	0.20	0.33 **	0.35	-0.37	-0.15
18	DMT-2	0.59	1.09*	-0.28 *	1.09**	-0.43 **	-0.29 *	-1.19**	-0.54	0.37
	S.Em±	0.78	0.52	0.13	0.13	0.13	0.13	0.42	0.34	0.29
	C.D. at 5%	1.58	1.06	0.26	0.27	0.27	0.26	0.85	0.68	0.59
	C.D.at 1%	2.12	1.42	0.35	0.36	0.36	0.32	1.14	0.91	0.79

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

Table 20. Specific combining ability effects for growth, flowering and earliness parameters in tomato

Sl. No.	Crosses	Plant height		Number of primary branches		Number of secondary branches		Days to first flowering	Days to 50 per cent flowering	Days to first fruit set
		60 DAT	90 DAT	60 DAT	90 DAT	60 DAT	90 DAT			
1	T-26 X Arka Abha	10.07**	7.71 **	2.35**	0.51	-2.02 **	-1.83 **	0.74	0.22	-0.71
2	T-26 X Arka Alok	2.50	0.78	-0.69	-0.52	-0.41	-0.61	-3.60**	-3.38**	0.12
3	T-26 X DMT-2	-6.31 *	3.18	-0.31	2.34**	-0.61	0.24	0.41	0.05	-3.89**
4	T-36 X Arka Abha	-0.91	2.04	-1.07 *	-0.92	-0.42	-0.91	0.41	-0.27	0.28
5	T-36 X Arka Alok	0.64	2.73	-0.57	-0.60	-0.32	-1.15 *	-1.08	-1.44	-0.71
6	T-36 X DMT-2	-1.43	-3.63	1.53 **	0.97	0.97	0.63	0.74	0.88	-0.54
7	Arka VikasX Arka Abha	-8.10 *	-12.48**	0.62	0.47	0.43	-0.68	-3.25**	-1.27	-3.51**
8	Arka Vikas X Arka Alok	-1.36	-6.97 **	-0.47	-0.39	3.04 **	2.74 **	-0.25	0.38	-3.87**
9	Arka Vikas X DMT-2	-2.00	-3.03	0.18	-0.10	0.00	0.28	-0.25	-3.98**	1.28
10	Swarna Naveen X Arka Abha	13.43 **	17.39 **	0.23	0.31	-0.06	0.68	-3.58 **	-0.77	-3.71 **
11	Swarna Naveen X Arka Alok	4.96	2.98	-0.74	-0.52	-1.46 **	-1.90 **	2.57*	2.05	2.62 *
12	Swarna Naveen X DMT-2	13.62**	-5.33 *	0.05	-0.19	0.07	-0.11	2.24*	0.55	0.62
13	Vaibhav X Arka Abha	-0.46	0.89	0.85	1.04	0.07	0.04	-2.42*	-1.77	-0.87
14	Vaibhav X Arka Alok	-4.84	-1.48	0.62	0.57	1.03	1.81 **	2.07*	0.05	-0.87
15	Vaibhav X DMT-2	0.52	-4.78 *	-0.19	-0.38	0.49	0.78	0.24	0.55	2.45 *
16	DMT -1 X Arka Abha	-2.70	0.24	2.33**	2.04**	2.19 **	1.71 **	-2.28*	0.32	0.72
17	DMT -1 X Arka Alok	-10.56 **	-2.33	-1.56 **	1.50 **	-0.33	-0.62	1.04	0.15	-0.44

Table 20 contd....

Sl. No.	Crosses	Plant height		Number of primary branches		Number of secondary branches		Days to first flowering	Days to 50 per cent flowering	Days to first fruit set
18	DMT -1 X DMT-2	-3.37	-0.35	0.36	0.53	1.66 **	1.29 *	0.21	1.48	-0.77
19	DMT-5 X Arka Abha	5.25	2.20	1.59 **	0.90	0.69	-0.32	1.21	-0.34	-0.27
20	DMT-5 X Arka Alok	-5.87	-10.58 **	-0.85	-0.23	-2.70**	-0.15	0.71	4.04**	0.22
21	DMT-5 X DMT-2	2.13	-6.25 **	-0.46	-0.50	0.09	0.76	2.54*	-0.17	-0.11
22	S-22 X Arka Abha	3.74	16.49 **	-0.80	-0.70	-0.83	-0.98	1.04	-0.34	-0.27
23	S-22 X Arka Alok	1.80	4.80 *	0.09	0.03	-0.83	-1.25 *	-2.95**	-1.17	0.38
24	S-22 X DMT-2	-1.93	17.43**	-0.53	-0.28	-0.07	-0.12	-1.95*	-3.60**	-1.27
25	Arka Meghali X Arka Abha	2.80	-0.91	-0.53	-0.86	-1.03	-1.82 **	-0.28	-0.34	2.22
26	Arka Meghali X Arka Alok	6.46 **	4.30 *	0.93	0.49	0.96	-2.44 **	-1.62	-2.51	-1.44
27	Arka Meghali X DMT-2	2.57	-0.50	0.73	0.83	0.09	-0.02	0.04	0.48	0.55
28	Megha X Arka Abha	3.87	5.27 *	1.13 *	0.76	0.89	0.84	0.87	0.65	0.05
29	Megha X Arka Alok	14.43**	-0.72	-0.70	-0.40	-1.83 **	-2.28 **	0.87	0.98	1.55
30	Megha X DMT-2	-2.70	-8.94 **	-0.01	0.08	1.07 *	0.52	0.54	-0.51	-1.11
31	K-3 X Arka Abha	-3.36	-7.96 **	-1.48 **	-1.34 *	-0.16	0.12	-3.16**	-3.96**	-0.01
32	K-3 X Arka Alok	8.06 *	1.55	2.26 **	2.02 **	0.75	1.24 *	-3.78**	-0.37	0.32
33	K-3 X DMT-2	9.68 **	2.83	-0.05	-0.29	-1.05	-1.54 **	-0.62	-1.54	0.98
34	T-57 X Arka Abha	-4.33	-4.25 *	-0.11	0.02	3.32**	2.81**	-1.62	0.62	-0.01
35	T-57 X Arka Alok	5.23	7.85 **	1.43 **	0.84	3.03 **	1.30 *	0.37	0.45	0.48

Table 20 contd....

Sl. No.	Crosses	Plant height		Number of primary branches		Number of secondary branches		Days to first flowering	Days to 50 per cent flowering	Days to first fruit set
36	T-57 X DMT-2	0.70	9.88 **	-0.58	-0.47	-1.06 *	-1.40 **	-3.28 **	-0.71	0.65
37	TB-1 X Arka Abha	4.36	-4.01	0.18	0.22	0.40	1.67 **	2.21*	1.62	0.48
38	TB-1 X Arka Alok	-0.43	2.17	0.38	0.35	-1.40 *	-1.49 **	3.21**	0.78	-0.84
39	TB-1 X DMT-2	3.93	5.74 **	0.34	0.39	0.06	-0.15	2.21*	-0.71	-0.01
40	HUB-18X Arka Abha	-16.23 **	-16.47 **	0.29	0.55	1.10 *	1.14 *	3.87 **	1.12	1.48
41	HUB-18X Arka Alok	-11.42 **	-7.29 **	-0.18	0.02	0.50	-0.54	-0.95	0.45	-1.17
42	HUB-18X DMT-2	0.11	5.84 **	-0.78	-0.64	-0.16	0.14	-2.28**	-1.04	-3.10**
43	DMT-3 X Arka Abha	-3.40	-6.16 **	-1.98 **	-1.80 **	-0.96	-0.89	1.54	1.12	0.82
44	DMT-3 X Arka Alok	8.32 **	2.21	0.08	-0.17	0.80	0.47	-2.95*	-1.04	-0.67
45	DMT-3 X DMT-2	2.17	13.73 **	2.21**	0.29	-1.56 **	-1.30 *	-0.78	-0.04	-1.34
	S.Em±	3.05	2.04	0.50	0.52	0.52	0.51	1.01	1.31	1.14
	C.D. at 5%	6.15	4.12	1.01	1.05	1.05	1.03	1.77	2.65	2.30
	C.D.at 1%	8.21	5.51	1.35	1.41	1.40	1.38	3.01	3.55	3.07

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

4.2.3 Number of secondary branches (Table 19 and 20)

For number of secondary branches at 60 DAT, four lines showed significant positive gca effects. The highest positive gca effects was observed in the line DMT-1 (1.96). The tester Arka Abha had significant gca effects in positive direction (0.38) among testers. Five hybrids exhibited positive and significant sca effects. The cross T-57 x Arka Abha (3.32) expressed maximum positive and significant sca effects.

Number of secondary branches at 90 DAT, the line HUB-18 (1.21) shown maximum gca effects among lines and seven lines exhibited positive and significant gca effects. Among testers, Arka Alok (0.33) exhibited positive and significant gca effects. Maximum sca effects were observed in the cross T-57 x Arka Abha (2.81) and four hybrids shown significant sca effects in positive direction.

4.3.4 Day to first flowering (Table 19 and 20)

The parents and hybrids with negative gca and sca effects are desirable. Out of 15 lines, two had negative and significant gca effects. The maximum and negative gca effects was exhibited by the line K-3 (-2.65). The tester DMT-2 (-1.19) noticed exhibited gca effects among testers. Seven hybrids exhibited negative and significant sca effects. The maximum negative sca effects was observed in the cross T-26 x Arka Alok (-3.60).

4.3.5 Day to 50 per cent flowering (Table 19 and 20)

The parents and hybrids with negative gca and sca effects are desirable for day to 50 per cent flowering. Among 15 lines, only one had negative and significant gca effect and the maximum negative gca effects was observed in the line Arka Vikas (-2.71). The tester Arka Abha (-0.92) expressed negative and significant gca effects among testers. Four hybrids exhibited negative and significant sca effects. The maximum negative sca effects was observed in the cross DMT-5 x Arka Alok (-4.04).

4.3.6 Days to first fruit set (Table 19 and 20)

With respect to days to first fruit set, only one line out of 15 had significant gca effects. The line Arka Vikas had maximum and significant negative gca effects (-1.98). Among testers, they did not vary significantly and the cross T-26 x DMT-2 shown significant and maximum sca effects in negative direction (-3.89). Out of 45 crosses, five crosses showed positive and significant sca effects.

4.3.7 Days to first fruit maturity (Table 21 and 22)

Regarding days to first fruit maturity, four lines exhibited significant and negative gca effects. The maximum gca effects was observed in the line HUB-18 (-3.05). The tester Arka Abha (-1.37) exhibited highest and negative significant gca effects. Among crosses, three exhibited significant negative sca effects and the highest sca effects was exhibited by the cross Vaibhav x Arka Abha (-3.57).

4.3.8 Equatorial diameter of fruit (Table 21 and 22)

Regarding equatorial diameter of fruit, only one line exhibited significant and positive gca effects. The maximum gca effects was observed in the line K-3 (2.94). The tester Arka Abha (1.91) exhibited highest and positively significant gca effects. Among crosses, seven exhibited significant positive sca effects and the highest sca effects was exhibited by the cross Vaibhav x Arka Abha (7.30).

Table 21. General combining ability effects for days to first fruit maturity and yield parameters in tomato

Sl. No.	Genotypes	Days to first fruit maturity	Equatorial diameter of fruit	Polar diameter of fruit	Number of fruits per cluster	Average fruit weight	Number of fruits per plant	Yield per plant	Yield per plot	Yield per ha
	Lines									
1	T-26	-0.52	-1.08	-2.20 **	0.57 **	-2.5	17.93**	1.12 **	16.96 **	26.10 **
2	T-36	-0.35	-0.42	0.62	-0.49 **	26.60**	17.10 **	0.93 **	14.03 **	21.74 **
3	Arka Vikas	-1.02	-1.92 *	1.32	0.10*	-41.73 **	1.49	-0.03 **	-0.46 **	-3.05 **
4	Swarna Naveen	-0.52	-2.25 *	-3.05 **	-0.02	99.10**	13.00 **	0.30 **	4.66 **	7.86 **
5	Vaibhav	-2.87**	-1.42	8.85 **	0.10*	109.10**	6.08 **	0.19 **	3.27 **	5.31 **
6	DMT-1	-0.68	0.07	-1.96 **	-0.09 **	265.76 **	-11.33 **	0.19 **	-3.457 **	-4.28 **
7	DMT-3	-0.52	-1.58	0.25	0.17**	89.10**	-8.08 **	-0.26 **	-3.88 **	-4.80 **
8	DMT-5	-0.68	-0.60	2.33**	0.50 **	314.26 **	6.21 **	0.55 **	8.31 **	12.33 **
9	S-22	-3.01**	0.07	6.00 **	-0.29 **	0.76	-4.82 **	0.80**	1.20	2.88*
10	Arka Meghali	1.47	1.91	-4.60 **	-0.02	-308.40 **	-1.23 **	-0.74 **	-11.03 **	-15.39 **
11	Megha	0.64	1.74	-1.04	0.14*	-262.56 **	-3.93 **	-0.59 **	-9.28 **	-14.64 **
12	K-3	0.64	2.94**	0.63	-0.15 **	-1.73	-9.43 **	-0.67 **	-10.48 **	-14.61 **
13	T-57	0.14	1.57	-1.85 *	-0.42 **	-150.90 **	-12.05 **	-0.74 **	-11.07 **	-15.27 **

Table 21 contd....

Sl. No.	Genotypes	Days to first fruit maturity	Equatorial diameter of fruit	Polar diameter of fruit	Number of fruits per cluster	Average fruit weight	Number of fruits per plant	Yield per plant	Yield per plot	Yield per ha
14	TB-1	0.14	0.24	-6.50 **	-0.19 **	-262.56 **	-14.15 **	0.24 **	3.75 **	6.48 **
15	HUB-18	-3.05**	1.24	1.18	0.09	9.76	-6.99 **	-0.16 **	-2.53 **	-10.65 **
	S.Em±	1.05	0.90	0.73	0.05	5.66	0.80	0.05	0.86	1.13
	C.D. at 5%	2.11	1.82	1.48	0.09	11.41	1.62	0.11	1.74	2.28
	C.D.at 1%	2.82	2.44	1.97	0.15	15.24	2.17	0.15	2.33	3.04
	Testers									
16	Arka Abha	-1.37**	1.91 **	0.91 **	0.09	-4.90 **	1.11 **	0.05	0.89 *	1.22 *
17	Arka Alok	-0.05	-0.62	-0.24	0.51 **	-13.03 **	-1.35 **	-0.04	-0.69	-0.06
18	DMT-2	-0.32	-0.28	-0.66	-0.14	17.93**	0.24	0.08**	1.18**	2.25 **
	S.Em±	0.46	0.40	0.32	0.11	2.53	0.36	0.02	0.38	0.50
	C.D. at 5%	0.94	0.81	0.66	0.23	5.10	0.72	0.05	0.78	1.02
	C.D.at 1%	1.26	1.09	0.88	0.31	6.81	0.97	0.06	1.04	1.36

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

Table 22. Specific combining ability effects for days to first fruit maturity and yield parameters in tomato

Sl. No.	Crosses	Days to first fruit maturity	Equatorial diameter of fruit	Polar diameter of fruit	Number of fruits per cluster	Average fruit weight	Number of fruits per plant	Yield per plant	Yield per plot	Yield per ha
1	T-26 X Arka Abha	-0.41	1.70	0.15	1.46**	7.60 **	-0.30	0.03	0.47	-0.21
2	T-26 X Arka Alok	3.92 **	-4.48 **	-0.59	0.10	6.76**	5.83 **	0.30 **	9.85 **	13.71 **
3	T-26 X DMT-2	-0.07	5.47 **	-1.39	0.20	69.06 **	13.06 **	0.60**	10.92**	15.29**
4	T-36 X Arka Abha	0.25	-2.09	-0.71	-0.36	-16.76	-12.87 **	-0.31 **	-5.97 **	-9.77**
5	T-36 X Arka Alok	-1.07	5.33 **	1.37	1.49**	-31.76 **	1.79	-0.05	-0.46	-2.18
6	T-36 X DMT-2	-2.07*	-2.96	-2.83*	-0.09	-228.43**	12.21**	-0.13	-2.29	-4.24 *
7	Arka VikasX Arka Abha	1.08	0.38	7.49 **	0.33	35.73 **	1.68	-0.05	-0.87	-2.17
8	Arka Vikas X Arka Alok	-3.07**	1.98	-1.17	-0.19	10.56	-5.35 **	-0.04	-0.54	-1.13
9	Arka Vikas X DMT-2	1.92	2.94	2.86 *	0.30	21.06 **	3.65 *	0.11	1.43	1.54
10	Swarna Naveen X Arka Abha	3.65**	1.38	-5.77**	0.53	30.23 **	-3.08 *	0.15	2.22	2.40
11	Swarna Naveen X Arka Alok	1.25	-1.85	-10.91 **	0.07	27.90 **	1.94	0.14	2.47	4.62 *
12	Swarna Naveen X DMT-2	-0.74	-6.33 **	9.42 **	0.27	-43.43 **	2.81	-0.25 *	-3.42 *	-5.92 **
13	Vaibhav X Arka Abha	-3.57**	7.30**	-0.19	0.03	8.23	0.58	-0.25 *	-3.66 *	-6.47**
14	Vaibhav X Arka Alok	2.75*	4.93 **	1.41	0.00	87.40 **	7.26 **	0.14	1.98	2.09
15	Vaibhav X DMT-2	-0.24	-4.43 **	0.87	0.17	-93.43 **	-4.79 **	-0.21 *	-3.12 *	2.43
16	DMT -1 X Arka Abha	1.12	0.22	0.81	0.47	-41.97 **	-5.96 **	0.38 **	5.74 **	7.61 **
17	DMT -1 X Arka Alok	-1.04	3.85 *	-2.81 *	0.14	56.36 **	-21.11 **	-0.45 **	-6.77 **	-11.02**

Table 22 contd...

Sl. No.	Crosses	Days to first fruit maturity	Equatorial diameter of fruit	Polar diameter of fruit	Number of fruits per cluster	Average fruit weight	Number of fruits per plant	Yield per plant	Yield per plot	Yield per ha
18	DMT -1 X DMT-2	0.45	1.38	-0.43	-0.55	-12.80	2.96 *	0.02	0.44	3.03
19	DMT-5 X Arka Abha	-0.21	-1.82	-0.18	0.47	8.86	14.26 **	0.61**	4.19 **	6.77**
20	DMT-5 X Arka Alok	-0.54	-1.33	-0.48	1.65**	88.86 **	10.32**	0.71**	5.09**	5.51**
21	DMT-5 X DMT-2	4.45 **	1.33	8.67 **	0.14	-132.80 *	-4.08 **	-0.32 **	-4.73 **	-7.66 **
22	S-22 X Arka Abha	0.12	-4.35 **	-6.38 **	-0.12	-98.63**	15.94**	0.78**	9.89**	8.77**
23	S-22 X Arka Alok	-0.04	4.24 **	-0.43	0.84	89.20 **	-5.53 **	0.03	0.37	0.51
24	S-22 X DMT-2	-3.61**	1.05	-3.79 **	-0.35	-17.80	8.691 **	-0.19	-2.72	-5.16 *
25	Arka Meghali X Arka Abha	1.12	-0.92	17.51 **	0.17	-36.13 **	1.46	-0.07	-1.02	-2.48
26	Arka Meghali X Arka Alok	-2.71*	-1.52	10.96 **	-0.48	5.53	7.51 **	0.08	1.73	3.48
27	Arka Meghali X DMT-2	1.78	-0.02	-10.98 **	0.31	-0.30	3.78 **	0.39 **	4.96**	6.32 **
28	Megha X Arka Abha	-0.54	-5.30 **	-3.44 **	-0.32	33.86 **	5.40 **	0.32 **	4.80 **	5.98 **
29	Megha X Arka Alok	-0.21	0.23	17.57**	1.52**	45.53 **	-4.39 **	0.02	0.48	-0.29
30	Megha X DMT-2	-2.71*	2.97	-2.33	0.06	12.20	-4.12 **	-0.25 *	-3.17 *	2.18
31	K-3 X Arka Abha	-0.71	-1.92	-0.96	-0.01	69.56 **	-5.65 **	-0.41 **	-6.22**	-7.40 **
32	K-3 X Arka Alok	-2.87*	0.63	3.41 *	-0.25	40.40 **	5.28 **	-0.20 *	-3.07 *	-2.69
33	K-3 X DMT-2	-0.37	-6.85 **	1.82	0.34	361.40 **	-6.03 **	-0.16	-2.37	-8.33 **
34	T-57 X Arka Abha	-0.04	3.92 *	0.90	-0.11	7.90	-8.60 **	0.18	2.77	5.99 **

Table 22 contd...

Sl. No.	Crosses	Days to first fruit maturity	Equatorial diameter of fruit	Polar diameter of fruit	Number of fruits per cluster	Average fruit weight	Number of fruits per plant	Yield per plant	Yield per plot	Yield per ha
35	T-57 X Arka Alok	1.62	-3.99 *	-0.88	0.24	-57.10 **	0.52	0.18	2.56	5.69 **
36	T-57 X DMT-2	-2.37*	1.63	-5.84 **	-0.05	361.23 **	1.87	0.45 **	7.02 **	11.90 **
37	TB-1 X Arka Abha	-1.21	3.96 *	-1.11	-0.21	62.90 **	-3.20 *	0.13	2.10	4.95 *
38	TB-1 X Arka Alok	3.12**	-6.23 **	1.60	1.56**	-99.76 **	1.88	0.01	0.17	0.61
39	TB-1 X DMT-2	-0.87	-3.99 *	0.93	0.04	-51.26 **	-12.34 **	0.07	1.28	3.61
40	HUB-18X Arka Abha	-1.21	-0.46	-11.74 **	-0.71	-62.10 **	1.54	-0.08	-1.20	0.07
41	HUB-18X Arka Alok	1.45	3.38 *	-0.04	-1.41**	-85.43 **	-9.45 **	-0.22 *	-4.20 **	-8.10 **
42	HUB-18X DMT-2	-1.04	6.36 **	1.55	-0.58	43.73**	-6.60 **	-0.13	-1.54	-0.39
43	DMT-3 X Arka Abha	4.12 **	7.26 **	3.64 **	0.28	-42.10 **	-5.99 **	-0.07	-1.14	0.48
44	DMT-3 X Arka Alok	-2.54*	-5.16 **	5.25 **	0.14	-112.93 **	11.66 **	-0.16	-2.46	-1.79
45	DMT-3 X DMT-2	2.95**	1.46	1.46	1.11 **	81.23 **	-8.91 **	0.43 **	6.30 **	-4.61 *
	S.Em±	1.01	1.57	1.27	0.44	9.80	1.39	0.09	1.50	1.96
	C.D. at 5%	2.06	3.16	2.56	0.90	19.76	2.81	0.20	3.02	3.95
	C.D.at 1%	2.90	4.23	3.42	1.20	26.40	3.76	0.26	4.04	5.27

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

4.3.9 Polar diameter of fruit (Table 21 and 22)

Out of 15 lines, the highest and significantly positive gca effects was exhibited by the line Vaibhav (8.85). Among testers, Arka Abha (0.91) possessed significant positive gca effects. Among crosses, eight crosses exhibited significant and positive sca effects. The highest positive sca effects was exhibited by the cross Megha x Arka Alok (17.57).

4.3.10 Number of fruit per cluster (Table 21 and 22)

Out of 15 lines, three exhibited significant positive gca effects. The highest and significant gca effects was exhibited by the line T-26 (0.57). Only the tester Arka Alok showed significant and positive gca effects (0.51). Six crosses exhibited significant and positive sca effects. The highest and significant sca effects was observed in the cross TB-1 x Arka Alok (1.56).

4.3.11 Average fruit weight (Table 21 and 22)

Regarding average fruit weight, six lines exhibited significant and positive gca effects. The maximum gca effects was observed in the line DMT-5 (314.26). The tester DMT-2 (17.93) exhibited highest and positively significant gca effects. Among crosses, 20 exhibited significant positive sca effects and the highest sca effects was exhibited by the cross K-3 x DMT-2 (361.40).

4.3.12 Number of fruits per plant (Table 21 and 22)

Out of 15 lines, the highest and significantly positive gca effects was exhibited by the line T-26 (17.93). Among testers, only Arka Abha (1.11) possessed significant positive gca effects. Among crosses, 11 crosses exhibited significant and positive sca effects. The highest positive sca effects was exhibited by the cross S-22 x Arka Abha (15.94).

4.3.13 Yield per plant (Table 21 and 22)

The highest significant gca effects was observed in the line T-26 (1.12). Eight lines showed positive and significant gca effects. Among testers, only DMT-2 (0.08) possessed significant positive gca effects. Among crosses, 10 exhibited positive and significant sca effects. The highest and significant positive sca effects was observed in the cross S-22 x Arka Abha (0.78).

4.3.14 Yield per plot (Table 21 and 22)

The highest and significantly positive gca effects was by the line T-26 (16.96). Six lines showed positive and significant gca effects. Among testers, only DMT-2 (1.18) possessed significant positive gca effects. Among crosses, 10 crosses exhibited significant and positive sca effects. The highest positive sca effects was exhibited by the cross S-22 x Arka Abha (9.89).

4.3.15 Yield per hectare (Table 21 and 22)

Out of 15 lines, six showed significant and positive gca effects. The highest significant gca effects was observed in the line T-26 (26.10). Among the testers, DMT-2 (2.25) exhibited positive and significant gca effects. Out of 45 crosses, 11 crosses exhibited significant and positive sca effects. The highest and significant positive sca effects was observed in the cross T-26 x DMT-2 (15.29).

4.3.16 Number of locules per fruit (Table 23 and 24)

The highest and significantly negative gca effects was by the line Arka Meghali (-0.68). There lines showed negative and significant gca effects. Among testers, only DMT-2 (-

0.22) possessed significant negative gca effects. Among crosses, five crosses exhibited significant and negative sca effects. The highest negative sca effects was exhibited by the cross Megha x Arka Alok (-1.12).

4.3.17 Rind thickness (Table 23 and 24)

Regarding rind thickness, four lines exhibited significant and positive gca effects. The maximum gca effects was observed in the line DMT-5 (0.16). The tester Arka Alok (0.06) exhibited highest and positively significant gca effects. Among crosses, 12 exhibited significant positive sca effects and the highest sca effects was exhibited by the cross Vaibhav x Arka Alok (0.39).

4.3.18 Total soluble solids (Table 23 and 24)

Out of 15 lines, two showed significant and positive gca effects. The highest and positive gca effects was observed in the line K-3 (0.49). Among testers, only Arka Abha (0.19) possessed significant positive gca effects. Maximum sca effects was observed in the cross T-26 x DMT-2 (1.20) and five hybrids shown significant sca effects in positive direction.

4.3.19 pH (Table 23 and 24)

The highest and significantly negative gca effects was by the line ArkaMeghali (-0.19). Five lines showed negative and significant gca effects. Among testers, they did not vary significantly. Among crosses, five crosses exhibited significant and negative sca effects. The highest negative sca effects was exhibited by the cross DMT-3 x Arka Alok (-0.55).

4.3.20 Lycopene (Table 23 and 24)

Out of 15 lines, one showed significant and positive gca effects. The highest and positive gca effects was observed in the line T-57 (41.28). None of testers noticed significant gca effects. Maximum sca effects was observed in the cross TB-1 x DMT-2 (86.19) and two hybrids shown significant sca effects in positive direction.

4.3.21 β -carotene (Table 23 and 24)

Out of 15 lines, four showed significant and positive gca effects. The highest and positive gca effects was observed in the line HUB-18 (2.52). Among testers, Arka Alok (0.66) possessed significant positive gca effects. A maximum sca effects was observed in the cross Vaibhav x Arka Abha (8.08) and 10 hybrids shown significant sca effects in positive direction.

4.3.22 Number of seeds per fruit (Table 23 and 24)

Out of 15 lines, four showed significant and positive gca effects. The highest and positive gca effects was observed in the line T-36 (35.02). Among testers, only Arka Alok (6.94) possessed significant positive gca effects. A maximum sca effect was observed in the cross T-36 x Arka Abha (57.77) and seven hybrids shown significant sca effects in positive direction.

4.3.23 Thousand seed weight (Table 23 and 24)

Out of 15 lines, five showed significant and positive gca effects. The highest and positive gca effects was observed in the line K-3 (1.14). Among testers, only DMT-2 (0.64) possessed significant positive gca effects. Maximum sca effects was observed in the cross K-3 x Arka Alok (2.51) and 13 hybrids shown significant sca effects in positive direction.

Table 23. General combining ability effects for quality and seed parameters in tomato

Sl. No.	Genotypes	Number of locules per fruit	Rind thickness	TSS	pH	Lycopene	β-carotene	Number of seeds per fruit	1000 seed weight	Seed weight per fruit	Seed yield per plant
	Lines										
1	T-26	-0.26 *	0.09 **	-0.12	0.04*	-3.61	-2.04 **	16.36**	-0.11	0.05 **	8.08 **
2	T-36	0.11	-0.09 **	-0.10	0.16 **	-3.20	-2.24 **	35.02**	-0.31 *	0.02 **	4.13 **
3	Arka Vikas	-0.02	-0.06 *	-0.45 **	-0.25 **	-3.60	2.51 **	2.15	-0.96 **	-0.05 **	-0.57 **
4	Swarna Naveen	0.18	-0.16 **	0.02	0.05**	-3.29	2.17 **	-0.54	-0.01	0.02 **	3.24 **
5	Vaibhav	1.05 **	-0.05	0.44 **	0.29 **	-0.67	1.81 **	0.57	-0.36 **	-0.01 **	0.36 *
6	DMT-1	-0.26 *	-0.19 **	0.04	0.11 **	-2.74	0.15	-13.72 **	0.57 **	0.01 **	-0.74 **
7	DMT-3	-0.37 **	-0.07 *	0.04	0.19 **	-3.26	0.45	18.14**	-0.73 **	-0.03 **	-1.07 **
8	DMT-5	0.23 *	0.16 **	-0.33 *	-0.05 **	-2.87	0.45	-15.83 **	0.53 **	-0.04 **	0.39 *
9	S-22	0.93 **	0.07 *	0.07	-0.02	-3.31	1.11 *	-7.57	0.09	-0.01 **	-0.46 *
10	Arka Meghali	-0.68 **	0.10 **	-0.08	-0.19 **	-2.67	-3.95 **	2.26	-0.42 **	-0.09 **	-1.44 **
11	Megha	-0.31 *	0.07 *	0.16	-0.16 **	-2.98	-1.50 **	-12.63 **	0.62 **	-0.05 **	-1.88 **
12	K-3	-0.16	-0.03 *	0.49 **	-0.17 **	-1.65	-3.64 **	-18.94 **	1.14 **	0.10 **	-2.14 **
13	T-57	-0.26 *	0.06 *	0.04	0.10	41.28**	0.99 *	-23.74 **	0.49 **	-0.05 **	-4.16 **
14	TB-1	0.35 **	0.11 **	0.19	-0.02	-3.60	0.69	-5.06 **	-0.44 **	-0.02 **	-3.12 **
15	HUB-18	-0.52 **	-0.14 **	-0.42 **	0.07	-3.79	2.52 **	23.54**	-0.09	0.06 **	-0.54 **

Table 23 contd...

Sl. No.	Genotypes	Number of locules per fruit	Rind thickness	TSS	pH	Lycopene	β-carotene	Number of seeds per fruit	1000 seed weight	Seed weight per fruit	Seed yield per plant
	S.Em±	0.12	0.02	0.15	0.01	9.89	0.43	4.25	0.11	0.002	0.18
	C.D. at 5%	0.24	0.05	0.30	0.02	19.95	0.86	8.57	0.23	0.004	0.37
	C.D.at 1%	0.33	0.07	0.40	0.03	26.65	1.15	11.46	0.31	0.006	0.50
	Testers										
16	Arka Abha	0.21 **	-0.04 **	0.19**	-0.04	-3.06	-0.37	-0.10	-0.29**	-0.01 **	-0.03
17	Arka Alok	0.04	0.06 **	0.17 *	0.01	-2.71	0.66 **	6.94**	-0.35 **	-0.06 **	-0.49 **
18	DMT-2	-0.22 **	0.03 *	-0.02	0.20 **	5.78	-0.29	-6.85 **	0.64 **	0.01 **	0.52 **
	S.Em±	0.05	0.01	0.06	0.05	4.42	0.19	1.90	0.05	0.001	0.08
	C.D. at 5%	0.11	0.02	0.13	0.10	8.92	0.38	3.83	0.10	0.002	0.16
	C.D.at 1%	0.14	0.03	0.18	0.13	11.91	0.51	5.12	0.13	0.002	0.22

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

Table 24. Specific combining ability effects for quality and seed parameters in tomato

Sl. No.	Crosses	Number of locules per fruit	Rind thickness	TSS	pH	Lycopene	β -carotene	Number of seeds per fruit	1000 seed weight	Seed weight per fruit	Seed yield per plant
1	T-26 X Arka Abha	-0.13	0.01	0.79 **	-0.24	2.90	-1.02	-10.56	1.10 **	0.10 **	2.25 **
2	T-26 X Arka Alok	-0.53 *	0.07	-0.87 **	-0.23	2.90	-0.51	57.27 **	-0.44 *	0.02 **	1.50 **
3	T-26 X DMT-2	0.53 *	-0.09	1.20 **	0.14	2.90	-4.11 **	-21.37 **	0.26	-0.03 **	0.11
4	T-36 X Arka Abha	-0.62 **	0.06	0.34	-0.38	4.39	1.18	57.77**	0.48 *	0.02 **	-1.93 **
5	T-36 X Arka Alok	0.29	-0.04	-0.07	-0.08	2.57	7.08 **	-12.52	0.64 **	0.01 *	0.18
6	T-36 X DMT-2	-0.08	0.06	0.02	0.52**	3.93	-1.11	-0.74	-0.68**	-0.05 **	0.05
7	Arka Vikas X Arka Abha	-0.26	-0.19 **	0.82**	-0.33	4.29	5.08 **	-32.21 **	0.65 **	-0.03 **	-0.69 *
8	Arka Vikas X Arka Alok	0.17	0.06	0.40	0.09	2.13	-3.91 **	29.01 **	-1.15 **	0.02 **	-0.16
9	Arka Vikas X DMT-2	0.16	-0.07	0.04	-0.05	2.19	0.96	4.57	0.08	0.01 *	0.91 **
10	Swarna Naveen X Arka Abha	0.21	0.19 **	0.15	-0.05	4.65	0.34	5.02	0.12	0.01 *	-0.13
11	Swarna Naveen X Arka Alok	0.51 *	-0.18 **	-0.39	-0.12	2.58	1.90 *	1.23	-1.02 **	-0.04 **	-1.09 **
12	Swarna Naveen X DMT-2	-0.93 **	-0.20 **	-0.37	-0.07	1.58	-0.35	13.99	-0.49 *	0.01 *	2.31**
13	Vaibhav X Arka Abha	-0.48 *	-0.15 **	-0.37	0.15	-42.44*	8.08**	-7.67	0.22	0.01 *	0.45
14	Vaibhav X Arka Alok	1.14 **	0.39 **	0.14	0.33	3.26	-2.99 **	-3.09	0.49 *	-0.05 **	1.95 **
15	Vaibhav X DMT-2	0.03	0.17**	0.44	0.31	2.97	-3.52 **	-22.01 **	0.71 **	0.04 **	-0.36
16	DMT -1 X Arka Abha	0.02	-0.17 **	-0.47	0.53* *	2.12	1.00	15.34 *	-0.19	0.04**	1.87 **
17	DMT -1 X Arka Alok	0.45 *	-0.02	-0.29	0.34	4.60	1.64 *	-24.26**	-0.66 **	-0.02 **	-6.12 **

Table 24 contd...

Sl. No.	Crosses	Number of locules per fruit	Rind thickness	TSS	pH	Lycopene	β -carotene	Number of seeds per fruit	1000 seed weight	Seed weight per fruit	Seed yield per plant
18	DMT -1 X DMT-2	-0.55 *	0.14 **	0.55 *	-0.04	3.54	5.18 **	6.85	0.48 *	0.04 **	2.23 **
19	DMT-5 X Arka Abha	-0.06	-0.05	0.07	0.57 **	1.76	-4.48 **	-17.07 *	0.06	-0.04**	-1.01 **
20	DMT-5 X Arka Alok	0.76 **	-0.06	-0.44	0.14	3.57	-3.34 **	1.53	-0.07	0.00	-0.90 **
21	DMT-5 X DMT-2	-0.17	0.11 *	0.05	-0.20	2.55	0.83	-2.79	0.18	0.03 **	1.01 **
22	S-22 X Arka Abha	-0.35	0.27 **	0.20	0.10	2.45	-2.67 **	53.61 **	-0.19	0.09 **	1.59 **
23	S-22 X Arka Alok	0.26	-0.27 **	0.08	-0.39	3.76	0.92	7.48	-1.31 **	0.00	0.15
24	S-22 X DMT-2	0.47 *	-0.22 **	-0.12	-0.41 *	4.12	-0.08	-28.17 **	0.88 **	-0.02 **	0.56
25	Arka Meghali X Arka Abha	-0.54 *	-0.28 **	-0.41	0.01	1.79	-1.15	9.19	-0.32	-0.08**	0.08
26	Arka Meghali X Arka Alok	-0.27	0.38 **	0.38	0.42 *	2.27	-2.36 **	-29.48 **	2.01 **	0.01 *	2.13 **
27	Arka Meghali X DMT-2	0.57 **	0.21 **	0.00	0.10	4.92	1.40	-17.23 *	1.24 **	0.01 *	1.24 **
28	Megha X Arka Abha	-0.42	-0.00	0.70**	-0.14	-42.75 *	3.40 **	0.25	-1.27 **	-0.03 **	0.39
29	Megha X Arka Alok	-1.12**	0.04	-0.12	-0.54**	2.28	-0.96	-12.48	0.29	-0.01 *	-1.28 **
30	Megha X DMT-2	-0.50 *	-0.06	-0.02	-0.47*	2.96	0.69	37.22 **	-1.11 **	-0.06 **	-1.95 **
31	K-3 X Arka Abha	0.15	0.15 *	-0.31	-0.27	-5.02	0.02	-4.78	-0.90 **	-0.07 **	-4.13 **
32	K-3 X Arka Alok	0.08	-0.05	1.17**	-0.11	-6.70	-1.12	-33.00 **	2.51**	0.05**	4.61**
33	K-3 X DMT-2	0.02	-0.05	0.52	-0.09	-6.38	-1.06	14.52	-0.74 **	-0.01 *	-2.35 **
34	T-57 X Arka Abha	0.68 **	-0.06	-0.26	-0.18	-6.16	3.29 **	17.97 *	0.55 **	0.01 *	2.94 **

Table 24 contd...

Sl. No.	Crosses	Number of locules per fruit	Rind thickness	TSS	pH	Lycopene	β -carotene	Number of seeds per fruit	1000 seed weight	Seed weight per fruit	Seed yield per plant
35	T-57 X Arka Alok	-1.06 **	0.11 *	0.52	-0.06	-6.15	-3.73 **	10.98	-0.57 **	-0.01 *	0.72 *
36	T-57 X DMT-2	0.25	-0.18 **	-0.07	-0.30	-6.48	0.27	3.54	0.50 *	0.02 **	-1.06 **
37	TB-1 X Arka Abha	0.62 **	-0.07	-1.02**	0.23	-6.75	-2.41 **	-21.39 **	-0.45 *	-0.05 **	-0.89 **
38	TB-1 X Arka Alok	-0.43 *	0.21 **	-0.49	0.29	-5.89	2.99 **	-36.49 **	2.47 **	-0.03 **	0.05
39	TB-1 X DMT-2	-0.64 **	0.30 **	0.08	0.42 *	86.19**	-0.88	23.60 **	-0.96 **	0.05**	-1.48 **
40	HUB-18X Arka Abha	0.33	0.16**	0.25	0.03	-6.45	0.81	-14.21	0.20	-0.01 *	0.05
41	HUB-18X Arka Alok	-0.24	-0.18 **	0.04	-0.29	-4.85	0.46	28.25 **	0.99 **	0.03 **	-1.03 **
42	HUB-18X DMT-2	0.35	-0.01	0.37	-0.03	-6.50	-1.04	3.23	0.75 **	-0.03 **	-2.10 **
43	DMT-3 X Arka Abha	0.90 **	0.16 **	-0.32	-0.01	85.19 **	4.40 **	7.41	1.05 **	0.02 **	-0.85 *
44	DMT-3 X Arka Alok	-1.51	-0.44**	-0.01	-0.55**	-5.54	3.96 **	15.58 *	0.19	0.06 **	3.24 **
45	DMT-3 X DMT-2	0.47 *	-0.11 *	-0.41	0.16	-5.93	2.83 **	-15.20 *	0.39	0.01 *	2.32 **
	S.Em \pm	0.21	0.04	0.25	0.19	17.14	0.74	7.37	0.19	0.003	0.32
	C.D. at 5%	0.43	0.10	0.52	0.39	34.55	1.50	14.85	0.40	0.007	0.65
	C.D.at 1%	0.57	0.13	0.69	0.52	46.16	2.00	19.84	0.53	0.01	0.87

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

4.3.24 Seed weight per fruit (Table 23 and 24)

Regarding seed weight per fruit, six lines exhibited significant and positive gca effects. The maximum gca effects was observed in the line K-3 (0.10). The tester DMT-2 (0.01) exhibited highest and positively significant gca effects. Among crosses, 15 exhibited significant positive sca effects and the highest sca effects was exhibited by the cross T-26 x Arka Abha (0.10).

4.3.25 Seed yield per plant (Table 23 and 24)

Regarding seed yield per plant, three lines exhibited significant and positive gca effects. The maximum gca effects was observed in the line T-26 (8.08). The tester DMT-2 (0.52) exhibited highest and positively significant gca effects. Among crosses, 15 exhibited significant positive sca effects and the highest sca effects was exhibited by the cross K-3 x Arka Alok (4.61).

4.4 Correlation studies (Table 25)

Simple correlation coefficient among growth, earliness, yield and quality parameters are presented in table 25.

Number of primary branches at 90 DAT ($r_p=0.13$) was positively and significantly ($p=0.01$) correlated with plant height at 90 days after transplanting. Number of secondary branches at 90 DAT ($r_p=0.30$) was positively and significantly ($p=0.01$) correlated with number of primary branches at 90 DAT and it had negatively and significantly ($p=0.01$) correlated ($r_p=-0.42$) with plant height at 90 days after transplanting. Days to 50 per cent flowering ($r_p=0.56$) was positively and significantly ($p=0.01$) correlated with plant height at 90 days after transplanting, number of primary branches at 90 DAT ($r_p=0.26$) and number of secondary branches at 90 DAT ($r_p=0.31$). Days to first fruit maturity ($r_p=0.41$) was positively and significantly ($p=0.01$) correlated with days to 50 per cent flowering and plant height at 90 DAT ($r_p=0.29$) but it had negatively and significantly ($p=0.01$) associated with number of primary branches at 90 DAT ($r_p=-0.38$) and number of secondary branches at 90 DAT ($r_p=-0.83$).

Equatorial diameter of the fruit was positively and significantly associated ($p=0.01$) with number of primary branches at 90 DAT ($r_p=0.34$) and number of secondary branches at 90 DAT ($r_p=0.80$), but it had negative and significant ($p=0.01$) associated with days to fruit maturity ($r_p=-0.34$). The polar diameter of the fruit was positively and significantly associated ($p=0.01$) with plant height at 90 DAT ($r_p=0.15$), number of primary branches at 90 DAT ($r_p=0.16$) and days to 50 per cent flowering ($r_p=0.14$), but it had negative and significant ($p=0.01$) associated with equatorial diameter of the fruit ($r_p=-0.18$) and days to first fruit maturity ($r_p=-0.15$). Number of fruits per cluster was positively and significantly associated ($p=0.01$) with plant height at 90 DAT ($r_p=0.16$), days to 50 per cent flowering ($r_p=0.19$), but it had negatively and significantly ($p=0.01$) associated with polar and equatorial diameter of fruit ($r_p=-0.18$ and $r_p=-0.14$, respectively).

Average fruit weight was positively and significantly associated at $p=0.01$ with equatorial diameter of the fruit ($r_p=0.77$), plant height at 90 DAT ($r_p=0.63$), number of secondary branches at 90 DAT ($r_p=0.46$), but it had negative and significant ($p=0.01$) associated with days to first fruit maturity ($r_p=-0.70$), polar diameter of the fruit ($r_p=-0.53$) and number of fruits per cluster ($r_p=-0.40$).

Number of fruits per plant was positively and significantly associated ($p=0.01$) with average fruit weight ($r_p=0.42$), polar diameter of fruit ($r_p=0.35$), equatorial diameter of fruit ($r_p=0.23$) and number of fruits per cluster ($r_p=0.37$). Number of locules per fruit was positively and significantly ($p=0.01$) associated with days to 50 per cent flowering ($r_p=0.47$) and average fruit weight ($r_p=0.36$), but it had negatively and significantly ($p=0.01$) associated with days to first fruit maturity ($r_p=-0.24$) and number of fruits per cluster ($r_p=-0.25$). Rind thickness was positively and significantly ($p=0.01$) associated with plant height at 90 DAT ($r_p=0.71$). Total

Table 25: Correlation coefficient among growth, earliness, yield and quality parameters in tomato

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	100	0.13**	-0.42**	0.56**	0.29*	0.11	0.15**	0.16**	0.63**	0.01	0.04	0.71**	0.34**	-0.14	0.43**	0.29**	0.33**
2		100	0.30**	0.26**	-0.83**	0.34**	0.16**	0.05	-0.04	-0.11	0.08	-0.18	0.19*	-0.15	0.08	0.06	0.01
3			100	0.31**	-0.38**	0.80**	-0.16**	0.10	0.46**	0.18*	0.08	0.26*	-0.26**	0.02	0.41	0.27**	0.51**
4				100	0.41**	0.08	0.14**	0.19**	0.36*	0.04	0.47**	0.08	0.03	0.08	-0.17	0.11	0.26**
5					100	-0.34**	-0.15**	-0.08	-0.70**	-0.14*	-0.24**	0.18	-0.05	-0.36**	0.03	-0.01	-0.38**
6						100	-0.18**	-0.14**	0.77**	0.23**	0.14*	0.36	-0.13	0.47**	0.19	-0.09	0.51**
7							100	-0.18**	-0.53**	0.35**	-0.06	0.17	-0.07	0.24*	0.87**	0.47**	0.47**
8								100	0.44**	0.37**	-0.25**	0.10	0.14*	0.14*	0.66**	-0.17*	0.21*
9									100	0.42**	0.36**	0.13	-0.10	0.30**	0.66**	0.29**	0.04
10										100	-0.06	0.09	0.74**	0.25*	0.65**	-0.06	-0.12
11											100	0.07	0.19	0.09	0.28*	0.13	0.21*
12												100	0.31**	-0.09	0.10	0.16	0.47**
13													100	0.18	-0.55**	-0.42**	0.14
14														100	0.36**	0.17	0.16*
15															100	-0.29**	0.22**
16																100	-0.08
17																	100

- 1 Plant height at 90 DAT
- 2 Number of primary branches at 90 DAT
- 3 Number of secondary branches at 90 DAT
- 4 Days to 50 percent flowering
- 5 Days to first fruit maturity
- 6 Equatorial diameter of fruit

- 7 Polar diameter of fruit
- 8 Number of fruits per cluster
- 9 Average fruit weight
- 10 Number of fruits per plant
- 11 Number of locules per fruit
- 12 Rind thickness

- 13 Total soluble solids
- 14 pH
- 15 Lycopene
- 16 β -carotene
- 17 Yield per plant

soluble solid was positive and significant ($p=0.01$) associated with plant height at 90 DAT ($r_p=0.34$), number of fruits per plant ($r_p=0.74$) and rind thickness ($r_p=0.31$) and it had negatively and significantly ($p=0.01$) associated with number of secondary branches at 90 DAT ($r_p=-0.26$).

pH of the fruit was positively and significantly ($p=0.01$) associated with average fruit weight ($r_p=0.30$) and equatorial diameter of fruit ($r_p=0.47$), but it had negatively and significantly ($p=0.01$) associated with days to first fruit maturity ($r_p=-0.36$). Lycopene was positive and significant ($p=0.01$) associated with plant height at 90 DAT ($r_p=0.66$), polar diameter of fruit ($r_p=0.87$), number of fruits per cluster ($r_p=0.66$), average fruit weight ($r_p=0.43$), number of fruits per plant ($r_p=0.65$) and pH ($r_p=0.36$), but it had negatively and significantly ($p=0.01$) associated with total soluble solid ($r_p=-0.55$).

β -carotene was positively and significantly ($p=0.01$) associated with plant height at 90 DAT ($r_p=0.29$), number of secondary branches at 90 DAT ($r_p=0.27$), average fruit weight ($r_p=0.29$) and polar diameter of fruit ($r_p=0.47$) but it had negatively and significantly ($r=0.01$) associated with TSS ($r_p=-0.42$) and lycopene ($r_p=-0.29$).

Yield per plant was positively and significantly ($p=0.01$) associated with plant height at 90 DAT ($r_p=0.33$), number of secondary branches at 90 DAT ($r_p=0.51$) days to 50 per cent flowering ($r_p=0.26$), equatorial and polar diameter of the fruit ($r_p=0.51$ and $r_p=0.47$, respectively), rind thickness, ($r_p=0.47$) and lycopene ($r_p=0.22$) but it had negatively and significantly ($p=0.01$) associated with days to first fruit maturity ($r_p=-0.38$).

5. DISCUSSION

Epitomized aim of the plant breeding programme is to increase the yielding ability of crop plants. Hybridization is one of the means of obtaining increased yield and exploitation of heterosis is an efficient approach for crop improvement. Heterosis can be defined as superiority of F_1 over its parents and F_1 hybrids derived from crossing of pure lines are uniform in growth and development, possess better adaptability to changing and diverse environmental conditions and give early as well as higher total yield.

In practical plant breeding, superiority of the F_1 over mid parent is of little value, since it does not offer any advantage to exploit it commercially. The commercial usefulness of the hybrid would depend on its performance in comparison to the best existing commercial variety or hybrid. Hence, heterosis over better parent, the best parent and the commercial check was worked out in the present investigation for identification of superior hybrids in tomato. The line x tester method developed by Kempthorne (1957) has been used in the present study for estimating combining ability and other genetic parameters. Heterosis and combining ability for growth, earliness, yield and quality parameters are discussed in this chapter.

For a systematic heterosis breeding programme, it is essential to identify the parents, as well as crosses which could be exploited. This is important in order to bring about further genetic improvement in economic characters. The line x tester analysis is one of the techniques where a large number of genotypes could be tested for their combining ability. It is also necessary to assess the genetic potentialities of the parents in hybrid combination through systematic studies in relation to general and specific combining abilities which are due to additive and non-additive gene effects respectively (Griffing, 1956).

Genetic diversity is pre-requisite for getting high magnitude of heterosis. In the present investigation, variance due to genotypes was highly significant for all the growth, earliness, yield and quality parameters studied and variance due to parents was highly significant for majority of characters studied (Table-4) indicating the presence of diversity among parents used in the study. In the present study, significant and higher magnitude of heterosis over better parent, the best parent and the commercial check was observed in desirable direction for plant height at 60 and 90 DAT, number of primary and secondary branches at 60 and 90 DAT. Similarly, heterosis over commercial check was reported for plant height and number of branches per plant in tomato by Patil (1997), Kulkarni (1999), Kumari and Sharma (2011) and Sunil *et al.* (2013).

Farmers prefer to grow early maturity hybrids in order to get high profit and avoid the problem of market glut. Days to first flowering, days to 50 per cent flowering, days to first fruit set and days to first fruit maturity are the indications of earliness and negative heterosis for these traits is desirable. The Swarna Naveen x Arka Abha, S-22 x DMT-2, T-26 x Arka Alok and Megha x DMT-2 are top ranking hybrids for days to first fruit maturity. Significant heterosis in the desirable direction in the present investigation is in the same line and earlier reports for days to first flowering (Laksmi, 1997 and Santosh and Manish, 2011), days 50 per cent flowering (Padma *et al.*, 2002 and Duhan *et al.*, 2005) and days to first fruit maturity (Sharma *et al.*, 2001 and Hannan *et al.*, 2007).

Yield components greatly influenced by the yield and expression of heterosis for polar and equatorial diameter of the fruit, number of fruits per cluster, number of fruits per plant and average fruit weight can greatly contribute for heterosis for total yield per plant. Commercial check was exhibited by 31 crosses for equatorial diameter, 38 crosses for polar diameter of the fruit, 17 crosses for number of fruits per cluster, four crosses for number of fruits per plant and five crosses for average fruit weight. Heterosis for commercial check was also reported for polar and equatorial diameter of the fruit (Sharma *et al.*, 2001; Mahendrakar, 2004 and Sunil *et al.*, 2013), number of fruits per cluster (Laksmi, 1997), number of fruits per plant (Patil, 1997; Santosh and Manish, 2011 and Sunil *et al.*, 2013) and Duhan *et al.*, 2005) in tomato.

Magnitude of heterosis over better parent, the best parent and the commercial check was highly significant for yield per plant. Out of 45 crosses, 13 crosses over better parent,

four crosses over best parent and four crosses over the commercial check. The hybrid which exhibited maximum heterosis over commercial check (JK Desi F₁) was S-22 x Arka Abha (8.52%) followed by DMT-5 x Arka Alok (5.71%), DMT-5 x Arka Abha (2.86%) and T-26 x DMT-2 (0.57%). The hybrid S-22 x Arka Abha was the first best hybrid selected for yield per plant and its estimated yield was 84.44 tonnes per hectare as compared to 77.78 tonnes per hectare of commercial check (JK-Desi F₁). Performance of this hybrid with respect to yield is attributed to significant standard heterosis observed in the desirable direction for number of primary branches at 60 and 90 DAT, polar and equatorial diameter of fruit, number of fruits per cluster, number of fruits per plant, average fruit, rind thickness and seed yield per plant. This hybrid is highly resistant to tomato fruit borer (Appendix-IV). This hybrid (S-22 x Arka Abha) is also identified as good specific combiner for plant height at 90 DAT, number of primary branches at 90 DAT, number of secondary branches at 60 and 90 DAT, polar and equatorial diameter of fruit, number of fruits per cluster, number of fruits per plant, average fruit weight, number of seeds per fruit, rind thickness, seed weight per fruit and seed yield per plant. The parent S-22 involved in development of this hybrid exhibited significant good general combining ability effects in the desirable direction for number of secondary branches at 90 DAT, polar and equatorial diameter of fruit, number of fruits per cluster, average fruit weight, number of fruits per plant, number of seeds per fruit and seed weight per fruit. Whereas Arka Abha is the other parent, exhibited significant good general combining ability effects in the development of desirable direction for number of secondary branches at 60 DAT, days to 50 per cent flowering, days first fruit maturity, polar and equatorial diameter of fruit, number of fruits per plant, number of locules per fruit and TSS.

The second best hybrid selected based on yield per plant was DMT-5 x Arka Alok. This hybrid exhibited 5.71 per cent standard heterosis for yield per plant with the total yield of 3.80 kg per plant higher yield is attributed to its significant heterosis over the commercial check in desirable direction for plant height at 90 DAT, number of primary branches at 60 and 90 DAT, number of secondary branches at 60 and 90 DAT, polar diameter of the fruit, number of fruits per plant, rind thickness, number of seeds per fruit and seed yield per plant. This hybrid is moderately resistant to tomato leaf curl virus (Appendix-III) and highly resistant to tomato fruit borer under field condition (Appendix-IV). This hybrid is also identified as a good specific combiner for plant height at 90 DAT, number of primary branches at 60 and 90 DAT, number of secondary branches at 60 and 90 DAT, average fruit weight, number of fruits per plant, rind thickness and seed weight per fruit. The line DMT-5 which was involved in development of this hybrid was identified as a good general combiner for plant height at 90 DAT, number of primary branches at 60 and 90 DAT, number of secondary branches at 60 and 90 DAT, polar diameter of the fruit, number of fruits per cluster, average fruit weight, number of fruits per plant, number of locules per fruit, rind thickness, pH and 1000 seed weight. The other parent involved in development of this hybrid was Arka Alok and it was identified as a good general combiner for number of primary branches at 60 DAT, number of secondary branches at 90 DAT, number of fruits per cluster, average fruit weight and number of fruits per plant, rind thickness, β -carotene and number of seeds per fruit.

The third best hybrid was DMT-5 x Arka Abha which exhibited 2.86 per cent standard heterosis for yield per plant and its estimated total yield was 80 tonnes per hectare and it was third best hybrid for yield per plant with *per se* of 3.60 kg per plant and its performance is attributed to significant standard heterosis in desirable direction for number of primary branches at 60 and 90 DAT, number of secondary branches at 60 and 90 DAT, days to 50 per cent flowering, days to first fruit set, polar and equatorial diameter of fruit and number of fruits per plant as those traits are positively and significantly associated with total yield per plant. This hybrid is moderately susceptible to tomato leaf curl virus (Appendix-III) and resistant to tomato fruit borer (Appendix-IV). This hybrid (DMT-5 x Arka Abha) is also identified as a good specific combiner for number of primary branches at 60 and 90 DAT, number of secondary branches at 60 and 90 DAT, days to first flowering, days to 50 per cent flowering, days to first fruit set, polar and equatorial diameter of the fruit, number of fruits per cluster and number of fruits per plant as those traits are positively and significantly associated with total yield per plant. These parent DMT-5 involved in development of this hybrid was exhibited significant general combining ability effects in desirable direction for number of primary branches at 60 and 90 DAT, number of secondary branches at 90 DAT, polar diameter of the fruit, number of fruits per cluster, average fruit weight, number of fruits per

plant, rind thickness, pH and 1000 seed weight. Whereas Arka Abha the other parent exhibited significant general combining ability effects in desirable direction for number of primary branches at 90 DAT, number of secondary branches at 60 DAT, days to first flowering, days to 50 per cent flowering, days to first fruit set, days to first fruit maturity, equatorial and polar diameter of fruit, number of fruits per plant, number of locules per fruit and TSS.

The fourth best hybrid selected based on yield per plant was T-26 x DMT-2 and this hybrid exhibited 0.57 per cent standard heterosis for yield per plant with the total yield of 78.22 tonnes per hectare higher yield is attributed to its significant heterosis over the commercial check in desirable direction for number of primary branches at 60 and 90 DAT, days to first flowering, days to 50 per cent flowering, days to first fruit set, number of fruits per cluster, number of fruits per plant, rind thickness and 1000 seed weight as these traits are significantly and positively associated with yield per plant. This hybrid is moderately resistant to tomato leaf curl virus (Appendix-III) and resistant to tomato fruit borer (Appendix-IV). This hybrid T-26 x DMT-2 can be commercially exploited after assessing its stability. The T-26 which involved in development of this hybrid was identified as good general combiner for plant height at 60 and 90 DAT, days to first flowering, days to 50 per cent flowering, days to first fruit set, number of fruits per cluster, number of fruits per plant, rind thickness, number of seeds per fruit and seed yield per plant. The other parent which involved in development of this hybrid was DMT-2 and it was identified as good general combiner for number of primary branches at 60 DAT, number of secondary branches at 90 DAT, days to first flowering, number of fruits per cluster, number of fruits per plant, rind thickness, number of seeds per fruit and seed yield per plant. Higher magnitude of heterosis for fruit yield per plant is attributed to better growth and yield parameters observed in hybrids as it is evident from correlation studies (Table 25), where fruit yield per plant was positively and significantly associated with plant height at 90 DAT ($r_p=0.33$), number of secondary branches at 90 DAT ($r_p=0.51$), days to 50 per cent flowering ($r_p=0.26$), equatorial diameter of the fruit ($r_p=0.51$), polar diameter of the fruit ($r_p=0.47$) and rind thickness ($r_p=0.38$). It is also evident from earlier studies on correlation in tomato (Arvindkumar, 2001; Padma *et al.*, 2002; Manna and Paul, 2012 and Ahirwar *et al.*, 2013). Heterosis observed for these component characters have greatly contributed for higher magnitude of heterosis observed for total yield per plant.

Tomato ranks first among processed vegetables in the world. High TSS and low pH are the major factors consider for manufacture of processed products. One per cent increases in TSS content of fruits results in 20 per cent increase in recovery of processed product (Berry and Uddin, 1991). Low pH is the most deciding factor for processing of tomatoes as it reduces heating time required for processing. From the present investigation, the crosses Swarna Naveen x Arka Alok and T-36 x Arka Alok were found to be superior for processing qualities. The cross Swarna Naveen x Arka Alok had high *per se* of 6.30^obrix TSS and had moderate pH of 4.50. The hybrid T-36 x Arka Alok had 5.50^obrix TSS and pH of 4.37.

For exploitation of heterosis, the information on gca should be supplemented with sca and hybrid performance. Heterosis in F_1 indicates operation of non-additive gene effects, but it cannot give any idea about the relative magnitude of non-additive (dominance + epistasis) and additive gene action. Hence, analysis of combining ability is one of the potential tools for identifying prospective parents to develop commercial F_1 hybrids (Griffing, 1956). General and specific combining ability effects and variances obtained from a set of F_1 's would enable a breeder to select desirable parents and crosses for each of the quantitative components. General combining ability effects of parents and sca effects of crosses were highly significant for the characters studied. From the present investigation, it is evident that gca or sca effects in parents or crosses were in desirable direction for some characters and in undesirable direction for some other traits. Therefore, it is important to ascertain the status of parent or hybrid with respect to combining ability effects over a number of component characters (Arunachalam and Bandopadhyay, 1979).

An assessment was carried out by considering all the characters related to yield and other economic traits simultaneously to identify the potential parents and hybrids. For every character, a parent was scored '0' for non-significant gca effects and '+1' for significant gca effects in the desirable direction and '-1' for significant gca effects in undesirable direction.

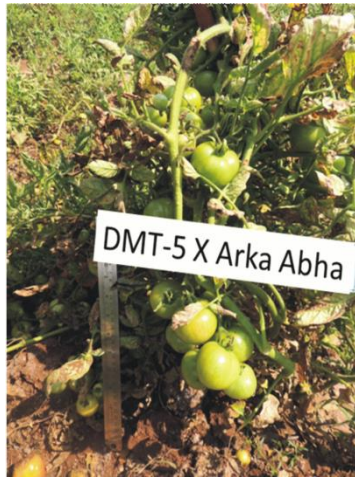
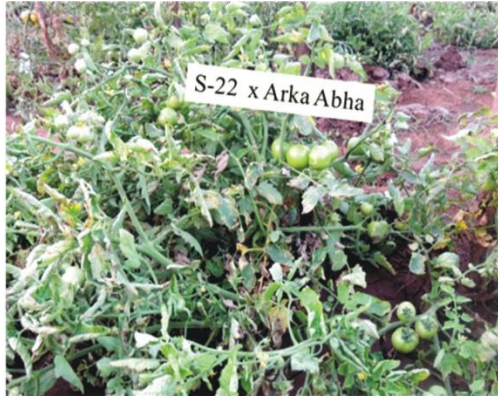


Plate 4: Top four hybrid for yield per plant

Table 26. Overall analysis of general combining ability status of the parents in tomato

Parent	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	Total	gca	
Lines																													+ve	-ve	status
T-26	+1	+1	0	-1	0	+1	+1	-1	-1	0	0	-1	+1	0	+1	+1	+1	+1	-1	+1	0	+1	0	-1	+1	0	+1	+1	14	6	H
T-36	+1	+1	0	+1	+1	0	0	0	0	0	0	0	-1	+1	+1	+1	+1	+1	0	-1	0	+1	0	-1	+1	-1	+1	+1	13	4	H
Arka Vikas	+1	+1	0	-1	+1	+1	0	-1	-1	0	-1	0	+1	-1	0	-1	-1	-1	0	-1	-1	-1	0	+1	0	-1	-1	-1	6	14	L
Swarna Naveen	-1	-1	-1	-1	-1	-1	+1	0	0	0	-1	-1	0	+1	+1	+1	+1	+1	0	-1	0	+1	0	+1	0	0	+1	+1	10	9	H
Vaibhav	0	+1	0	+1	0	0	+1	0	0	-1	0	+1	+1	+1	+1	+1	+1	+1	+1	0	+1	+1	0	+1	0	-1	-1	+1	15	3	H
DMT-1	0	+1	+1	+1	+1	+1	+1	0	0	0	0	-1	-1	+1	-1	+1	-1	-1	-1	+1	0	+1	0	0	-1	+1	+1	-1	12	8	H
DMT-3	0	+1	+1	+1	+1	+1	+1	0	-1	0	0	0	+1	+1	-1	-1	-1	-1	-1	-1	0	+1	0	0	+1	-1	-1	-1	10	10	A
DMT-5	0	+1	+1	+1	+1	+1	0	0	0	0	0	+1	+1	+1	+1	+1	+1	+1	+1	+1	-1	-1	0	0	-1	+1	-1	+1	16	4	H
S-22	-1	0	+1	0	-1	+1	0	0	0	-1	0	+1	-1	0	-1	+1	0	+1	+1	+1	0	0	0	+1	0	0	-1	-1	8	7	H
Arka Meghali	+1	+1	0	+1	-1	0	0	0	0	0	0	-1	0	-1	-1	-1	-1	-1	-1	+1	0	-1	0	-1	0	-1	-1	-1	4	13	L
Megha	0	0	-1	-1	-1	-1	0	0	0	0	0	0	+1	-1	-1	-1	-1	-1	-1	+1	0	-1	0	-1	-1	+1	-1	-1	3	15	L
K-3	-1	-1	-1	-1	-1	-1	-1	0	0	0	+1	0	-1	0	-1	-1	-1	-1	0	-1	+1	-1	0	-1	-1	+1	+1	-1	14	17	L
T-57	-1	-1	+1	-1	+1	0	0	0	+1	0	0	-1	-1	-1	-1	-1	-1	-1	-1	+1	0	0	+1	+1	-1	+1	-1	-1	7	14	L
TB-1	0	0	+1	+1	-1	-1	0	0	+1	0	0	-1	-1	-1	-1	+1	+1	+1	+1	+1	0	0	0	0	-1	-1	-1	-1	8	10	L
HUB-18	-1	0	+1	+1	0	+1	0	+1	+1	+1	0	0	0	0	-1	-1	-1	+1	-1	-1	-1	0	0	+1	+1	0	+1	-1	9	9	A

Table 26 contd....

Parent	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	Total	gca	
Testers																															
Arka Abha	0	0	0	+1	+1	0	-1	-1	+1	+1	+1	+1	0	-1	+1	0	+1	+1	+1	-1	+1	0	0	0	0	-1	-1	0	11	6	H
Arka Alok	0	-1	+1	-1	0	+1	0	0	0	0	0	0	+1	-1	-1	0	0	0	0	+1	+1	0	0	+1	+1	-1	-1	-1	7	7	A
DMT-2	0	+1	-1	+1	-1	-1	-1	0	0	0	0	0	0	+1	0	+1	+1	+1	-1	+1	0	+1	0	0	-1	-1	+1	+1	10	7	H

- 1 Plant height at 60 DAT
- 2 Plant height at 90 DAT
- 3 Number of primary branches at 60 DAT
- 4 Number of primary branches at 90 DAT
- 5 Number of secondary branches at 60 DAT
- 6 Number of secondary branches at 90 DAT
- 7 Days to first flowering
- 8 Days to 50 per cent flowering
- 9 Days to first fruit set
- 10 Days to first fruit maturity
- 11 Equatorial diameter of fruit

- 12 Polar diameter of fruit
- 13 Number of fruits per cluster
- 14 Average fruit weight
- 15 Number of fruits per plant
- 16 Yield per plant
- 18 Yield per hectare
- 19 Number of seeds per fruit
- 20 Seed weight per fruit
- 21 1000 seed weight
- 22 Seed yield per plant
- 23 Number of locules per fruit

- 24 Rind thickness
- 25 Total soluble solids
- 26 pH
- 27 Lycopene
- 28 β-carotene
- L Low general combiner
- A Average general combiner
- H High combiners
- 0 Non-significant gca effects
- +1 gca effects in desirable direction,
- 1 gca effects in undesirable direction,
- DAT Days after transplanting,

Table 27. Overall analysis of the standard heterosis status of hybrids in tomato

Crosses	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	Total		Status	
	+ve	-ve	CH	PG																												
T-26 X 1	+1	-1	+1	+1	-1	-1	-1	0	-1	-1	0	+1	+1	0	-1	-1	-1	-1	-1	-1	-1	-1	+1	+1	+1	0	-1	08	16	L	HXH	
T-26 X 2	0	-1	+1	+1	+1	+1	-1	-1	-1	-1	+1	+1	+1	0	-1	-1	-1	-1	-1	-1	+1	-1	-1	-1	-1	+1	0	-1	09	16	L	HXA
T-26 X 3	0	-1	-1	+1	+1	+1	-1	-1	-1	-1	+1	+1	+1	0	+1	+1	+1	+1	0	+1	+1	+1	-1	-1	-1	+1	0	-1	14	10	H	HXH
T-36 X 1	0	0	+1	+1	+1	+1	-1	0	-1	0	+1	+1	+1	0	-1	-1	-1	-1	+1	+1	+1	-1	+1	+1	-1	-1	0	-1	12	10	H	HXH
T-36 X 2	-1	0	-1	+1	+1	-1	0	0	0	-1	+1	+1	+1	+1	-1	-1	-1	-1	0	-1	-1	-1	-1	-1	+1	-1	0	-1	07	15	L	HXA
T-36 X 3	+1	+1	+1	+1	-1	+1	-1	0	-1	-1	0	+1	+1	0	-1	-1	-1	-1	-1	+1	+1	+1	-1	-1	-1	+1	0	-1	11	13	L	HXH
Arka Vikas X 1	0	-1	+1	+1	+1	+1	-1	0	-1	-1	+1	+1	0	0	-1	-1	-1	-1	+1	-1	-1	+1	-1	+1	+1	-1	0	-1	10	13	L	LXH
Arka Vikas X 2	0	-1	+1	+1	+1	+1	-1	0	-1	-1	+1	+1	+1	0	-1	-1	-1	-1	-1	-1	+1	-1	+1	+1	-1	-1	0	-1	10	14	L	LXA
Arka Vikas X 3	+1	-1	+1	+1	+1	-1	-1	0	-1	0	0	-1	+1	0	-1	-1	-1	-1	-1	0	+1	-1	+1	-1	-1	+1	0	-1	08	14	L	LXH
Swrna Naveen X 1	-1	-1	-1	+1	+1	0	-1	0	-1	-1	+1	0	0	0	-1	-1	-1	-1	0	-1	-1	-1	+1	+1	-1	-1	0	-1	05	16	L	HXH
Swrna Naveen X 2	-1	-1	+1	+1	+1	+1	0	+1	0	-1	0	-1	+1	0	-1	-1	-1	-1	0	-1	+1	-1	0	+1	+1	-1	0	-1	09	12	L	HXA
Swrna Naveen X 3	-1	-1	-1	+1	-1	-1	0	-1	-1	0	0	+1	+1	0	-1	-1	-1	-1	-1	+1	+1	-1	+1	-1	+1	+1	0	-1	08	15	L	HXH
Vaibhav X 1	0	0	+1	+1	-1	-1	-1	-1	-1	-1	+1	+1	+1	0	-1	-1	-1	-1	+1	-1	-1	-1	-1	-1	-1	-1	0	-1	06	18	L	HXH
Vaibhav X 2	-1	-1	+1	+1	+1	+1	+1	+1	+1	0	+1	+1	+1	+1	-1	-1	-1	-1	+1	+1	+1	+1	+1	+1	-1	-1	0	-1	17	08	H	HXA
Vaibhav X 3	0	0	+1	-	+1	+1	0	0	-1	-1	0	+1	+1	0	-1	-1	-1	-1	+1	-1	-1	-1	-1	-1	-1	0	0	-1	06	14	L	HXH
DMT-1 X 1	0	-1	+1	+1	+1	+1	0	0	-1	0	+1	0	+1	0	-1	-1	-1	-1	-1	-1	+1	-1	-1	+1	-1	+1	0	-1	09	12	L	HXH
DMT-1 X 2	0	-1	+1	0	+1	+1	0	0	-1	-1	0	+1	+1	0	-1	-1	-1	-1	-1	-1	+1	-1	+1	+1	-1	-1	0	-1	08	13	L	HXA
DMT-1 X 3	0	+1	+1	+1	+1	+1	0	0	0	0	+1	0	0	0	-1	-1	-1	-1	0	-1	-1	-1	-1	+1	-1	-1	0	-1	07	11	L	HXH
DMT-5 X 1	-1	-1	+1	+1	+1	+1	0	-1	-1	0	+1	+1	+1	0	+1	+1	+1	+1	0	+1	+1	-1	-1	+1	+1	-1	0	-1	15	08	H	HXH

Table 27 Contd....

Crosses	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	Total		Status	
	+ve	-ve	CH	PG																												
DMT-5 X 2	0	+1	+1	+1	+1	+1	-1	-1	-1	-1	+1	+1	+1	0	+1	+1	+1	+1	0	+1	+1	+1	-1	+1	-1	+1	0	-1	17	07	H	HXA
DMT-5 X 3	0	0	+1	-	-1	-1	-1	0	-1	-1	0	+1	+1	0	0	0	0	0	0	-1	+1	-1	-1	-1	-1	-1	0	-1	04	13	L	HXH
S-22 X 1	-1	-1	+1	-	+1	+1	0	0	0	-1	+1	+1	+1	0	+1	+1	+1	+1	+1	-1	-1	+1	-1	-1	-1	-1	0	-1	12	11	H	HXH
S-22 X 2	0	-1	+1	-	-1	-1	0	0	-1	-1	+1	+1	+1	0	-1	-1	-1	-1	0	-1	-1	-1	+1	+1	-1	+1	0	-1	07	15	L	HXA
S-22 X 3	0	+1	+1	+1	+1	+1	-1	-1	-1	-1	+1	+1	+1	0	-1	-1	-1	-1	-1	+1	+1	+1	-1	+1	+1	0	0	-1	13	11	H	HXH
Arka Meghali X 1	+1	-1	+1	+1	-1	+1	0	-1	-1	-1	+1	+1	+1	0	-1	-1	-1	-1	-1	-1	-1	-1	+1	+1	-1	-1	0	+1	10	15	L	LXH
Arka Meghali X 2	-1	-1	+1	+1	+1	+1	-1	0	-1	-1	+1	+1	+1	0	-1	-1	-1	-1	0	-1	-1	-1	-1	+1	-1	-1	0	-1	08	16	L	LXA
Arka Meghali X 3	+1	0	+1	+1	-1	0	-1	-1	-1	-1	-1	+1	+1	0	-1	-1	-1	-1	0	-1	-1	-1	-1	-1	-1	-1	0	-1	05	18	L	LXH
Megha X 1	+1	+1	+1	-1	+1	-1	0	0	0	-1	0	0	+1	0	-1	-1	-1	-1	0	+1	+1	-1	-1	-1	+1	-1	0	-1	08	12	L	LXH
Megha X 2	0	-1	0	+1	-1	-1	0	0	0	0	0	+1	+1	0	-1	-1	-1	-1	-1	-1	+1	-1	-1	-1	-1	+1	0	-1	05	14	L	LXA
Megha X 3	-1	-1	+1	-1	-1	-1	-1	-1	-1	-1	0	0	-1	0	-1	-1	-1	-1	0	+1	+1	+1	+1	-1	-1	-1	-1	-1	05	19	L	LXH
K-3 X 1	0	-1	-1	-1	+1	+1	-1	0	-1	-1	+1	+1	+1	0	-1	-1	-1	-1	-1	-1	+1	-1	+1	-1	-1	+1	0	+1	09	15	L	LXH
K-3 X 2	-1	-1	+1	+1	+1	+1	0	-1	-1	0	+1	+1	-1	0	-1	-1	-1	-1	-1	-1	-1	-1	+1	+1	-1	+1	0	-1	09	15	L	LXA
K-3 X 3	-1	-1	-1	+1	+1	+1	0	0	-1	0	+1	+1	-1	+1	-1	-1	-1	-1	0	-1	+1	-1	-1	-1	+1	+1	0	+1	10	13	L	LXH
T-57 X 1	-1	-1	-1	+1	+1	+1	0	0	0	0	0	+1	-1	0	-1	-1	-1	-1	-1	-1	+1	-1	-1	+1	-1	+1	0	-1	07	14	L	LXH
T-57 X 2	+1	+1	+1	+1	+1	+1	-1	0	0	0	+1	+1	-1	0	-1	-1	-1	-1	-1	+1	+1	-1	-1	-1	-1	-1	0	-1	10	13	L	LXA
T-57 X 3	-1	-1	-1	+1	+1	+1	-1	0	-1	0	+1	+1	-1	0	-1	-1	-1	-1	-1	+1	+1	-1	-1	+1	-1	-1	0	-1	08	16	L	LXH
TB-1 X 1	-1	-1	+1	+1	+1	+1	-1	-1	-1	-1	+1	+1	+1	+1	-1	-1	-1	-1	-1	-1	+1	-1	-1	-1	+1	-1	0	-1	10	17	L	LXH
TB-1 X 2	-1	-1	+1	+1	+1	+1	0	-1	-1	0	0	+1	+1	0	-1	-1	-1	-1	+1	+1	-1	-1	-1	+1	-1	+1	0	-1	10	13	L	LXA
TB-1 X 3	-1	-1	-1	+1	+1	+1	0	0	0	0	+1	+1	-1	0	-1	-1	-1	-1	-1	-1	+1	-1	-1	+1	-1	+1	0	-1	08	14	L	LXH

Table 27 Contd....

Crosses	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	Total		Status	
	+ve	-ve	CH	PG																												
HUB-18X 1	-1	-1	+1	+1	+1	+1	-1	0	-1	0	0	+1	+1	+1	-1	-1	-1	-1	0	-1	-1	-1	+1	+1	-1	-1	0	-1	09	14	L	A X H
HUB-18X 2	-1	-1	-1	+1	+1	-1	-1	0	-1	0	0	+1	+1	+1	-1	-1	-1	-1	-1	-1	-1	-1	+1	+1	-1	-1	0	-1	07	17	L	A X A
HUB-18X 3	0	-1	0	+1	+1	-1	-1	-1	0	0	+1	+1	-1	+1	-1	-1	-1	-1	-1	-1	+1	-1	-1	+1	-1	+1	0	-1	08	15	L	A X H
DMT-3 X 1	-1	-1	+1	+1	+1	+1	0	+1	0	0	+1	+1	-1	+1	-1	-1	-1	-1	-1	-1	+1	-1	+1	+1	-1	-1	-1	-1	12	13	L	A X H
DMT-3 X 2	-1	-1	+1	+1	+1	-1	-1	-1	0	0	0	+1	-1	0	-1	-1	-1	-1	-1	-1	+1	-1	+1	-1	-1	-1	0	-1	06	17	L	A X A
DMT-3 X 3	0	+1	+1	+1	+1	0	0	0	-1	-1	0	+1	-1	0	-1	-1	-1	-1	0	-1	+1	-1	-1	+1	-1	+1	0	-1	08	12	L	A X H

- | | | | | | |
|----|--|----|-----------------------------|-----|------------------------------------|
| 1 | Plant height at 60 DAT | 15 | Number of fruits per plant | H | High heterotic |
| 2 | Plant height at 90 DAT | 16 | Yield per plant | L | Low heterotic |
| 3 | Number of primary branches at 60 DAT | 17 | Yield per plot | A | Average heterotic |
| 4 | Number of secondary branches at 90 DAT | 18 | Yield per hectare | 0 | Non-significant gca effects |
| 5 | Number of primary branches at 60 DAT | 19 | Number of seeds per fruit | +1 | Heterosis in desirable direction |
| 6 | Number of secondary branches at 90 DAT | 20 | Seed weight per fruit | -1 | Heterosis in undesirable direction |
| 7 | Days to first flowering | 21 | 1000 seed weight | DAT | Days after transplanting, |
| 8 | Days to 50 percent flowering | 22 | Seed yield per plant | CH | Heterosis of crosses |
| 9 | Days to first fruit set | 23 | Number of locules per fruit | PG | Parental gca status |
| 10 | Days to first fruit maturity | 24 | Rind thickness | A | Average heterotic |
| 11 | Equatorial diameter of fruit | 25 | Total soluble solids | 1 | Arka Abha |
| 12 | Polar diameter of fruit | 26 | pH | 2 | Arka Alok |
| 13 | Number of fruits per cluster | 27 | Lycopene | 3 | DMT-2 |
| 14 | Average fruit weight | 28 | β-carotene | DAT | Days after transplanting |

Similarly, for every character, a hybrid was scored '0' for non-significant standard heterosis and '+1' for significant standard heterosis in desirable direction and '-1' for significant standard heterosis in undesirable direction. All the parents and crosses were scored for each character and final score was computed by adding scores obtained in all the 28 characters. Finally, the parents or hybrids were classified as low, average and high based on the mean value of the total scores obtained over all the 28 characters and details are presented in table 26 for parents and in Table 27 for F₁ hybrids.

Comprehensive assessment of parents by considering gca effects of 28 characters studied has resulted into identification of lines, viz., T-26, T-36, Swarna Naveen, Vaibhav, DMT-1, DMT-5, S-22 and HUB-18 as good combiners over all characters and lines, viz., Arka Vikas, DMT-3, Arka Meghali, Megha, K-3, TB-1 and T-57 were identified as poor combiners over all characters. Among the testers, Arka Abha and DMT-2 was identified as good combiners overall characters and Arka Alok were identified as average combiners over all characters.

By comprehensive assessment of crosses by considering standard heterosis values of 28 characters revealed that, out of 45 crosses, 28 crosses were highly heterotic, 10 crosses were low heterotic and seven crosses was average heterotic. Among 28 highly heterotic crosses, 18 crosses involved high x low or low x high parental combinations for overall gca status, 14 crosses involved high x high parental combinations for overall gca status, 19 crosses involved high x average or average x high parental combinations for overall gca status. Out of 28 highly heterotic hybrids, four involved at least one parent as poor or average combiners. These results indicated that high frequency of highly heterotic hybrids could be obtained from parental combinations with high x low or low x high general combining ability which clearly indicates that, the parental contribution to the heterosis is mainly through non-additive gene effects. Thus, they may be improved through recurrent selection schemes.

Ratio of general combining ability variance (GCA) to specific combining ability variance (SCA) is an indication of predominance of additive or non-additive genetic variance. In the present study GCA to SCA ratio (Table 18) was very low for the traits pH (Kulkarni, 2003), number of fruits per cluster (Patil, 1997) and equatorial diameter of the fruit (Kaur *et al.*, 2002) indicating preponderance of non-additive gene action and hence these traits can be improved through recurrent selection for specific combining ability or heterosis breeding. Non-additive component of genetic variance was higher than additive component for plant height (Sharma, 1996; Izge and Garba, 2012 and Akram *et al.*, 2013), number of branches per plant (Dharmatti *et al.*, 1999 and Izge and Garba, 2012), days to first flowering (Lakshmi, 1997; Kumar *et al.*, 2013 and Akram *et al.*, 2013), days to 50 per cent flowering (Patil, 1984 and Izge and Garba, 2012), days to first fruit set (Dhaliwal *et al.*, 2000), days to first fruit maturity (Saleem *et al.*, 2013), number of fruits per plant (Viredewala *et al.*, 1981; Mittal *et al.*, 1974 and Saleem *et al.*, 2013), yield per plant (Sathyanarayana and Anand, 1992; Roopa *et al.*, 2001; Gaikwad *et al.*, 2002; Izge and Garba, 2012), rind thickness (Tendulkar, 1994; Sharma *et al.*, 1999 and Mahendrakar, 2004), TSS (Sidhu *et al.*, 1981 and Prashanth, 2004), lycopene (Sathyanarayana and Anand, 1992) and beta-carotene (Amaral *et al.*, 1997), average fruit weight (Tendulkar, 1994; Kumar *et al.*, 1997 and Kumar *et al.*, 2013), number of locules per fruit (Patil, 1997; Gaikwad *et al.*, 2002; Joshi and Thakur, 2003 and Yashavantakumar, 2008). Hence, these characters can be improved through recurrent selection schemes. There is great scope for heterosis breeding to exploit the non-additive genetic variance observed for yield components.

Future line of work

S-22 x Arka Abha, DMT-5 x Arka Alok, DMT-5 x Arka Abha and T-26 x DMT-2 were the best hybrid selected for yield per plant and can be commercially exploited after assessing their stability. The parents T-26, T-36, S-22 and DMT-5 are good general combiners for yield per plant and can be used in identifying superior new heterotic combinations. The parent T-26, T-36, Swarna Naveen, Vaibhav, DMT-1, DMT-5, S-22 and HUB-18 as good combiners over all characters can be further subjected to recurrent selection for improving combining ability for exploitations of heterosis with still higher magnitude for economically important traits, where non-additive components is predominant. For development of highly heterotic crosses from the existing genetic stock, generally parental combinations of low x high or high x low combining ability can be rewarding. The characters number of fruits per cluster, equatorial diameter of the fruit, plant height, number of branches per plant, days to first flowering, days to 50 per cent flowering, days to first fruit maturity, average fruit weight, number of locules per fruit, days to first fruit set, number of fruits per plant, yield per plant, rind thickness, TSS and lycopene are predominantly controlled by non-additive gene action and hence heterosis breeding and recurrent selection can be employed for improvement.

6. SUMMARY AND CONCLUSIONS

The present investigation on “heterosis and combining ability studies in tomato” was undertaken at Vegetable Science fields of Kittur Rani Channamma College of Horticulture, Arabhavi, Belgaum (Karnataka). Forty five crosses were developed by crossing 15 lines with each of three testers. All the crosses were evaluated along with the parents in randomised block design with two replications with the objective of assessing the magnitude and direction of heterosis and identifying good combiners for growth, earliness, yield and quality parameters. Various growth, earliness, yield and quality parameters recorded were subjected to line x tester analysis. The variance due to the genotype was significant for all the growth, earliness, yield and quality parameters (Table 4).

The magnitude of heterosis over the commercial check (JK Desi F₁) was very high in desirable direction and it ranged from -30.84 to 17.76 per cent for TSS, -69.57 to 100.00 per cent for rind thickness, -31.58 to 46.05 per cent for number of locules per fruit, -13.09 to 11.80 per cent for pH, -52.69 to 65.28 per cent for lycopene, -51.95 to 20.80 per cent for beta-carotene, -35.35 to 30.54 per cent for plant height at 60 DAT, -28.09 to 16.17 per cent for plant height at 90 DAT, -29.18 to 55.81 per cent for number of primary branches at 60 DAT, -.26.45 to 50.97 per cent for number of primary branches at 90 DAT, -23.64 to 76.36 per cent for number of secondary branches at 60 DAT, -32.35 to 55.88 per cent for number of secondary branches at 90 DAT, -15.63 to 10.94 per cent for days to first flowering, -9.72 to 6.94 per cent for days to 50 per cent flowering, -12.20 to 7.32 per cent for days to first fruit set, -8.59 to 7.32 per cent for days to first fruit maturity, -5.76 to 60.51 per cent for equatorial diameter of fruit, -12.03 to 49.87 per cent for polar diameter of fruit, -30.95 to 28.57 per cent for number of fruits per cluster, 30.95 to 101.89 per cent for average fruit weight, -67.65 to 29.81 per cent for number of fruits per plant, -72.00 to 8.57 per cent for yield per plant, -72.00 to 8.57 per cent for yield per plot, -72.00 to 8.56 per cent for yield per hectare, -80.47 to 79.27 per cent for number of seeds per fruit, -32.40 to 188.31 per cent for 1000 seed weight, -47.83 to 65.22 per cent for seed weight per fruit and -78.59 to 46.70 per cent for seed yield per plant.

Out of 45 crosses, 13 crosses over better parent, four crosses over best parent and four crosses over commercial check exhibited positively and significant standard heterosis for yield per plant. The maximum standard heterosis for yield per plant was observed in the cross was S-22 x Arka Abha (8.57%) followed by DMT-5 x Arka Alok (5.71%), DMT-5 x Arka Abha (2.86%) and T-26 x DMT-2 (0.57%).

The hybrid S-22 x Arka Abha was the best hybrid selected for yield per plant and its estimated yield was 84.44 tonnes per hectare. This hybrid also exhibited significant and high standard heterosis in desirable direction for number of primary branches at 60 and 90 DAT, polar and equatorial diameter of fruit, number of fruits per cluster, number of fruits per plant, average fruit, rind thickness and seed yield per plant. The cross DMT-5 x Arka Alok was second best hybrid for yield per hectare (82.22t/ha) and yield per plant (3.70kg/plant). This hybrid also exhibited significant and high standard heterosis in desirable direction for number of primary branches at 60 and 90 DAT, number of secondary branches at 60 and 90 DAT, polar diameter of the fruit, number of fruits per plant, rind thickness, number of seeds per fruit and seed yield per plant.

The cross DMT-5 x Arka Abha was the third best hybrid and estimated yield was 80.22 tonnes per hectare and yield per plant was 3.60 kg per plant. This hybrid also exhibited significant and high standard heterosis in desirable direction for number of primary branches at 60 and 90 DAT, number of secondary branches at 60 and 90 DAT, days to first flowering, days to 50 per cent flowering, equatorial and polar diameter of fruit, number of fruits per plant and rind thickness.

The hybrid T-26 x DMT-2 was fourth best hybrid and its estimated yield was 78.22 tonnes per hectare and yield per plant was 3.52 kg. This hybrid also exhibited significant and high standard heterosis in desirable direction for number of primary branches at 90 DAT, days

to first flowering, days to 50 per cent flowering, days to first fruit set, number of fruits per cluster, number of fruits per plant, rind thickness and 1000 seed weight.

The line T-26, T-36, DMT-5 and S-22 were identified as the good general combiners for yield per plant. Similarly, T-26, T-36, Arka Vikas and Arka Meghali for plant height at 60 DAT, T-36, DMT-3, Arka Vikas and T-26 for plant height at 90 DAT, T-36, DMT-3, Vaibhav and DMT-1 for number of primary branches at 90 DAT, HUB-18, DMT-3, DMT-1 and S-22 for number of secondary branches at 90 DAT, K-3, Swarna Naveen and T-26 for days to first flowering, HUB-18, S-22 and Vaibhav for days to first fruit maturity, K-3 for equatorial diameter of the fruit, Vaibhav, S-22 and DMT-5 for polar diameter of the fruit, T-26, DMT-5 and DMT-3 for number of fruits per cluster, DMT-5, DMT-1, Vaibhav and Swarna Naveen for average fruit weight, T-26, S-22, DMT-5 and Swarna Naveen for yield per plant and K-3, Megha, DMT-5 and DMT-1 for 1000 seed weight.

The crosses S-22 x Arka Abha, DMT-5 x Arka Alok, DMT-5 x Arka Abha and T-26 x DMT-2 are identified as the good specific combiner for yield per plant. The cross Arka Meghali x DMT-2, T-36 x DMT-2, DMT-5 x DMT-2, Swarna Naveen x Arka Abha and S-22 x Arka Abha for plant height at 60 DAT, S-22 x DMT-2, S-22 x Arka Abha, TB-1 Arka Abha and DMT-3 x DMT-2 for plant height at 90 DAT, T-26 x DMT-2, DMT-1 x Arka Abha, K-3 x Arka Alok and T-26 x Arka Abha for number of primary branches at 90 DAT, T-57 x Arka Abha, Arka Vikas x Arka Alok, DMT-5 x Arka Abha and DMT-5 x Arka Alok for number of secondary branches at 90 DAT, DMT-2 x Arka Alok, Swarna Naveen x Arka Abha, K-3 x Arka Abha, T-26 x Arka Alok for days to first flowering, S-22 x DMT-2, Vaibhav x Arka Abha, Swarna Naveen x Arka Abha and Arka Vikas x Arka Alok for days to first fruit maturity, Arka Meghali x Arka Abha, Vaibhav x Arka Abha, HUB-18 x DMT-2 and T-26 x Arka Alok for equatorial diameter of the fruit, T-57 x Arka Alok, Arka Meghali x Arka Abha, Arka Meghali x Arka Alok and Swarna Naveen x DMT-2 for polar diameter of the fruit, HUB-18 x Arka Alok, TB-1 x Arka Alok, Megha x Arka Alok and T-36 x Arka Alok for number of fruits per cluster, T-57 x DMT-2, T-57 x DMT-2, S-22 x Arka Alok and DMT-5 x Arka Alok for average fruit weight, S-22 x Arka Abha, DMT-5 x Arka Abha, DMT-5 x Arka Alok and T-26 x DMT-2 for number of fruits per plant, S-22 x Arka Abha, DMT-5 x Arka Alok, DMT-5 x Arka Abha and T-26 x DMT-2 for yield per plant, K-3 x Arka Abha, T-54 x DMT-2, Megha x Arka Abha and T-26 x Arka Alok for 1000 seed weight.

By comprehensive assessment of parents by considering gca effects of 28 characters has resulted into identification of lines, viz., T-26, T-36, Swarna Naveen, Vaibhav, DMT-1, DMT-5, S-22 and HUB-18 and the testers Arka Abha and DMT-2 as good combiners over all characters. Comprehensive assessment of crosses by considering heterosis values of 28 characters revealed that, out of 45 crosses 28 crosses were highly heterotic, 10 crosses were low heterotic and seven crosses were average heterotic. Among 28 highly heterotic crosses, 18 crosses involved high x low or low x high parental combinations for overall gca status, 14 crosses involved high x high parental combinations.

Studies on combining ability variance revealed that, non-additive gene action was predominant for number of fruits per cluster, equatorial diameter of the fruit, plant height, number of branches per plant, days to first fruit maturity, average fruit weight, number of locules per fruit, days to first flowering, days to 50 per cent flowering, days to first fruit set, number of fruits per plant, yield per plant, rind thickness, TSS and lycopene and it is suggested to improve these traits for combining ability through recurrent selection schemes.

REFERENCES

- Adhi, S., Reddy, V. S., Sujatha, M. and Pratap M., 2013, Combining ability and gene action studies for yield and yield contributing traits in tomato (*Solanum lycopersicum* L.). *Helix*, **6**: 431– 435.
- Ahirwar, C. S., Vijay, B. and Vinay, P., 2013, Genetic variability, heritability and correlation studies in tomato genotypes (*Lycopersicon esculentum* Mill.). *Int. J. Agric. Sci.*, **9** (1) : 172-176.
- Ahmad, S., Quamruzzaman, A. K. and Islam, M. R., 2011, Estimate of heterosis in tomato (*Solanum lycopersicum* L.). *Bangladesh J. Agric. Res.*, **36** (3) : 521-527.
- Ahmed, M. B., 2011, Heterosis and correlation of yield and yield component in tomato (*Lycopersicon esculentum* Mill.). *American-Eurasian J. Scientific Res.*, **2** (2) : 146-150.
- Ahmed, S. V., Sha, H. K. and Sharfeuddin, A. F. M., 1988, Study on heterosis and correlation in tomato. *Thaiwan J. Agric. Sci.*, **21**: 117-123.
- Akram, F., Hossein, N., Hossein, A., Amin, M. K. and Navid. V., 2012, The estimate of combining ability and heterosis for yield and yield components in tomato (*Lycopersicon esculentum* Mill.). *J. Biol. Environ. Sci.*, **6** (17) :129-134.
- Akram, F., Hussein, N., Hossein, A. and Amin, M. K., 2013, The estimate of heterosis and combining ability some morphological characters in tomato transplants (*Lycopersicon esculentum* Mill.). *Intl. J. Farm and Alli. Sci.*, **2** (11) : 290-295.
- Alice, K., Peter, K. V. and Rajan, S., 2011, Heterosis for yield components and fruit character in tomato. *J. Tropical Agric.*, **39** (10) : 5-8.
- *Amaral, A. T. A., Casali, V. W. D., Finger, F. L. and Cruz, C. D., 1997, *Ciencia-e-Agrotechnology*, **21**:313-323.
- Anandgowda, N., 1997, Variability and gene action- studies for characteristics related to processing in tomato (*Lycopersicon esculentum* Mill.). M.Sc. (Agri.) Thesis, Uni. Agric. Sci., Dharwad (India).
- Anbu, S., Muthukrishnan, C. R. and Irulappan, I., 1980, Line x tester analysis in tomato (*Lycopersicon esculentum* Mill.) Part-I, Combining ability. *South Indian Hort.*, **2** (10) : 280-285.
- Anbu, S., Muthukrishnan, C. R. and Irulappan, I., 1981, Line x tester analysis in tomato (*Lycopersicon esculentum* Mill.). *South Indian Hort.*, **29**: 49-53.
- Anonymous, 1976, Agricultural Research Service. *Nalt. Heliothis* Planning Conf. New Orleans. La, US. Department of Agriculture. Washington D.C. p. 36.
- Anonymous, 2007, Improved cultivation practices for horticultural crops (Karnataka). Uni. Agric. Sci., Dharwad (India). pp. 194-199.
- Anonymous, 2013, Indian horticulture database. <http://www.nhb.gov.in>.
- Aravindakumar, J. S., 2001, Stability analysis in tomato (*Lycopersicon esculentum* Mill.) varieties and hybrids. M. Sc. (Hort.) Thesis, Uni. Agric. Sci., Dharwad (India).
- Arunachalam, V. and Bandopadhyay, A., 1979, Arc multiple cross pollen – an answer for productivity population in *Brassica campestris* var. Brown Serson. *Theoretical and Applied Genetics*, **54**:203-207.

- Asati, B. S., Singh, G., Rai, N. and Chaturvedi, A. K., 2007, Heterosis and combining ability studies for yield and quality traits in tomato. *Veg. Sci.*, **34**:92-94.
- Ashwini, M. C., 2005, Heterosis and combining ability studies for heat tolerance in tomato. M.Sc. (Agri.) Thesis, Uni. Agric. Sci., Dharwad (India).
- Azizi, A., Javad, M. and Masoud, S. B., 2008, Phenotypic and molecular screening of tomato germplasm for resistance to tomato leaf curl virus. *Iranian J. Biot.*, **6** (4) : 199-206.
- Baishaya, K. C., Shyamal, M. M. and Singh, K. P., 2001, Heterotic studies in tomato (*Lycopersicon esculentum* Mill.). *Veg. Sci.*, **28** (2) : 168-169.
- Berry and Uddin, 1991, Breeding tomato for quality and processing attributes. In *Genetic improvement of tomato*. Ed. Kallo, G., Springer-Verlag, pp. 196-206.
- Bhatt, R. P., Adhekari, R. S. and Narendra, K., 2004, Genetical analysis for quantitative and qualitative traits in tomato (*Lycopersicon esculentum* Mill.) under open and protected environment. *The Indian J. Genet. Pl. Breed.*, **64**: 125-129.
- Bhatt, R. P., Biswas, V. R. and Kumar, N., 1999, Studies on heterosis for certain characters in tomato (*Lycopersicon esculentum* L.) (Karsten) under mid hill condition. *Prog. Hort.*, **36** (1-2) : 41-43.
- Bhutani, 1973, *Vegetable Breeding: Principals and Practices*. Kalyani Publishers, New Delhi, pp. 182-183.
- Bhutani, R. D., 1980, Diallel analysis for yield and quality traits in tomato (*Lycopersicon esculentum* Mill.). Ph.D. Thesis, Haryana Agric. Uni., Hisar.
- Bhutani, R. D. and Kallo, G., 1989, Genetics of carotenoids and lycopene in tomato (*Lycopersicon esculentum* Mill.). *Genetica AGRARIA*, **37**-1-6.
- Bhutani, R. D., Kallo, G., Pandita, M. L. and Singh, G.P., 1973, Studies on heterosis in tomato. *Haryana J. Hort. Sci.*, **2**: 156-163.
- Bose, T. K., Bose, J., Kabir, T. K., Maity, V. A. and Som, M. G., 2002, *Vegetable crops*, bhumani mitra publication, Calcutta, India. 1st Edn., pp. 456-471.
- *Brajendra, S., Naorem, P., Amitava, W., Shabir, H. and Laishram, J. M., 2013, Heterosis studies for quality traits in tomato (*Solanum lycopersicum* L.) using bacterial wilt tolerant and high yielding varieties. *J. Plant Sci. Res.*, **29** (1) : 67-71
- Buckseth, T., Manish, K. S. and Thakur, K. S., 2012, Genetic diversity and correlation studies in tomato (*Lycopersicon esculentum* Mill.). *Veg. Sci.*, **39** (2) : 221-223.
- Chadha, S. and Kumar, J., 2001, Heterosis for marketable fruit yield and some quality attributes in bacterial wilt resistant tomato lines. *Karnataka J. Agric. Sci.*, **14** (4) : 1134-1136.
- Chadha, S., Vidyasagar and Kumar, J., 2002, Combining ability and gene action studies for some fruit characters in bacterial wilt resistant tomato lines. *South Indian Hort.*, **50**:65-71.
- *Dechin, D., Kumar, R., Subodh, J. and Yadav, R. K., 2012, Genetic studies of quality traits in tomato (*Solanum lycopersicum* L.) under low temperature. *Veg. Sci.*, **39** (2) : 189-191.

- Dhaliwal, M. S., Singh, S. and Cheema, D. S., 2000, Estimating combining ability effects of the genetic male sterile lines of tomato for their use in hybrid breeding. *J. Genet. Pl. Breed.*, **54**: 199-205.
- Dhandapani, N. U., Shekhar, R. and Murugan, M., 2003, Bio-intensive pest management (BIPM) in major vegetable crops: an Indian perspective. *Food, Agric. Environ.*, **1**:333-339.
- Dharmatti, P. R., 1995, Investigations on summer tomatoes with special reference to tomato leaf curl virus (ToLCV). Ph. D. Thesis, Uni. Agric. Sci., Dharwad (India).
- Dharmatti, P. R., Madalageri, B. B., Mannikeri, I. M. and Patil, R. V., 1999, Combining ability for tomato leaf curl virus resistance in summer tomatoes (*Lycopersicon esculentum* Mill.). *Adv. Agric. Res. India*, **11**:67-72.
- Dharmatti, P. R., Madalageri, B. B., Mannikeri, I. M., Patil, R. V. and Patil, G., 2001, Genetic studies in summer tomatoes. *Karnataka J. Agric. Sci.*, **14**: 407-411.
- Dixit, J., Kalloo, G., Bhutani, R. D. and Sidhu, A. S., 1980, Line x tester analysis for the study of heterosis and combining ability in tomato. *Haryana J. Hort. Sci.*, **28**: 128-135.
- Dod, V. N. and Kale, P. B., 1992, Heterosis for certain quality traits in tomato (*Lycopersicon esculentum* Hill.). *Crop Res.*, **5**: 302-308.
- Dod, V. N., Kale, P. B. and Wankhade, R. V., 1995, Heterosis and combining ability in tomato (*Lycopersicon esculentum* Mill.). *PKV. Res. J.*, **19**: 125-129.
- Dudi, B. S., Kalloo, G. and Pandita, M. L., 1979, Line x tester analysis for the study of combining ability in tomato (*Lycopersicon esculentum* Mill.). *Haryana J. Hort. Sci.*, **8** (3-4) : 117-123.
- Duhan, D., Partap, P. S., Rana, M. K. and Basawana, K. S., 2005, Study of heterosis for growth and yield characters in tomato. *Haryana J. Hort. Sci.*, **34**:366-370.
- Dundi, K.B., 1991, Development of F₁ hybrids in tomato (*Lycopersicon esculentum* Mill.). M.Sc. (Agri.) Thesis, Uni. Agric. Sci., Dharwad (India).
- Fageria, M. S., Kohli, U. K. and Dhaka, R. S., 2001, Studies on heterobeltiosis for fruit and yield attributing traits in tomato (*Lycopersicon esculentum* Mill.). *J. Hort. Sci.*, **30** (1 & 2) : 131-133.
- Falconer, D.S., 1981, Introduction to Quantitative Genetics, Longman Inc. Ltd., New York, p.340.
- Fonesca, A. and Patterson, F. L., 1968, Hybrid vigour in a seven parent diallel cross in common winter wheat (*Triticum aestivum* L.). *Crop. Sci.*, **8**: 85.
- *[Gabry](#), M. A. H., Solieman, T. I. H. and Abido, A. I. A., 2014, Combining ability and heritability of some tomato (*Solanum lycopersicum* L.) cultivars. *Scientia Hort.*, Vol. 168.
- Gaikwad, S. P., Rajjadhav, S. B., Dumbre, A. D. and Bhor, T. J., 2002, Combining ability analysis in tomato by use of line x tester technique. *J. Maharashtra Agric. Uni.*, **27** (3) : 308-310.
- Gaikwad, S. P. and Cheema, S., 2012, Studies on hybrid vigour of F₁ and its retention in F₂ generation of tomato. *Crop Res.*, **5**: 302-308.

- Ghosh, P. K., Syamal, M. M. and Rath, S., 1997, Heterosis studies in tomato (*Lycopersicon esculentum* Mill.). Haryana J. Hort. Sci., **26**: 114-117.
- Govindarasu, P., Muthukrishnan, C. R. and Irulappan, I., 1981, Combining ability for yield and its components in tomato. Scientia Hort., **14**: 125-130.
- Govindarasu, P., Muthukrishnan, C. R. and Irulappan, I., 1982, Studies on heterosis in tomato (*Lycopersicon esculentum* Mill.). South Indian Hort., **30**: 9-12.
- Griffing, B., 1956, Concept of general combining ability in relation to diallel crossing system. Aus. J. Bio. Sci., **9**:463-493.
- Gul, R., Rahman, H. U., Khalil, H. I., Shah, A. S. and Abdul., 2010, Heterosis for flower and fruit traits in tomato (*Lycopersicon esculentum* Mill.).African J. Biot.,**9** (27) : 4144-4151.
- Gul, R., Rahman, H., Tahir, M., Naeem, M. and Ghafoor, A., 2013, Estimates of heterosis for morphological and flavor attributes in tomato. African J. Biot., **10** (28) : 5244-5251.
- Hannan, M. M., Ahmed, M. B., Razvy, M. A., Karim, R., Khatun, M., Haydar, A., Hossain, M. and Roy, U. K., 2007, Heterosis and correlation of yield and yield components in tomato (*Lycopersicon esulentum* Mill.). American-Eurasian J. Scientific Res., **2** (2) : 146-150.
- Harer, P. N., Lad, D.B. and Bhor, T. J., 2002, Correlation and path coefficient studies in tomato (*Lycopersicon esculentum* Mill.). J. Maharashtra Agric. Uni., **27** (3) :302-303.
- Hari, H. R., 1997, Vegetable breeding principles and practices, Kalyani Publishers. India.
- Holmes, F. D., 1948, Resistance to spotted wilt in tomato. Pytopath.,**38**: 467-473.
- Islam, M. R., Ahmad, S. and Rahman, M. M., 2012, Heterosis and qualitative attributes in wintertomato (*Solanum lycopersicum* L.) hybrids. Bangladesh J. Agric. Res., **37** (1) : 39-48.
- *Izge, A. U. and Garba, Y. M., 2012, Combining ability for fruit worm resistance in some commercially grown tomatoes in lake alau near maiduguri and hong in adamawa state, Nigeria.J. Environmental issues and Agriculture in developing countries, **4** (1) : 332-338.
- Jamwal, R. S., Rattan, R. S. and Saini, S. S., 1984, Hybrid vigour and combining ability in tomato.South Indian Hort., **32**: 67-74.
- Johnson, S. J., King, E. G. and Bradlay, J. R.,1986, Theory and tactics of *Heliothis* population management. Cultural and biological control.South. Coop. Ser. Bull., 316:161.
- Joshi, A. and Thakur, M. C., 2003, Exploitation of heterosis for yield and yield contributing traits in tomato (*Lycopersicon esculentum* Mill.). Progressive Hort., **35** (1) : 64-68.
- Joshi, A., Thakur, M.C. and Kohli, U. K., 2005, Heterosis and combining ability for shelf-life,whole fruit firmness and related traits in tomato.Indian J. Hort.,**62**: 33-36.
- Joshi, A., Vikram, A. and Thakur, M. C., 2004, Studies on genetic variability, correlation and path analysis for yield and physico- chemical traits in tomato (*Lycopersicon esculentum* Mill.). Progr. Hort., **36** (1) : 51-58.

- Kaloo, G., Singh, R. K. and Bhutani, R. D., 1973, Combining ability studies in tomato (*Lycopersicon esculentum* Mill.). Theoretical Appl. Genet., **44**: 358-363.
- Kamalveer, Vinodkumar, S. and Uniyal, S. P., 2006, Combining ability studies in tomato (*Solanum lycopersicum* L.). Veg. Sci., **33** (1) : 76-78.
- Kanthaswamy, V. and Balakrishnan, R., 1989, Studies on hybrid vigour of F₁ and its retention in F₂ generation of tomato. South Indian Hort., **37**: 77-83.
- Karabhantanal, S. S., Awaknavar, J. S., Patil, R. K. and Patil, B. V., 2005, Integrated management of the tomato fruit borer, *Helicoverpa armigera*. Karnataka J. Agric. Sci., **18** (4) : 977-981.
- Kashyap, R. K. and Verma, A. N., 1986, Screening of tomato genotypes for susceptibility to fruit borer, *Heliothis armigera* (Hubner). Indian J. Ent., **48** (1) : 46-53.
- Kaur, P., Dhaliwal, M. S., Surjan, S. and Singh, S., 2002, Genetic analysis of some parameters associated with fruit firmness in tomato by involving genetic male sterile lines. Veg. Sci., **29** (1) : 20-23.
- Kavitha, S., Sekar, K. and Kalyanasundaram, 2007, Combining ability and gene action studies for salinity tolerance in tomato (*Solanum lycopersicum* Mill.). Veg. Sci., **34**: 37-39.
- Kemphorne, O., 1957, An Introduction to genetic statistics, New York, John Wiley and Sons,
- Kulkarni, G. P., 1999, Heterosis, combining ability and reaction to tomato leaf curl virus in tomato. M.Sc. (Agri.) Thesis, Uni. Agric. Sci., Dharwad (India).
- Kulkarni, G. P., 2003, Investigations on bacterial wilt resistance in tomato. Ph.D. Thesis, Uni. Agric. Sci., Dharwad (India).
- Kumar, N., Bisht, J.K. and Joshi, M.C., 1988, Genetic studies of quantitative traits in pearshape tomato. Prog. Hort., **20**: 105-108.
- Kumar, P. T., Tewari, R. N. and Pachauri, D. C., 1995, Line x tester analysis for processing characters in tomato. Veg. Sci., **2**: 34-38.
- Kumar, R. K., Srivastava, N., Pal, S., Vasistha, N. K., Singh, R. K. and Singh, M. K., 2013, Combining ability analysis for yield and quality traits in tomato (*Solanum lycopersicum* L.). J. Agric. Sci., Vol. 5 No. 2.
- Kumar, R., Mishra, N.K., Singh, J., Rai, G.K., Verma, A. and Rai, M., 2006, Studies on yield and quality traits in tomato (*Solanum lycopersicum* Mill.). Veg. Sci., **33**: 126-132.
- Kumari, S., Banarjee, M. K. and Partap, P. S., 1995, Heterosis study for fruit yield and its components in tomato. Annu. Agric. Res., **16** (2) : 212-217.
- Kumari, S. and Sharma, K. M., 2011, Exploitation of heterosis for yield and its contributing traits in tomato (*Solanum lycopersicum* L.). Inter. J. Farm Sci., **1** (2) : 45-55.
- Kurian, A. and Peter, K. V., 1995, Line x tester analysis for yield and processing characters in tomato. J. Trop. Agric., **33**: 23-25.
- Lakshmi, B. L., 1997, Studies on the production and evaluation of triple cross F₁ hybrids resistant to bacterial wilt caused by *Pseudomonas solanacearum* in tomato (*Lycopersicon esculentum* Mill.). M. Sc. (Hort.) Thesis, Uni. Agric. Sci., Bangalore (India).

- Lakshmikanth and Mani, 2004, Association and contribution of different characters towards fruit yield in tomato (*Lycopersicon esculentum* Mill.) in north western hill zone. Indian J. Hort., **61** (4) : 327-330.
- Lukefahr, M. J. 1982, A review of the problems, progress and prospects for host plant resistance to *Heliothis* spp. p.223-231. International workshop on *heliothis* management. ICRISAT, India.
- Mageswari, K. and Natarajan, S., 1999, Studies on heterosis for yield and quality in tomato (*Lycopersicon esculentum* Mill.). South Indian Hort., **47** (1-6) : 216-217.
- Mahendrakar, P., 2004, Development of F₁ hybrids in tomato (*Lycopersicon esculentum* Mill.). M. Sc. (Hort.) Thesis, Uni. Agric. Sci., Dharwad (India).
- *Manish. B. and Leena, S., 2014, Correlation studies of shelf life related fruit traits in *Solanum lycopersicum* L. Germplasm. Int. J. Bio. Res., **3** (2) : 226-231.
- Manna, M. and Paul, A., 2012, Association between fruit yield and some yield components in tomato (*Lycopersicon esculentum* Mill.). Hort. Flora Res. Spectrum, **1** (3) : 215-219.
- Mishra, C. H. and Khanna, K. R., 1977, Heterosis and combining ability studies some vegetative character in tomato. Indian J. Hort., **34**: 396-403.
- Mittal, R. K., Singh, H. N., Singh, R. R. and Singh, J. B., 1974, Combining ability in tomato. Haryana J. Hort. Sci., **3** (3-4) : 168-176.
- Mohammad, S., Mohammad, A. and Shehnaz, A., 2011, Screening of tomato genotypes for resistance to tomato fruit borer (*Helicoverpa armiger* Hubner.) in Pakistan. Pakistan J. Agric. Sci., **1** (48) : 59-62.
- Monowara, Y., 2007, Varietal performance and management of tomato fruit borer (*Helicoverpa armigera*). M. Sc. (Agri.) Thesis, Uni. Agric. Sci. Bangla (Dhaka).
- Muniyappa, V., Jalikop, S. H., Saikia, A. K., Chennarayappa, S. G., Ishwarabhat, A. and Ramappa, H. K., 1991, Reaction to *Lycopersicon* cultivars and wild accessions to tomato leaf curl virus. Euphytica, **56**: 37-41.
- Muniyappa, V., Venkatesh, H. M., Ramappa, H. K., Kulkarni, R. S., Zeidan, M., Tarba, C.Y., Ghanim, M. and Czosnek, H., 2000, Tomato leaf curl virus from Bangalore (ToLCV-Ban4) : sequence comparison with Indian ToLCV isolates, detection in plants and insects and vector relationships. Archives Virology, **145** (8) : 1583-98.
- Nagaraja, T. E., 1995, Studies on genetic architecture of fruit yield, its components and inheritance of leaf curl virus resistance in interspecific crosses of tomato (*Lycopersicon esculentum* Mill.). Ph. D. Thesis, Uni. Agric. Sci., Bangalore (India).
- Padma, E., Ravishankar, C. and Arinivasalu, R., 2002, Correlation and path coefficient studies in tomato (*Lycopersicon esculentum* Mill.). J. Res. ANGRAU., **30** (4) : 68-71.
- Padma, E., Senkar, C. R. and Rao, B. V., 2002, Heterosis and combining ability in tomato (*Lycopersicon esculentum* Mill.). The Andhra Agric. J., **49** (3-4) : 285-292.
- Pandey, S. K., Dixit, J., Pathak, V. N. and Singh, P. K., 2006, Line x tester analysis for yield and quality characters in tomato [*Solanum lycopersicon* (Mill.) Wettst.]. Veg. Sci., **33**: 13-17.

- Paterson, R. G., Scott, S. J. and Gergerich, R. C., 1989, Resistance in two *lycopersicon* species to an Arkanras isolate of tomato spotted wilt virus. *Euphytica*, **43**: 173-178.
- Patagaonkar, D. R., Ingavale, M. T., Mangave, K. and Kadam, D. D., 2003, Heterosis studies for fruit characters in heat tolerant lines of tomato (*Lycopersicon esculentum* Mill.). *South Indian Hort.*, **51** (1-6) : 134-136.
- Patil, A. A., 1984, Studies on correlation, path analysis, genetic divergence, heterosis and combining ability in ten parental diallel cross of tomato. Ph.D. Thesis, Univ. Agric. Sci., Bangalore.
- Patil, A. A. and Bojappa, K. M., 1988, Studies on heterosis as influenced by genetic diversity and combining ability. *J. Maharashtra Agric. Uni.*, **13** (2) : 150-151.
- Patil, A. A. and Bojappa, K. M., 1993, Studies on phenotypic and genotypic correlations on growth, yield and quality attributes in tomato (*Lycopersicon esculentum* Mill.). *Karnataka J. Agric. Sci.*, **46**: 395-398.
- Patil, G. S., 1997, Genetic analysis and economic usage of compound inflorescence in tomato. Ph.D. Thesis, Uni. Agric. Sci., Dharwad (India).
- Patil, M. G., 1996, Investigation on genetic improvement and production practices in processing tomato (*Lycopersicon esculentum* Mill.). Ph.D. Thesis, Uni. Agric. Sci., Dharwad (India).
- Patil, S. S., 1998, Studies on association of characters, heterosis and combining ability in processing tomato (*Lycopersicon esculentum* Mill.). M. Sc. (Agri.) Thesis, Uni. Agric. Sci., Dharwad (India).
- Peter, K. V. and Rai, B., 1978, Heterosis as a function of genetic distance in tomato. *Indian J. Genet. Pl. Breed.*, **38**: 173-178.
- Prabhushankar, H.R., 1990, Genetic analysis of yield and yield components in tomato (*Lycopersicon esculentum* Mill.). M.Sc. (Agri.) Thesis, Univ. Agric. Sci., Dharwad (India).
- Prashanth, H., 2004, Heterosis and combining ability analysis for higher lycopene content in tomato. M. Sc. (Agri.) Thesis. Uni. Agric. Sci., Dharwad (India).
- Premalakshmi, V., 2010, Heterosis and combining ability analysis in tomato (*Lycopersicon esculentum* Mill.) for yield and yield contributing traits. *South Indian Hort.*, **50**: 360-369.
- Premalakshmi, V., Thargaraj, T., Veeranagavathatham, D. and Armugam, T., 2006, Heterosis and combining ability analysis in tomato (*Solanum lycopersicon* Mill.) for yield and yield contributing traits. *Veg. Sci.*, **33**: 5-9.
- Pujari, C.V. and Kale, P.N., 1994, Heterosis studies in tomato. *J. Maharashtra Agric. Univ.*, **19**: 83-85.
- Rai, M., Singh, A. K., Pan, R. S. and Krishna Prasad, V. S. R., 2003, Combining ability of quality and yield in tomato (*Lycopersicon esculentum*). *Veg. Sci.*, **30** (1) :21-24.
- Rai, N., Syamal, M. M., Joshi, A. K. and Ghosh, P. K., 1998, Diallel analysis for pericarp thickness and storability of tomato (*Lycopersicon esculentum* Mill.). *Annu. Agric. Res.*, **18**: 71-75.
- Raijadhav, S. B., Chaudhari, K. G., Kale, P. N. and Patil, R. S., 1996, Heterosis in tomato under high temperature stress. *J. Maharashtra Agric. Uni.*, **21** (2) : 229-231.

- Raijadhav, S. B. and Kale, P. N., 1987, Combining ability for processing characters in tomato. J. Maharashtra Agric. Uni., **12** (3) : 379-380.
- Rajput, J. C., 1987, Exploitation of F₂ heterosis for yield and processing qualities in tomato (*Lycopersicon esculentum* Mill.). Ph.D. Thesis, Univ. Agric. Sci., Bangalore.
- Ramamohan, 1988, Genetics of heat tolerance in tomato. M.Sc. (Agri.) Thesis, Univ. Agric. Sci., Bangalore.
- Ranganna, S., 1986, Hand Book of Analysis and quality control of fruit and vegetable products. Tata McGraw Hill Publishing Co. Ltd. New Delhi.
- Rattan, R. S. and Arvind, B., 2002, Reaction of tomato (*Lycopersicon esculentum* Mill.) genotypes against leaf curl virus. Veg. Sci., **29** (2) : 176-177.
- Reddy, V. V. D. and Reddy, B. M. M., 1994, Heterosis for fruit characters in tomato. J. Maharashtra Agric. Univ., **19**: 312-314.
- Rick, C. M., 1965, Cytogenetic of tomato. Advance in Genetics, **8**: 267-382.
- Riggs, T. J., 1988, Breeding F₁ hybrid varieties of vegetables. J. Hort. Sci., **63**: 362-369.
- Roopa, S. A. T., Reddy, K. M., Gopalakrishna Rao, K. P. and Narasimha Prasad, 2001, Combining ability studies for long shelf-life in tomato. Veg. Sci., **28**: 24-26.
- Sadashiam, S. and Manickam, A., 1992, Biochemical methods for agricultural science. Wiley Eastern Ltd., pp. 6-178.
- Sajjan, M. N., 2002, Heterosis, combining ability, RAPD analysis and resistance breeding for leaf use virus and bacterial wilt in tomato (*Lycopersicon esculentum* Mill.). M.Sc. (Agri.) Thesis, Uni. Agric. Sci., Dharwad (India).
- Saleem, M. Y., Muhammad, A. Q., Attiq, U. and Muhammad, A., 2013, Diallel analysis of yield and some yield components in tomato (*Solanum lycopersicum* L.). Pak. J. Bot., **45** (4) : 1247-1250.
- Samadia, D. K., Aswani, R. C. and Dhandar, G., 2006, Genetic analysis for yield components in tomato land races. Haryana J. Hort. Sci., **35** (1&2) : 116-119.
- Santosh and Manish, 2011, Exploitation of heterosis for yield and its contributing traits in tomato (*Solanum lycopersicum* L.). International J. Farm Sci., **1**(2) : 45-55.
- Saraladevi, P., 1984, Line x tester analysis in tomato (*Lycopersicon esculentum* Mill.). M. Sc. (Agri.) Thesis, Faculty of Horticulture, Tamil Nadu, Agric. Univ., Coimbatore.
- Sastry, K. S. M. and Singh, S. J., 1973, Effect of different insecticides on the control of whitefly (*Bemisia tabaci* Genn.) population in tomato crop and the incidence of the tomato leaf curl virus. Indian J. Hort., **28**: 304-309.
- Sathyanarayana, H. V. and Anand, N., 1992, Combining ability studies in bacterial wilt resistant tomato (*Lycopersicon esculentum* Mill.) for processing qualities and yield. Veg. Sci., **19** (2) : 192-200.
- Sekar, L., Prakash, B. G., Salimath, P. M., Channayya, P., Hiremath, O., Sridevi and Patil, A. A., 2010, Implications of heterosis and combining ability among productive single cross hybrids in tomato. Electronic J. Plant Breeding, **1** (4) : 706-711.
- Sharma, D. K., Chaudhary, D. R. and Pandey, D. P., 2001, Studies on hybrid vigour in tomato (*Lycopersicon esculentum* Mill.). Haryana J. Hort. Sci., **30**: 236-238.
- Sharma, D.K., Chaudhary, D.R. and Sharma, P.P., 1999, Line x tester analysis for study of combining ability of quantitative traits in tomato. Indian J. Hort., **56**: 163-168.

- Sharma G. D., Devi, N. and Raj, D., 2006, Relative susceptibility of tomato genotypes to fruit borer, *Helicoverpa armigera* Hübner. J. Entomological Res., **30** (4) : 309-312.
- Sharma, D. and Thakur, M. C., 2008, Evaluation of diallel progenies for yield and its contributing traits in tomato under mid-hill conditions. Indian J. Hort., **65**: 297-301.
- Sharma, S., 1996, Screening of international set of tomato genotypes to bacterial wilt disease. Reg. Agric. Res. Centre, **96**: 17.
- Shashikanth, Basavaraj, N. and Dhotre, M., 2012, Correlation and path co-efficient studies in tomato. Asian J. Hort., **7** (2) : 379-384.
- Shull, G. H., 1914, What is heterosis?. Genetica, **33**:430-446.
- Sidhu, A. S., Kalloo, G., Dixit, J. and Bhutani, R. D., 1981, Heterosis and combining ability in pear shaped tomato (*Lycopersicon esculentum* Mill.). Haryana Agric. Uni. J. Res., **11** (1) : 1-7.
- Singh, A. K. and Asati, B. S., 2011, Combining ability and heterosis studies in tomato under bacterial wilt condition. Bangladesh J. Agric. Res., **36** (2) : 313-318.
- Singh, A. K., Pan, R. S. and Rai, M., 2007, Heterosis for fruit yield and its components in tomato (*Solanum lycopersicum* Mill.). Veg. Sci., **34**:108.
- Singh, B., Joshi, S. and Kumar, N., 1976, Heterosis and combining ability in tomato. Veg. Sci., **3**: 91.
- Singh, B., Kumar, N. and Joshi, S., 1978, Hybrid vigour in tomato. Prog. Hort., **10**: 20.
- Singh, B., Shabir, H., Haribhushan, A. and Nongthombam, R., 2012, Heterosis studies for yield and its components in tomato (*Solanum lycopersicum* L.) under valley conditions of Manipur. J. Veg. Sci., **25** (2) : 257-265.
- Singh, C. B., Rai, N., Singh, R. K., Singh, M. C., Singh, A. K. and Chaturvedi, A. K., 2008, Heterosis, combining ability and gene action studies in tomato (*Solanum lycopersicum* L.). Veg. Sci., **35**: 132-135.
- Singh, N. P., Bharadwaj, A. K., Abnish Kumar and Singh K. M., 2004, Modern technology on vegetable production, Int. Book distribution Co., Lucknow, pp. 84-98.
- Singh, J. K., Singh, J. P., Jain, S. K. and Joshi, A., 2004, Correlation and path coefficient analysis in tomato (*Lycopersicon esculentum* Mill.). Prog. Hort., **36** (1) : 82-86.
- *Singh, K., 2014, Evaluation of tomato genotypes and its reaction against ToLCV causing leaf curl disease in tomato (*Solanum lycopersicum* L.). J. Experimental Bio. and Agric. Sci., **2** (1S) : 120-125.
- *Singh, M. S., Baruah, B. K. and Singh, K. L., 2013, Field screening of certain tomato varieties for their resistant reaction against *Helicoverpa armigera* (Hubner) in Manipur valley, India. The Clarion, **2** (1) : 56-58.
- Singh, R. K. and Singh, V. K., 1993, Heterosis breeding in tomato (*Lycopersicon esculentum* Mill.). Ann. Agric. Res., **14**: 416-420.
- Sparague, G. F. and Tatum, L. A., 1942, General versus specific combining ability in single crosses of corn. J. American Society Agron., **34**: 923-932.
- Srivastava, J. P., Singh, H., Srivastava, B. P. and Verma H. P. S., 1998, Heterosis in relation to combining ability in tomato. Veg. Sci., **25** (1) : 43-47.

- Stevens, M. R., Scott, S. J. and Gergerich, R. C., 1992, Inheritance of a gene for resistance to tomato spotted wilt virus (TSWV) from. *Lycopersicon peruvianum* Mill. *Euphytica*, **59**: 9-17.
- Sunil, K. Y., Singh, B. K., Baranwal, D. K. and Solankey, S. S., 2013, Genetic study of heterosis for yield and quality components in tomato (*Solanum lycopersicum*). *Afr. J. Agric. Res.*, **8** (44) :5585-5591.
- Sureshkumar, B. M. K. and Pratap, P. S., 1995, Heterosis study for fruit yield and its components in tomato. *Ann. Agric. Res.*, **16**: 212-217.
- Tendulkar, S. K., 1994, Studies on line x tester analysis for development of F₁ hybrids in tomato (*Lycopersicon esculentum* L.). M.Sc. (Agri.) Thesis, Univ. Agric. Sci., Dharwad.
- Thakur, A. K. and Kohli, U. K., 2005, Studies on genetics of shelf-life in tomato. *Indian J. Hort.*, **62**: 163-167.
- Thakur, M. C. and Joshi, A., 2000, Combining ability analysis of yield and other horticultural traits in tomato. *Haryana J. Hort. Sci.*, **29**: 214-216.
- Tiwari, A. and Lal, G., 2004, Studies on heterosis for quantitative and qualitative characters in tomato (*Lycopersicon esculentum* Mill.). *Progr. Hort.*, **36** (1) :122-127.
- Tiwari, G. C. and Krishna Moorthy, P. N., 1984, Yield loss in tomato caused by fruit borer. *Indian J. Agric. Sci.*, **54** (4) : 341-343.
- Uppal, G. S., Tarsem, L., Cheema, D. S. and Lal, T., 1997, Performance of tomato hybrids with regard to yield and quality characters. *Punjab Agric. Uni. J. Res.*, **34** (1) : 45-56.
- Venkata Raman, C., Prasad Rao, R. D. J., Reddy, I. P., Venkata Rao, P. and Reddy, Y. N., 2006, Screening of tomato germplasm and wild relatives against tomato leaf curl virus disease. *Indian J. Pl. Prot.*, **34** (1) : 59-61.
- Vineet Kumar, Singh, B. M. and Sugha, S. K., 1997, Reaction of tomato genotypes to bacterial wilt. *Plant Disease Res.*, **12** (1) : 90-94.
- Vinod, K. R., Nandan, S. K., Sharma, K., Srivastava., Ravindra K. and Singh, M. K., 2013, Heterosis study for quality attributing traits in different crosses in tomato (*Solanum lycopersicum* L.). *Plant Archives.*, **13** (1) : 21-26.
- Virelwal, H. A., Nandpuri, K. S. and Singh, S., 1981, Heterosis and combining ability in tomato, *Veg. Sci.*, **8**:120-129.
- Yadav, E. D., Kale, P. N. and Wavhal, K. N., 1989, Heterosis for yield, fruit number and weight of fruiting tomato. *J. Maharashtra Agric. Univ.*, **14**: 338-340.
- Yashavantakumar, K. H., 2008, Heterosis and combining ability for resistance against tospovirus in tomato (*Solanum lycopersicum* (Mill.) Wettst.). M. Sc. (Agri.) Thesis, Univ. Agric. Sci., Dharwad (India).

**Appendix I: Meteorological data recorded during the period of experimentation
(2013) from Agricultural Research Station, Arabhavi**

Month	Temperature (°C)		Relative Humidity (%)		Evaporation (mm)	Rainfall (mm)
	Minimum	Maximum	Morning	Evening		
January 2013	12.85	31.25	88	32	3.2	0.00
February 2013	13.97	32.45	92.07	32.93	3.15	3.60
March 2013	15.63	35.49	81	23	4.76	0.00
April 2013	19.14	34.53	72.67	30.83	6.55	6.10
May 2013	22.41	37.63	85	47	7.18	87.80
June 2013	21.74	30.95	87.73	66.33	4.1	11.70
July 2013	21.22	28.02	93	80	1.87	53.50
August 2013	20.35	28.69	91	71	2.63	31.30
September 2013	20.39	29.48	91.03	66.20	2.97	77.20
October 2013	19.77	30.13	92	60	3.14	83.80
November 2013	13.76	29.40	93.33	47.23	3.38	0.00
December 2013	11.13	28.28	91	42	2.95	0.00

Appendix II: Sensory evaluation or market appeal of parents and crosses in tomato

Sl. No.	Genotypes	Average score
Lines		
1	T-26	3.81
2	T-36	3.12
3	Arka Vikas	3.55
4	Swarna Naveen	2.12
5	Vaibhav	3.87
6	DMT-1	3.68
7	DMT-3	2.93
8	DMT-5	2.87
9	S-22	3.62
10	Arka Meghali	3.63
11	Megha	3.27
12	K-3	3.17
13	T-57	3.25
14	TB-1	3.31
15	HUB-18	3.50
Testers		
16	Arka Abha	2.37
17	Arka Alok	3.15
18	DMT-2	3.40
Commercial check		
19	JK-Desi (F ₁)	3.66
Crosses		
20	T-26 x Arka Abha	3.75
21	T-26 x ArkaAloka	3.50
22	T-26 x DMT-2	3.75
23	T-36 x Arka Abha	3.87
24	T-36 x ArkaAloka	3.52
25	T-36 x DMT-2	3.45
26	Arka Vikas x Arka Abha	2.43
27	Arka Vikas x Arka Alok	3.00
28	Arka Vikas x DMT-2	3.40
29	Swarna Naveen x Arka Abha	4.31
30	Swarna Naveen x Arka Alok	3.22
31	Swarna Naveen x DMT-2	3.67
32	Vaibhav x Arka Abha	3.77
33	Vaibhav x Arka Alok	3.95

Contd....

Sl. No.	Genotypes	Average score
34	Vaibhav x DMT-2	3.62
35	DMT-1 x Arka Abha	3.42
36	DMT-1 x Arka Alok	3.67
37	DMT-1 x DMT-2	2.62
38	DMT-3 x Arka Abha	3.93
39	DMT-3 x Arka Alok	3.42
40	DMT-3 x DMT-2	3.81
41	DMT-5 x Arka Abha	3.87
42	DMT-5 x Arka Alok	3.12
43	DMT-5 x DMT-2	3.60
44	S-22 x Arka Abha	4.00
45	S-22 x Arka Alok	4.02
46	S-22 x DMT-2	3.77
47	Arka Meghali x Arka Abha	3.81
48	Arka Meghali x Arka Alok	4.31
49	Arka Meghali x DMT-2	4.00
50	Megha x Arka Abha	3.40
51	Megha x Arka Alok	3.75
52	Megha x DMT-2	3.70
53	K-3 x Arka Abha	3.27
54	K-3 x Arka Alok	3.52
55	K-3 x DMT-2	3.62
56	T-57 x Arka Abha	3.31
57	T-57 x Arka Alok	3.32
58	T-57 x DMT-2	3.46
59	TB-1 x Arka Abha	3.35
60	TB-1 x Arka Alok	3.07
61	TB-1 x DMT-2	3.62
62	HUB-18 x Arka Abha	3.56
63	HUB-18 x Arka Alok	3.38
64	HUB-18 x DMT-2	3.75



Plate 5: Sensory evaluation or market apple of parents and crosses in tomato

Appendix III: Reaction of parents and crosses to tomato leaf curl virus (ToLCV) in tomato

Sl. No.	Reaction	Number of genotypes	Genotypes
1.	Resistant (5-9%)	00.00	00.00
2.	Moderately resistant (10-19%)	4	Parents: DMT-5 and DMT-2 Crosses: DMT-5 x Arka Alok and T-26 x DMT-2
3.	Moderately Susceptible (20-39%)	11	Parents: S-22, T-26 and Arka Abha Crosses: DMT-3 x Arka Abha, DMT-3 x Arka Alok, DMT-5 x Arka Abha, TB-1 x Arka Alok Vaibhav x Arka Abha, DMT-1 x DMT-2, DMT-5 x DMT-2, Arka Meghali x DMT-2 and JK-Desi (F ₁).
4.	Susceptible (40-69%)	44	Parents: SwarnaNaveen, S-22, Arka Megali, Megha, K-3, T-57, HUB-18, Arka Alok, DMT-1, Arka Vikas, Vaibhav and DMT-3. Crosses: T-26 x Arka Abha, Vaibhav x DMT-2, T-26 x Arka Alok, T-26 x DMT-2, Vaibhav x Arka Alok, DMT-1 x Arka Abha, T-36 x Arka Alok, T-36 x DMT-2, Arka Vikas x Arka Abha, Arka Vikas x Arka Alok, Arka Vikas x DMT-2, S-22 x DMT-2, Swarna Naveen x Arka Abha, Swarna Naveen x DMT-2, Megha x Arka Abha, S-22 x Arka Alok, Arka Meghali x Arka Abha, Arka Meghali x Arka Alok, Megha x Arka Abha, Megha x DMT-2, K-3 x Arka Abha, K-3 x Arka Alok, DMT-3 x DMT-2, K-3 x DMT-2, T-57 x Arka Abha, TB-1 x Arka Alok, TB-1 x DMT-2, HUB-18 x Arka Abha, HUB-18 x Arka Alok, S-22 x Arka Abha and HUB-18 x DMT-2.
5.	Highly susceptible (70-100%)	7	Parents: T-36, DMT-1 and TB-1. Crosses: DMT-1 x Arka Alok, T-36 x Arka Abha, Swarna Naveen x Arka Alok.

Appendix IV: Reaction of parents and crosses to fruit borer (*Helicoverpa armigera*) incidence in tomato

Sl. No.	Reaction	No. of genotypes	Genotypes
1.	Highly resistant (0-5%)	26	<p>Parents: Swarna Naveen,S-22, Arka Meghali,HUB-18, Arka Alok and Arka Abha.</p> <p>Crosses: T-26 x Arka Alok, T-36 x Arka Abha,T-36 x ArkaAloka, T-36 x DMT-2,Arka Vikas x Arka Abha, Vaibhav x Arka Abha,Vaibhav x Arka Alok,Swarna Naveen x Arka Abha,DMT-5 x DMT-2,Swarna Naveen x DMT-2,DMT-5 x Arka Alok,DMT-1 x Arka Alok, S-22 x Arka Abha,S-22 x DMT-2, Arka Meghali x Arka Abha,Arka Meghali x Arka Alok, Megha x Arka Abha,K-3 x DMT-2, T-57 x DMT-2, HUB-18 x Arka Abha andHUB-18 x Arka Alok.</p>
2.	Resistant (5-10%)	10	<p>Parents:T-26 and Vaibhav.</p> <p>Crosses:T-26 x DMT-2, Vaibhav x DMT-2, DMT-5 x Arka Abha, S-22 x Arka Alok, Arka Meghali x DMT-2, TB-1 x Arka Alok, TB-1 x DMT-2 and JK-Desi (F₁).</p>
3.	Moderately susceptible (10-20%)	19	<p>Parents: T-36, Arka Vikas, DMT-3, DMT-5 and Megha</p> <p>Crosses:T-26 x Arka Abha, Arka Vikas x Arka Alok, Swarna Naveen x Arka Alok, DMT-1 x Arka Abha, DMT-1 x Arka Alok, DMT-1 x DMT-2, DMT-3 x Arka Alok, DMT-3 x DMT-2, Megha x Arka Alok, Megha x DMT-2, T-57 x Arka Abha, T-57 x Arka Alok and TB-1 x Arka Abha.</p>
4.	Susceptible (> 20%)	09	<p>Parents: DMT-1,K-3, T-57, TB-1 andDMT-2.</p> <p>Crosses: Arka Vikas x DMT-2, K-3 x Arka Abha, K-3 x Arka Alok andHUB-18 x DMT-2.</p>

HETEROISIS AND COMBINING ABILITY STUDIES IN TOMATO (*Solanum lycopersicum* L.)

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2014

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ABSTRACT

The investigation on “Heterosis and combining ability studies in tomato (*Solanum lycopersicum* L.)” was undertaken at vegetable science unit of Kittur Rani Channamma College of Horticulture, Arabhavi (Karnataka). Forty five crosses were developed by crossing three males (testers) with each of 15 females (lines). Crosses were evaluated along with the parents and commercial check in randomized block design with two replications and data was subjected to line × tester analysis. The magnitude of heterosis over the commercial check (JK-Desi) was high in the desirable direction for lycopene (65.28 %), rind thickness (100.00 %), average fruit weight (101.89 %), number of primary branches at 90 DAT (76.36 %), polar diameter of fruit (49.87 %), yield per plant (8.57 %), number of primary branches at 60 DAT (55.61 %), number of locules per fruit (11.80 %), equatorial diameter of fruit (49.87 %), number of secondary branches at 90 DAT (77.36 %), plant height at 60 DAT (16.17 %), number of fruits per plant (29.81 %), beta-carotene (30.54%) and TSS (100.00 %). The hybrid which expressed maximum heterosis for total yield per plant over the commercial check (JK-Desi) S-22 x Arka Abha (8.57 %) followed by DMT-5 x Arka Alok (5.71 %), DMT-5 x Arka Abha (2.86 %) and T-26 x DMT-2 (0.57 %).

The crosses S-22 x Arka Abha, DMT-5 x Arka Alok, DMT-5 x Arka Abha and T-26 x DMT-2 are identified as the good specific combiners and the lines T-26, T-36, DMT-5 and S-22 were identified as the good general combiners for yield per plant. The lines T-26, T-36, Swarna Naveen, Vaibhav, DMT-1, DMT-5, S-22 and HUB-18 and testers Arka Abha and DMT-2 were identified as good combiners over all characters based on comprehensive study considering gca effects of 28 characters. Non-additive gene action was predominant for number of fruits per cluster, equatorial diameter of the fruit, plant height, number of branches per plant, days to first fruit maturity, average fruit weight, number of locules per fruit, days to first flowering, days to 50 per cent flowering, days to first fruit set, number of fruits per plant, yield per plant, rind thickness, TSS and lycopene and it is suggested to improve these traits for combining ability through recurrent selection schemes.