COMBINING ABILITY AND HETEROSIS STUDIES IN MUSKMELON (*Cucumis melo* L.)

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JANUARY, 2009

COMBINING ABILITY AND HETEROSIS STUDIES IN MUSKMELON (*Cucumis melo* L.)

Thesis submitted to the
University of Agricultural Sciences, Dharwad

in partial 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 "**COMBINING ABILITY AND HETEROSIS STUDIES IN MUSKMELON (*Cucumis melo* L.)**" submitted by **NAVEEN BADIGER** for the degree of **MASTER OF SCIENCE (HORTICULTURE)** in **VEGETABLE SCIENCE** of the University of Agricultural Sciences, Dharwad is a record of research work done 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 for the award of any degree, diploma, associateship, fellowship or other similar titles.

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ACKNOWLEDGEMENT

It always is a nostalgic feeling whenever one glances back to the days of hard work, tensions and the need of the hour to excel. One would not achieve whatever one is now, without all the help, encouragement and the wishes of the near and dear ones. Teachers, parents, friends and well wishers are an integral part of this. I own them a lot and it always is a difficult task expressing and putting into words, the sense of gratitude I feel towards them.

It is an immense pleasure to express my deep sense of gratitude and indebtedness to **Dr. RAVINDRA MULGE***, Associate Professor and Head, Department of Vegetable Science, Kittur Rani Channamma College of Horticulture, Arabhavi and Chairman of my advisory committee for his invaluable guidance, kind encouragement and constant advise throughout the period of this investigation and sustained interest and help in compilation of the thesis.*

I avail myself of this opportunity to express my sincere gratitude with great reverence to **Dr. M.B. MADALAGERI***, Special Officer, College of Horticulture, Bagalkot and member of my advisory committee for his support and suggestions during the course of my investigation*

I am highly grateful to the members of my advisory committee **Dr. R.C. JAGADEESHA,** *Associate Professor, Department of Genetics and Plant Breeding and* **Dr. LAXMINARAYAN HEGDE***, Associate Professor, Department of Medicinal and Aromatic Plants for their valuable suggestions and constant encouragement in planning the research work and critically going through the manuscript.*

I avail this opportunity to express my profound thanks to ***Mr. V.D. Gasti,*** *Assistant Professor, Department of Vegetable Science, Dr. G.S.K. Swamy, Associate Professor and Head, Department of Fruit Science, Dr. M.L. Chavan, Associate Professor, Department of Crop Physiology, Mr. Mahesh Kulkarni, Shelf Assistant, Mr. S.A. Savalagi and Mr. Maruti, Field Assistants of Department of Vegetable Science for their encouragement during the studies. I sincerely express my gratitude to Mr. Appalal of Department of Vegetable Science for his assistance during the course of this investigation.*

I express my sincere gratitude and heartfelt regards to my beloved father ***Sri. Veeresh D. Badiger****, mother* ***Smt. Vijayshree*** *and I owe all my success to loving brother* ***Chetan*** *and my relatives Sri V.S.M., M.S.M., R.S.M., S.J.P., V.J.P., N.J.P., R.V.P., V.P.S., V.A.D., J.S.S.,* *S.B.P. and cousin brothers Prabhakar, Vijay, Vivekanand, Sadu, Shivu, Abhi, Vivek and sisters Rajeshwari, Vanishree, Madhu and Vidya, and brother-in-laws Prakash, Rajeev, Sanjeev and Santosh, son-in-law Tushar and daughter-in-law Vasudha. No diction would fulfill to express their sacrifice towards my development.*

I was lucky to have a brilliant and even dedicated galaxy of friends who were always willing to help me at the time of my research work and have always been source of energy for me, dear Arun S., Vivek H., Vivekanand, Mohan, Balaji, Shivanand, Hongal, Praveen, Kamati, Viji, Poli Reddy, Sachin, Santosh, Sanjay, Takali, Sudeesh, Tia, Muttu, Timma, Prassanna, Vasant and senior friends Iranna, Maruti, Mahantesh, Yogesh, Bagali, Prashant, Suma, Yallesh, Kamraj, Thoke, Vinay and junior friends Vasu, Srinivas, Arvind, Ajit, Pranav, Dada, Prakash, Ravi, Shivu, Sunil, Sada, Kapil, Niyaz, Vini, Shinde, Manju, Vasant, Shivanand, Vinay, Devendra and all my PG and UG friends for their direct and indirect help throughout the course of my study.

I thank to entire non-teaching staff for their cooperation throughout my studies here.

Finally, I am thankful to Mr. Shripad Majali for typing this manuscript neatly. Any omission in this brief acknowledgement does not mean lack of gratitude to any one.

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Arabhavi
January, 2009 (NAVEEN BADIGER)

Affectionately dedicated to

My Beloved Parents,

Brothers and Sisters

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1. INTRODUCTION

Muskmelon (*Cucumis melo* L.) is an important crop grown in India. It is popular in North India especially in Uttar Pradesh and Punjab and is grown in almost every place in the plains. Muskmelon has many vernacular names, such as 'Kharbooza' (Hindi), 'Kharbuz' (Punjabi), 'Sakkartoti' (Gujarati), 'Kalinga' (Sanskrit), 'Velapalam' (Tamil) and 'Kekkari kai' (Kannada). The species *Cucumis melo* L. is a large polymorphic taxon having large number of botanical and horticultural varieties or groups. It is said to be a native of tropical Africa more specially in the eastern region and South of Sahara Desert. Central Asia comprising some parts of Southern Russia, Iran, Afghanistan, Pakistan and North-West India may be regarded as a secondary centres of origin (Whitakar and Devis, 1962). Oriental pickling melon (*Cucumis melo* var. *conomon*) and snap melon (*Cucumis melo* var. *momordica*) which are unique and found throughout in India.

Muskmelon (2n=24) belongs to the family Cucurbitaceae. Edible melons belong to either *Cucumis melo* var. *reticulatus* or *Cucumis melo* var. *cantaloupensis*. Plants are either monoecious or andromonoecious annuals with long trailing vines with shallow lobed round leaves. There is considerable variation in fruit size and shape. External appearance may be smooth with netted, the skin colour may be white, green, yellow, yellowish brown or speckles yellow or orange with green or yellow background. Fruits of some cultivars crack when ripe. Upon ripening, fruits soften and fruity aromatic essences are formed in the fruit.

Muskmelon is used as dessert fruit and fruit juice has cooling effect. At green stage, it is used as a cooked vegetable in rural areas. The fruit juice is nutritive and acts as demulcent and diuretic drink. Juice is also remedy for skin diseases, tan freckles and in case of dyspepsia. The seeds are edible and its kernel is rich in oil (40-44%). This oil is useful in overcoming the problems like painful discharge and suppression of urine. The roots of melon have purgative and vomit causing properties. Fruits are good source of vitamins and minerals and relatively low in protein. The yellow and orange fleshed melons contain β-carotene and particularly cantaloupes are high in provitamin A (4200 IU/100 g). Melons are also high in vitamin C (26 mg/100 g edible portion). For every 100 g edible portion, melons provide 26 to 17 calories energy, 0.3 g protein, 32 mg calcium, 1.4 mg iron and 14 mg phosphorus (Chakrabarti, 2001).

Muskmelon occupies an area of 12,73,880 ha with an annual production of 3,08,52,000 metric tonnes in the world (Anon., 2006a). In India, it is cultivated in an area of 31,500 ha with an annual production of 6,45,000 MT and productivity of 31.5 tonnes per hectare (Anon., 2004). In

Karnataka, it is being cultivated in an area of 548 ha with annual production of 8,023 tonnes (Anon., 2005).

In India, muskmelon is commonly grown during summer in river beds or tank beds and also cultivated in fields. It is cross-pollinated crop; hence genetically pure strains are rather rare. Crop improvement in muskmelon resulted in the development of several improved varieties in the country. Many local strains like *Cucumis melo* var. *conomon* (Oriental pickling melon or Chinese white cucumber), *Cucumis melo* var. *mornordica* (snap melon or phooth) and *Cucumis melo* var. *utilissimum* (long melon or kakri) are being grown in some parts of Karnataka and neighbouring states. Muskmelon, snap melon and long melon are easily crossed with each other. The flesh of snap melon fruits is crispy and sweet in taste and skin of fruit breaks at ripening. Fruits of oriental pickling melons are smooth, glabrous and not have the musky odour while muskmelon fruits are large with poor keeping and transport quality, thin and mushy flesh, large cavity, low sugar content and fruit skin breaking at ripening stage accompanied with low yield. Its poor yield and susceptibility to fruit fly and downy mildew have limited the expansion of area under this crop. Thus, there is prime need for its improvement and to develop varieties or hybrids suited to specific agro-ecological conditions.

The commercial exploitation of hybrid vigour depends on the ease with which the techniques are employed for hybrid seed production with minimum cost of seed production. Monoecious and andromonoecious sex expression in muskmelon can be profitably utilised for the production of F_1 hybrid seed at low cost where higher seed yield per pollination is observed. Monoecious lines used as female parents proved worthy for exploitation of heterosis observed for earliness and yield and yield component traits. Time required for pollination of given number of flowers is reduced by 50 per cent and fruit set percentage is high in monoecious varieties compared to andromonoecious varieties (Kesavan and More, 1991). Because of its wider spacing, the seed requirement per hectare for commercial hybrid cultivation would be low and cost effective. Therefore, muskmelon offers greater scope for the exploitation of hybrid vigour on commercial scale to increase the productivity and production. Intervarietal crosses of muskmelon recorded the marked heterosis for characters, such as the earliness, fruit weight and total yield per vine (Singh *et al*., 1976 and Munshi and Verma, 1997). Lal and Singh (1997) studied the genetic variability in 51 genotypes of muskmelon and genotypes showed the high genetic variability for earliness, vine length, yield and quality characters except for number of fruits per vine. As the efforts in heterosis breeding are inadequate, the area under F_1 hybrids in muskmelon is very negligible in India. Most essential step in this direction is identification of superior heterotic F_1 hybrids for yield, quality and earliness. General and specific combining ability for quantitative characters influencing yield and its components is very helpful in selecting parents for production of superior hybrids. Several biometrical methods are available for studying the combining ability, heterosis and gene action. The line x tester (l x t) analysis is one of the most used methods to test the large number of lines for combining ability and heterosis. With these backdrops, an effort to exploit heterosis in muskmelon was made in the present investigation through line x tester mating design with the following objectives:

1. To assess the general and specific combining ability of parents and crosses, respectively in muskmelon for growth, earliness, yield and quality components.
2. To assess the magnitude and direction of heterosis for growth, earliness, yield and fruit quality parameters in muskmelon.
3. To study the association among different growth, earliness, yield and quality parameters in muskmelon.

2. REVIEW OF LITERATURE

Hybridisation is the main tool to obtain increased yield and exploit the heterosis present in a given crop. Muskmelon is a cross-pollinated crop and heterosis breeding is quite feasible. Usually the heterosis is manifested in yield contributing characters like number of fruits with early maturity and large size (or weight) of the fruit. The information on genetics of various quantitative and qualitative traits will be most useful in planning a breeding programme which will be successful. Present investigation on combining ability and heterosis studies in muskmelon is planned and literature on this aspect is reviewed on muskmelon and other relevant crops and presented in this chapter under different headings.

2.1 HETEROSIS

The term heterosis is now widely used, which refers to the phenomenon in which F_1 hybrid obtained by crossing the two genetically dissimilar homozygous gametes or individuals, shows increased or decreased vigour over the parental values. The term heterosis was first coined by Shull (1910) using two Greek words 'heteros', meaning different and 'osis' means condition. Hybridisation offer opportunities for improvement in productivity, earliness, uniformity, wider adaptability and quality and for rapid deployment of dominant genes for resistance to diseases and pest (Riggs, 1988). The expression of heterosis may be due to factors, such as heterozygosity, allelic interactions, such as dominance or over-dominance, non-allelic interactions or epistatis and maternal interactions. The degree of heterosis depends upon the number of heterozygous alleles. Higher number of heterozygous alleles, the more is the heterosis expected (East and Hays, 1912). The term heterobeltiosis has been coined by Fonesca and Patterson (1968), which refers to the increased or decreased vigour of F_1 over its better parent.

Exploitation of hybrid vigour in melons were demonstrated as early as in 1942 by Munger. Seshadri *et al*. (1983) reported that the hybrids can be expected to have better adoption to different environments as found in other crop plants. A group of hybrids with one common parent, out yielded the commercial parent by 84 per cent (Foster, 1967). In muskmelon, heterosis for earliness (Bohn and Devis, 1957; Lipert and Legg, 1972a, b), total soluble solids, total yield and netting intensity (Lippert and Legg, 1972a, b) have been reported. A considerable degree of heterosis has been documented in muskmelon and other cucurbits for various characters. The details of heterosis reported for various characters are presented in tabular form as under (Table 1).

Table 1. Review of literature on heterosis for different characters in muskmelon and other cucurbits

Sl. No.	Character	Crop	Number of hybrids	Heterosis over			References
				Better parent	Best parent	Commercial check	
1.	Vine length	Muskmelon	15	-	0.16 to 0.39	-	Chadha and Nandapuri (1980)
			20	1.81 to 25.65	-	-	More and Seshadri (1980)
			28	-	15.67 to 16.35	-6.67 to 14.48	Choudhary *et al*. (2003a)
			15	-24.27 to 21.41	-	-26.00 to 42.51	Vishwanatha (2003)
		Ridge gourd	28	30.21 to 39.73	-	-	Narsimharao *et al*. (2000)
			10	-17.96 to 14.50	-4.03 to 36.27	-	Mole *et al*. (2001)
			45	-12.45 to -0.21	-	-	Hedau and sirohi (2004)
		Sponge gourd	28	-	13.50 to 60.70	-	Abusaleha and Dutta (1995)
		Cucumber	24	0.90 to 22.60	-	0.60 to 22.60	Vijayakumari *et al*. (1993)
			45	-8.40 to 15.91	-	-	Dogra *et al*. (1997)
			10	0.00 to 55.19	-	-	Singh *et al*. (1999)
			28	-	-	-20.10 to 19.70	Bairagi *et al*. (2005)
		Bitter gourd	45	0.99 to 20.98	1.41 to 4.21	-	Munshi and Sirohi (1993)
			10	0.23 to 18.20	-	-7.27 to 24.99	Celine and Sirohi (1996)
			24	-29.29 to 41.23	-	-	Ram *et al*. (1997)
		Bottle gourd	45	-	0.44 to 43.37	-	Sirohi *et al*. (1985)
			66	0.32 to 35.81	3.55 to 12.06	-	Sirohi *et al*. (1987)
			10	-	6.27 to 26.29	-	Janakiram and Sirohi (1992)
			39	-	20.63 to 31.13	-	Kumar *et al*. (1999)
		Pumpkin	36	4.04 to 41.26	0.86 to 4.60	-	Sirohi (1994)
			28	-15.40 to 17.80	-	-	Mohanty and Mishra (1999)

Table 1. Continued…

Sl. No.	Character	Crop	Number of hybrids	Heterosis over			References
				Better parent	Best parent	Commercial check	
2.	Number of branches per vine	Muskmelon	39	-	-2.44 to 31.13	-	Kumar *et al*. (1999)
			15	-18.18 to 22.72	-	-20.83 to 14.58	Vishwanath (2003)
		Cucumber	90	9.73 to 21.46	-	15.63 to 68.31	Singh *et al*. (1999)
			28	-45.50 to 46.10	-	-43.80 to 21.00	Bairagi *et al*. (2005)
		Bitter gourd	28	-	3.30 to 25.85	-	Khattra *et al*. (1994)
			24	-	-60.00 to 26.09	-	Ram *et al*. (1997)
			3	-8.50 to 29.26	-	14.73 to 10.27	Tewari and Ram (1999)
			42	-48.64 to 56.05	-51.32 to 9.43	-49.66 to 13.16	Kallimani (2004)
		Bottle gourd	39	-	-2.44 to 31.13	-	Kumar *et al*. (1999)
			36	1.23 to 72.22	1.18 to 45.88	-	Dubey and Maurya (2003)
		Pumpkin	32	-0.70 to 18.10	-	-	Mohanty and Mishra (1999)
		Ridge gourd	28	-54.33 to 60.82	-	-	Narsimharao *et al*. (2000)
3.	Number of leaves	Muskmelon	15	-6.53 to 46.98	-	-2.19 to 62.50	Vishwanatha (2003)
		Bitter gourd	42	-46.75 to 25.00	-57.62 to 16.78	-52.85 to 32.67	Kallimani (2004)
		Ridge gourd	15	-15.30 to 8.24	-	-	Kanthraj (2003)
4.	Days to first flowering	Muskmelon	15	-35.78 to 16.53	-	-22.39 to 22.11	Vishwanatha (2003)
		Cucumber	210	-50.80 to 44.50	-	-	Dogra *et al*. (1997)
			38	-3.49 to 13.89	-	-2.69 to -22.02	Singh *et al*. (1999)
			28	-15.10 to 8.10	-	-13.00 to 11.00	Bairagi *et al*. (2005)

Table 1. Continued…

Sl. No.	Character	Crop	Number of hybrids	Heterosis over			References
				Better parent	Best parent	Commercial check	
	Days to first flowering	Bitter gourd	10	-3.15 to 9.11	1.23 to 7.67	-7.63 to 32.44	Celine and Sirohi (1996)
			3	-4.40 to 10.00	-	-18.50 to -8.33	Tewari and Ram (1999)
			30	-	-0.12 to -6.50	-3.61 to -14.02	Singh *et al*. (2001)
			42	-34.43 to 20.00	-11.11 to 40.00	-9.52 to 50.00	Kallimani (2004)
		Bottle gourd	45	-	-0.06 to -5.81	-	Sirohi *et al*. (1985)
			66	-0.10 to -5.98	-	-	Sirohi *et al*. (1987)
			10	-	-0.24 to -8.03	-	Janakiram and Sirohi (1992)
		Sponge gourd	28	-	-3.00 to -15.00	-	Abusaleha and Dutta (1995)
		Pumpkin	45	-0.70 to -20.41	-2.12 to -5.93	-	Sirohi *et al*. (1985)
			36	0.07 to 4.23	0.07 to 3.13	-	Sirohi (1994)
			18	-2.07 to 46.28	-21.09 to 46.28	-0.53 to 1.31	Durgaprasad (2005)
			28	-30.60 to 8.90	-	-	Mohanty (2001b)
		Summer squash	45	-3.05 to 1.82	-	-	Dhillon and Sharma (1987)
5.	Days to first female flowering	Muskmelon	28	-7.06 to -8.47	-	-1.58 to -2.68	Choudhary *et al*. (2003a)
			15	-31.99 to 12.85	-	-14.52 to 29.35	Vishwanatha (2003)
		Cucumber	24	5.00 to 47.80	-	-	Hormuzdi and More (1989)
			45	-3.49 to -13.89	-2.69 to -22.02	-	Singh *et al*. (1999)
			28	-10.12 to 3.89	-	-	Kumbhar *et al*. (2005)
		Bitter gourd	3	-5.45 to 4.81	-	-2.73 to 4.37	Tewari and Ram (1999)

Table 1. Continued…

Sl. No.	Character	Crop	Number of hybrids	Heterosis over			References
				Better parent	Best parent	Commercial check	
	Days to first female flowering	Bitter gourd	21	-6.08 to -18.37	-	-	Singh *et al*. (2000)
			30	-6.50 to -0.12	-	-14.02 to -3.61	Singh *et al*. (2001)
		Bottle gourd	66	-0.10 to -5.98	-	-	Sirohi *et al*. (1987)
			36	-0.32 to 4.42	-0.11 to 9.32	-	Dubey and Maurya (2003)
			15	-3.98 to 13.06	-3.20 to 26.53	-	Pandey *et al*. (2004)
		Pumpkin	18	-35.95 to 43.90	-24.84 to 43.88	-47.56 to 0.38	Durgaprasad (2005)
6.	Number of nodes upto first female flower	Muskmelon	30	-29.40	-	-	Dixit and Kalloo (1983)
			15	-50.00 to 30.00	-	-50.00 to 4.54	Vishwanatha (2003)
		Cucumber	24	1.80 to 43.80	-	-	Hormuzdi and More (1989)
			15	0.50 to 37.30	-	3.80 to 18.30	Vijayakumari *et al*. (1993)
			10	-54.52 to -3.23	-	-9.72 to 106.25	Dogra *et al*. (1997)
			45	-13.85 to -33.19	0.00 to -21.36	-	Singh *et al*. (1999)
			28	-24.70 to 38.80	-	-6.70 to 48.00	Bairagi *et al*. (2005)
		Bitter gourd	21	-14.71 to -27.80	-	-14.44 to -27.80	Singh *et al*. (2000)
			28	-	-	-24.72 to -20.37	Ranpise (1992)
		Bottle gourd	8	-2.49	-	-	Pal *et al*. (1984)
			39	-	-0.44 to 16.11	-	Kumar *et al*. (1999)
			36	-1.02 to 38.88	-0.85 to 28.21	-	Dubey and Maurya (2003)
			15	-10.01 to 43.45	-0.64 to 65.55	-	Pandey *et al*. (2004)
		Ridge gourd	36	-36.71 to 23.11	-25.45 to 41.50	-	Kadam *et al*. (1995)

Table 1. Continued…

Sl. No.	Character	Crop	Number of hybrids	Heterosis over			References
				Better parent	Best parent	Commercial check	
7.	Days to first harvest	Muskmelon	20	0.03 to 8.68	-	-	More and Seshadri (1980)
			15	-0.54 to -8.80	-0.40 to -7.56	-	Munshi and Verma (1997)
			60	-	-	-17.00 to -2.10	Dhaliwal and Lal (1996)
			28	-7.67 to -6.95	-	-10.67 to -0.80	Choudhary *et al*. (2003a)
		Cucumber	28	-10.90 to 13.12	-	-	Kumbhar *et al*. (2005)
		Watermelon	15	-26.92 to 2.00	-	-	Pratapreddy *et al*. (1987)
		Bitter gourd	28	67.67 to 82.00	-	-	Singh *et al*. (1997)
			21	-6.19 to -22.20	0.00 to -6.20	-	Singh *et al*. (2000)
			30	-5.97 to -0.47	-	-11.26 to -0.01	Singh *et al*. (2001)
		Bottle gourd	39	-	-2.00 to 0.00	-	Kumar *et al*. (1999)
			36	-0.44 to 7.92	-0.74 to 11.36	-	Dubey and Maurya (2003)
			15	-4.42 to 6.67	1.85 to 18.94	-	Pandey *et al*. (2004)
8.	Number of fruiting branches per plant	Muskmelon	15	0.00 to 40.71	-	-17.45 to 7.69	Vishwanatha (2003)
9.	Number of fruits per vine	Muskmelon	20	0.63 to 29.55	-	-	More and Seshadri (1980)
			56	1.10 to 51.80	-	-	Kesavan and More (1991)
			15	4.17 to 14.68	1.01 to 11.50	-	Munshi and Verma (1997)
			28	13.90 to 15.96	0.00 to 15.96	-	Choudhary *et al*. (2003a)
		Cucumber	10	-33.77 to 15.94	-	-40.08 to 11.48	Dogra *et al*. (1997)
			45	16.29 to 91.89	15.26 to 112.65	-	Singh *et al*. (1999)

Table 1. Continued…

Sl. No.	Character	Crop	Number of hybrids	Heterosis over			References
				Better parent	Best parent	Commercial check	
	Number of fruits per vine	Cucumber	28	-16.65 to 36.23	-	-	Kumbhar *et al*. (2005)
		Watermelon	15	-5.21 to 131.97	-	-	Prathapreddy *et al*. (1987)
		Bitter gourd	28	2.87 to 75.59	-	-	Khattra *et al*. (1994)
			10	6.47 to 44.85	0.00 to 2.18	6.47 to 51.65	Celine and Sirohi (1996)
			28	21.09 to 46.22	-	-	Singh *et al*. (1997)
			24	-66.67 to 30.61	-	-	Ram *et al*. (1997)
			21	13.15 to 130.06	25.39 to 86.20	-	Singh *et al*. (2000)
			30	4.46 to 74.05	-	1.91 to 53.84	Singh *et al*. (2001)
		Bottle gourd	39	-	11.75 to 30.55	-	Kumar *et al*. (1999)
			36	7.50 to 143.33	6.52 to 95.65	-	Dubey and Maurya (2003)
		Pumpkin	36	3.25 to 91.18	-	-	Sirohi (1994)
			36	11.10 to 150.00	-	-	Mohanty and Mishra (1999)
10.	Average fruit weight	Muskmelon	20	4.51 to 58.75	-	-	More and Seshadri (1980)
			18	76.00	-	-	Randhawa and Singh (1990)
			15	0.67 to 18.67	7.40 to 17.90	-	Munshi and Verma (1997)
		Cucumber	24	0.70 to 44.80	-	-	Hormuzdi and More (1989)
			45	22.01 to 50.01	0.00 to 23.08	-	Singh *et al*. (1999)
			28	-42.85 to 40.51	-	-	Kumbhar *et al*. (2005)
		Watermelon	30	-75.51 to 6.81	-	-	Nandpuri *et al*. (1974)
			15	-20.35 to 43.97	-	-	Prathapreddy *et al*. (1987)

Table 1. Continued…

Sl. No.	Character	Crop	Number of hybrids	Heterosis over			References
				Better parent	Best parent	Commercial check	
	Average fruit weight	Bitter gourd	28	3.08 to 16.71	-	-	Khattra *et al*. (1994)
			28	28.43 to 53.71	-	-	Singh *et al*. (1997)
			30	1.37 to 25.16	-	0.01 to 29.05	Singh *et al*. (2001)
		Bottle gourd	10	-	0.92 to 24.32	-	Janakiram and Sirohi (1992)
			15	-32.65	-	41.81	Pandey *et al*. (2004)
			36	0.00 to 8.03	1.96 to 39.34	-	Dubey and Maurya (2003)
11.	Fruit yield per vine	Muskmelon	20	3.37 to 87.16	-	-	More and Seshadri (1980)
			56	1.70 to 88.90	-	-	Kesavan and More (1991)
			15	2.15 to 48.86	0.97 to 28.15	-	Munshi and Verma (1997)
			28	38.65 to 44.44	6.45 to 9.03	-	Choudhary *et al*. (2003a)
			15	-41.34 to 34.05	-	-30.35 to 27.98	Vishwanatha (2003)
		Cucumber	10	-24.82 to 51.35	-	-29.20 to 29.45	Dogra *et al*. (1997)
			45	54.81 to 187.80	28.52 to 59.26	-	Singh *et al*. (1999)
			28	-64.49 to 17.22	-	-	Kumbhar *et al*. (2005)
		Watermelon	15	-7.96 to 137.66	-	-	Pratapreddy *et al*. (1987)
		Bitter gourd	55	15.52 to 86.09	-	-	Lawande and Patil (1989)
			45	1.62 to 95.82	-	0.026 to 58.03	Munshi and Sirohi (1993)
			28	4.35 to 64.28	-	-	Khattra *et al*. (1994)
			10	0.47 to 54.00	0.47 to 54.00	1.63 to 55.86	Celine and Sirohi (1996)
			28	0.81 to 2.00	-	-	Singh *et al*. (1997)

Table 1. Continued…

Sl. No.	Character	Crop	Number of hybrids	Heterosis over			References
				Better parent	Best parent	Commercial check	
	Fruit yield per vine	Bitter gourd	24	-66.67 to 30.61	-	-	Ram *et al*. (1997)
			21	25.85 to 200.00	38.13 to 100.00	-	Singh *et al*. (2000)
			30	4.85 to 95.31	-	-	Singh *et al*. (2001)
		Bottle gourd	39	-	1.68 to 13.80	-	Kumar *et al*. (1999)
			36	3.11 to 91.02	1.86 to 89.47	-	Dubey and Maurya (2003)
			15	-30.05 to 59.73	-44.39 to 43.82	-	Pandey *et al*. (2004)
12.	Fruit shape index	Muskmelon	15	-38.96 to 39.45	-	-27.47 to 109.34	Vishwanatha (2003)
		Pumpkin	45	1.57 to 76.93	2.16 to 21.46	-	Sirohi *et al*. (1985)
			36	0.22 to 65.16	2.08 to 5.43	-	Sirohi (1994)
			21	14.50 to 151.40	-	-	Doijode *et al*. (1982)
13.	Rind thickness	Muskmelon	15	-	13.33	-	Thomas *et al*. (1984)
14.	Flesh thickness	Muskmelon	20	1.64 to 17.57	-	-	More and Seshadri (1980)
			15	-	12.84	-	Thomas *et al*. (1984)
			60	-	-	-26.80 to 5.20	Dhaliwal and Lal (1996)
			15	0.10 to 6.03	3.50 to 6.03	-	Munshi and Verma (1997)
			28	17.37 to 20.33	-	2.97 to 7.81	Choudhary *et al*. (2003a)
			15	-18.84 to 64.92	-	5.00 to 144.60	Vishwanatha (2003)
		Bitter gourd	28	2.94 to 26.63	-	-	Sirohi and Choudhury (1978)
			45	1.45 to 20.16	1.45 to 18.55	-	Munshi and Sirohi (1993)

Table 1. Continued…

Sl. No.	Character	Crop	Number of hybrids	Heterosis over			References
				Better parent	Best parent	Commercial check	
	Flesh thickness	Bitter gourd	10	6.13 to 16.26	1.47 to 6.27	6.13 to 11.16	Celine and Sirohi (1996)
			15	0.10 to 6.03	3.50 to 6.03	-	Munshi and Verma (1997)
		Pumpkin	45	0.68 to 28.64	2.55 to 19.35	-	Sirohi *et al*. (1985)
			36	0.38 to 20.87	1.71 to 5.14	-	Sirohi (1994)
			36	0.90 to 48.40	-	-	Mohanty and Mishra (1999)
			18	-28.75 to 73.40	-62.11 to 26.28	-3.28 to 247.36	Durgaprasad (2005)
15.	Cavity length	Muskmelon	30	-12.50	-12.30	-	Dixit and Kalloo (1983)
			15	-58.98 to 38.88	-	-50.08 to 95.65	Vishwanatha (2003)
		Pumpkin	18	-100.00 to 331.65	-100.00 to 347.52	-100.00 to 16.18	Durgaprasad (2005)
16.	Cavity width	Muskmelon	30	-27.90	-9.50	-	Dixit and Kalloo (1983)
			15	-38.18 to 51.51	-	-39.66 to 65.28	Vishwanatha (2003)
		Pumpkin	18	-100.00 to 53.85	-100.00 to 63.17	-100.00 to 13.84	Durgaprasad (2005)
17.	Total soluble solids	Muskmelon	20	1.23 to 52.78	-	-	More and Seshadri (1980)
			12	-	-22.55 to 30.77	-	Lianjie *et al*. (1995)
			60	-	-	-23.30 to 1.80	Dhaliwal and Lal (1996)
			15	0.55 to 5.02	-	-	Munshi and Verma (1997)
			28	14.35 to 16.24	-	-4.72 to -3.15	Choudhary *et al*. (2003a)
			15	-38.07 to 9.86	-	-45.27 to 20.85	Vishwanatha (2003)
		Watermelon	30	-25.57 to 20.04	-	-	Nandpuri *et al*. (1974)
			15	-12.89 to 22.18	-	-	Pratapreddy *et al*. (1987)

Table 1. Continued…

Sl. No.	Character	Crop	Number of hybrids	Heterosis over			References
				Better parent	Best parent	Commercial check	
	Total soluble solids	Pumpkin	28	1.38	18.18	-	Sirohi and Yayasani (2001)
			18	-19.15 to 30.77	-33.78 to 16.66	-21.40 to 38.48	Durgaprasad (2005)
18.	Sugar content	Muskmelon	15	-38.46 to 21.60	-	-40.25 to 20.75	Vishwanatha (2003)
			28	1.67 to 10.42	0.92 to 8.23	20.16 to 28.83	Moon *et al*. (2006)
		Pumpkin	18	-39.45 to 20.64	-52.13 to 23.27	-53.05 to 20.90	Durgaprasad (2005)
19.	β-carotene content	Muskmelon	28	2.84 to 141.82	49.23 to 55.23	30.50 to 35.75	Moon *et al*. (2006)
		Pumpkin	28	1.09 to 37.65	3.07 to 26.15	-	Sirohi and Yayasani (2001)
			18	-26.42 to 15.09	-41.09 to 12.32	-9.09 to 73.36	Durgaprasad (2005)

2.2 COMBINING ABILITY

The combining ability concept was first proposed by Spargue and Tatum (1942) in corn. The concept is useful in selection of parents, for production of superior hybrids. It is also helpful in measuring hybrid performance and to compare the performance of lines in hybrid combinations. The selection of suitable parents is one of the most important steps in hybridisation programme. Selection of parents on the basis of phenotypic performance alone is not valid, since phenotypically superior lines may not lead to expected degree of heterosis. Therefore, selection of potential parents, based on genetic information and knowledge of their combining ability is important. Combining ability is useful in providing information on gene action which is of great value to the vegetable breeder in adopting the appropriate breeding method. According to Spargue and Tatum (1942), the general combining ability is the comparative ability of the line to combine with other lines. It is the deviation of the mean performance of all the crosses involving a parent from overall mean. Specific combining ability is defined as the deviation in the performance of specific cross from the performance expected on the basis of general combining ability effects (gca) of parents involved in the crosses. A positive general combining ability indicates a parent that produces above average progeny, whereas parent with negative gca produces progeny that performs below average of population. Specific combining ability effects (sca) can be either negative or positive and sca always refers to specific cross.

The general and specific combining ability effects and variances obtained from a set of hybrids would enable a breeder to select desirable parents and crosses for each of the quantitative components separately. The general combining ability is largely the result of additive gene action, while the specific combining ability is the result of the dominance, epistasis and genotype environment interaction.

The most commonly used designs for combining ability studies is line x tester technique given by Kempthorne (1957) and Arunachalam (1974). Review of literature on combining ability and gene action in muskmelon and other cucurbits is presented in tabular form as under (Table 2).

Table 2. Review of literature on combining ability and gene action in muskmelon and other cucurbits

Sl. No.	Character	Crop	Material and methods used	Combining ability variance		Gene action		References
				GCA	SCA	Additive	Non-additive	
1.	Vine length	Muskmelon	8 x 8 HD		Highly significant	-	+	Kalloo *et al*. (1990)
			11 x 11 HD	Significant	Significant	+	+	Gurav *et al*. (2000)
		Cucumber	6 x 4 L x T	Significant		-	+	Krishnaprasad and Singh (1992)
			6 x 6 HD		Significant	-	+	Krishnaprasad and Singh (1994)
			8 x 8 HD	Highly significant		+	-	Bairagi *et al*. (2001)
			6 x 6 HD	Significant		+	-	Krishnaprasad *et al*. (2004)
			6 x 6 HD	Highly significant	Highly significant	+	+	Nehe *et al*. (2007)
		Bitter gourd	11 x 11 HD	Significant	Significant	+	+	Choudhari and Kale (1991)
			10 x 3 L x T	Highly significant	Significant	+	+	Khattra *et al*. (2000)
			8 x 8 FD	Highly significant	Highly significant	+	+	Sundaram (2008)
		Bottle gourd	10 x 10 HD	Highly significant		+	-	Janakiram and Sirohi (1988)
			13 x 3 L x T		Highly significant	-	+	Kumar and Singh (1997)
			13 x 3 L x T	Highly significant	Highly significant	+	+	Sharma *et al*. (2002)
			10 x 3 L x T	Significant		+	-	Maurya *et al*. (2004)

FD = Full diallel HD = Half diallel L x T = Line x tester '+' = Predominant '-' = Not predominant

Table 2. Continued…

Sl. No.	Character	Crop	Material and methods used	Combining ability variance		Gene action		References
				GCA	SCA	Additive	Non-additive	
	Vine length	Bottle gourd	9 x 9 HD	Significant	Significant	+	+	Dubey and Maurya (2006)
		Ridge gourd	10 x 10 HD	Significant	Significant	+	+	Shaha *et al*. (1999)
		Pumpkin	8 x 8 HD	Highly significant	Highly significant	+	+	Mohanty (2002)
			6 x 3 L x T	Significant	Significant	+	+	Durgaprasad (2005)
2.	Number of branches per vine	Muskmelon	11 x 11 HD	Significant	Significant	+	+	Gurav *et al*. (2000)
		Cucumber	8 x 8 HD	Highly significant	Highly significant	+	+	Bairagi *et al*. (2001)
		Bitter gourd	5 x 5 HD	Highly significant		+	-	Singh and Joshi (1980)
			8 x 8 HD	Highly significant	Highly significant	+	+	Kharitra *et al*. (1994)
			9 x 9 HD	Highly significant	Highly significant	+	+	Mishra *et al*. (1993)
			8 x 8 FD	Highly significant	Highly significant	+	+	Sundaram (2008)
		Bottle gourd	13 x 3 L x T		Highly significant	-	+	Kumar *et al*. (1997)
			13 x 3 L x T	Highly significant	Highly significant	+	+	Sharma *et al*. (2002)

FD = Full diallel HD = Half diallel L x T = Line x tester '+' = Predominant '-' = Not predominant

Table 2. Continued…

Sl. No.	Character	Crop	Material and methods used	Combining ability variance		Gene action		References
				GCA	SCA	Additive	Non-additive	
	Number of branches per vine	Bottle gourd	9 x 9 HD	Highly significant	Highly significant	+	+	Dubey and Maurya (2003)
		Ridge gourd	10 x 10 HD	Significant		+	-	Shaha *et al*. (1999)
		Pumpkin	8 x 8 HD	Highly significant		+	-	Mohanty (2002)
			6 x 3 L x T	Significant	Significant	+	+	Durgaprasad (2005)
3.	Number of leaves	Ridge gourd	6 x 6 HD	Significant	Highly significant	+	+	Kantharaj (2003)
4.	Days to first flowering	Muskmelon	3 x 20 L x T	Highly significant	Highly significant	+	+	Dhaliwal and Lal (1996)
		Pumpkin	8 x 8 HD	Significant	Significant	+	+	Mohanty (1999)
			8 x 8 HD	Significant	Significant	+	+	Mohanty and Mishra (2000)
			8 x 8 HD	Highly significant	Highly significant	+	+	Mohanty (2001a)
			6 x 3 L x T	Highly significant	Highly significant	+	+	Durgaprasad (2005)
		Bottle gourd	10 x 3 L x T		Significant	-	+	Maurya *et al*. (2004)
5.	Days to first female flowering	Muskmelon	3 x 20 L x T	Highly significant	Highly significant	+	+	Dhaliwal and Lal (1996)
		Cucumber	6 x 6 HD	Significant		+	-	Krishnaprasad and Singh (1994)
			10 x 10 HD	Highly significant	Highly significant	+	+	Singh *et al*. (1998)

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Table 2. Continued…

Sl. No.	Character	Crop	Material and methods used	Combining ability variance		Gene action		References
				GCA	SCA	Additive	Non-additive	
	Days to first female flowering	Cucumber	8 x 8 HD	Significant	Significant	+	+	Kumbhar *et al*. (2005)
			6 x 6 HD	Highly significant	Highly significant	+	+	Nehe *et al*. (2007)
		Watermelon	4 x 10 L x T	Highly significant		+	-	Gill and Kumar (1988)
		Bitter gourd	11 x 11 HD	Significant	Significant	+	+	Chaudhuri and Kale (1991)
			8 x 8 HD	Highly significant	Highly significant	+	+	Kharitra *et al*. (1994)
			8 x 8 HD	Significant	Significant	+	+	Singh *et al*. (2004)
			8 x 8 FD	Significant	Significant	+	+	Sundaram (2008)
		Bottle gourd	10 x 10 HD	Significant	Highly significant	+	+	Janakiram and Sirohi (1988)
			7 x 7 HD		Significant	-	+	Singh *et al*. (1995)
			13 x 3 L x T	Significant	Significant	+	+	Sharma *et al*. (2002)
			9 x 9 HD	Highly significant	Highly significant	+	+	Dubey and Maurya (2003)
			6 x 6 HD	Highly significant	Highly significant	+	+	Pandey *et al*. (2004)
			10 x 3 L x T	Significant		+	-	Maurya *et al*. (2004)
		Ridge gourd	10 x 10 HD	Significant	Significant	+	+	Shaha *et al*. (1999)
		Pumpkin	8 x 8 HD	Significant	Significant	+	+	Mohanty and Mishra (2000)

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Table 2. Continued…

Sl. No.	Character	Crop	Material and methods used	Combining ability variance		Gene action		References
				GCA	SCA	Additive	Non-additive	
	Days to first female flowering	Pumpkin	8 x 8 HD	Significant	Significant	+	+	Mohanty (2001b)
			6 x 3 L x T	Significant	Significant	+	+	Durgaprasad (2005)
6.	Number of nodes upto first female flower	Muskmelon	3 x 20 L x T	Highly significant	Highly significant	+	+	Dhaliwal and Lal (1996)
		Cucumber	7 x 7 HD	Highly significant	Highly significant	+	+	Musmade and Kale (1986)
			10 x 10 HD	Highly significant	Highly significant	+	-	Singh *et al*. (1998)
			8 x 8 HD	Highly significant	Highly significant	+	-	Bairagi *et al*. (2001)
		Bitter gourd	8 x 8 HD	Significant	Significant	+	+	Singh *et al*. (2004)
			8 x 8 FD	Significant	Significant	+	+	Sundaram (2008)
		Bottle gourd	10 x 3 L x T	Highly significant		+	-	Sharma *et al*. (2002)
			10 x 3 L x T	Highly significant		+	-	Maurya *et al*. (2004)
			9 x 9 HD	Highly significant	Highly significant	+	+	Dubey and Maurya (2006)
7.	Days to first harvest	Muskmelon	2 x 15 L x T	Significant	Significant	+	+	More and Seshadri (1980)
			4 x 14 L x T	Highly significant	Highly significant	+	+	Kesavan and More (1991)

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Table 2. Continued…

Sl. No.	Character	Crop	Material and methods used	Combining ability variance		Gene action		References
				GCA	SCA	Additive	Non-additive	
	Days to first harvest	Muskmelon	3 x 20 L x T	Significant	Significant	+	+	Dhaliwal and Lal (1996)
		Cucumber	8 x 8 HD	Significant	Significant	+	+	Kumbhar *et al*. (2005)
			6 x 6 HD	Significant	Significant	+	+	Munshi *et al*. (2006)
			6 x 6 HD	Highly significant	Highly significant	+	+	Nehe *et al*. (2007)
		Watermelon	7 x 7 HD	Significant	Significant	+	+	Brar and Sidhu (1977)
		Bitter gourd	11 x 11 HD	Highly significant	Highly significant	+	+	Chaudhari and Kale (1991)
		Bottle gourd	10 x 10 HD	Significant	Significant	+	+	Janakiram and Sirohi (1988)
			13 x 3 L x T		Significant	-	+	Kumar and Singh (1997)
			13 x 3 L x T	Significant	Significant	+	+	Sharma *et al*. (2002)
			6 x 6 HD	Highly significant	Highly significant	+	+	Pandey *et al*. (2004)
			9 x 9 HD	Highly significant	Highly significant	+	+	Dubey and Maurya (2006)
8.	Number of fruits per vine	Muskmelon	2 x 15 L x T	Significant	Significant	+	+	More and Seshadri (1980)
			8 x 8 HD	Highly significant	Highly significant	+	+	Kalloo *et al*. (1990)
			3 x 20 L x T	Significant	Significant	+	+	Dhaliwal and Lal (1996)

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Table 2. Continued…

Sl. No.	Character	Crop	Material and methods used	Combining ability variance		Gene action		References
				GCA	SCA	Additive	Non-additive	
			6 x 6 HD	Highly significant	Highly significant	+	+	Munshi and Verma (1999)
			11 x 11 HD	Significant	Significant	+	+	Gurav *et al*. (2000)
		Cucumber	7 x 7 HD	Highly significant	Highly significant	+	+	Musmade and Kale (1986)
			6 x 6 HD	Highly significant		+	+	Krishnaprasad and Singh (1994)
			10 x 10 HD	Highly significant	Highly significant	+	-	Singh *et al*. (1998)
			7 x 3 L x T	Significant		+	-	Verma *et al*. (2000)
			6 x 6 HD	Highly significant	Highly significant	+	+	Munshi *et al*. (2006)
			6 x 6 HD	Highly significant	Highly significant	+	+	Nehe *et al*. (2007)
		Bitter gourd	10 x 10 HD	Highly significant	Highly significant	+	+	Matoria and Khandelwal (1999)
			10 x 3 L x T	Highly significant	Highly significant	+	+	Khattra *et al*. (2000)
			8 x 8 HD	Significant	Significant	+	+	Singh *et al*. (2004)
			8 x 8 FD	Highly significant	Highly significant	+	+	Sundaram (2008)
		Ridge gourd	10 x 10 HD	Significant	Significant	+	+	Hedau and Sirohi (2004)

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Table 2. Continued…

Sl. No.	Character	Crop	Material and methods used	Combining ability variance		Gene action		References
				GCA	SCA	Additive	Non-additive	
9.	Average fruit weight	Muskmelon	10 x 10 HD	Significant	Significant	+	+	Lippert and Legg (1972b)
			2 x 15 L x T	Significant	Significant	+	+	More and Seshadri (1980)
			8 x 8 HD		Significant	-	+	Kalloo *et al*. (1990)
			3 x 20 L x T	Significant	Significant	+	+	Dhaliwal and Lal (1996)
			6 x 6 HD	Highly significant	Highly significant	+	+	Munshi and Verma (1999)
			11 x 11 HD	Significant	Significant	+	+	Gurav *et al*. (2000)
		Cucumber	10 x 10 HD	Highly significant	Highly significant	+	+	Singh *et al*. (1998)
			8 x 8 HD	Significant	Significant	+	+	Kumbhar *et al*. (2005)
			6 x 6 HD	Highly significant	Highly significant	+	+	Nehe *et al*. (2007)
		Bitter gourd	11 x 11 HD	Highly significant	Highly significant	+	+	Lawande and Patil (1990)
		Bottle gourd	13 x 3 L x T	Significant	Significant	+	+	Kumar and Singh (1997)
			9 x 9 HD	Significant	Significant	+	+	Dubey and Maurya (2006)
		Ridge gourd	10 x 10 HD	Highly significant	Highly significant	+	+	Hedau and Sirohi (2004)
10.	Fruit yield per vine	Muskmelon	2 x 15 L x T		Highly significant	-	+	More and Seshadri (1980)

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Table 2. Continued…

Sl. No.	Character	Crop	Material and methods used	Combining ability variance		Gene action		References
				GCA	SCA	Additive	Non-additive	
	Fruit yield per vine	Muskmelon	8 x 8 HD	Highly significant	Highly significant	+	+	Kalloo *et al*. (1990)
			6 x 6 HD	Highly significant	Highly significant	+	+	Munshi and Verma (1999)
			11 x 11 HD	Significant	Significant	+	+	Gurav *et al*. (2000)
		Cucumber	7 x 7 HD	Highly significant	Highly significant	+	+	Musmade and Kale (1986)
			6 x 6 HD	Highly significant	Significant	+	+	Krishnaprasad and Singh (1994)
			10 x 10 HD	Highly significant	Highly significant	+	-	Singh *et al*. (1998)
			7 x 3 L x T	Significant	Significant	-	+	Verma *et al*. (2000)
			6 x 6 HD	Highly significant	Highly significant	+	+	Munshi *et al*. (2006)
			6 x 6 HD	Highly significant	Highly significant	+	+	Nehe *et al*. (2007)
		Bitter gourd	11 x 11 HD	Highly significant	Highly significant	+	+	Lawande and Patil (1990)
			8 x 8 HD	Highly significant		+	-	Singh *et al*. (2004)
		Bottle gourd	10 x 10 HD	Highly significant	Significant	+	+	Janakiram and Sirohi (1988)

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Table 2. Continued…

Sl. No.	Character	Crop	Material and methods used	Combining ability variance		Gene action		References
				GCA	SCA	Additive	Non-additive	
	Fruit yield per vine	Bottle gourd	13 x 3 L x T	Significant	Significant	+	+	Kumar and Singh (1997)
			9 x 9 HD	Significant	Significant	+	+	Samadia and Khandelwal (2002)
			6 x 6 HD	Highly significant	Highly significant	+	+	Pandey *et al*. (2004)
11.	Fruit shape index	Muskmelon	10 x 10 HD	Highly significant	Highly significant	+	+	Lippert and Legg (1972a)
			6 x 6 FD	Significant	Significant	+	+	Thomas *et al*. (1984)
			8 x 8 HD	Highly significant	Highly significant	+	+	Kalloo *et al*. (1990)
		Pumpkin	10 x 10 HD	Highly significant	Highly significant	+	+	Sirohi *et al*. (1986)
12.	Rind thickness	Muskmelon	10 x 10 HD	Highly significant	Highly significant	+	+	Lippert and Legg (1972a)
			6 x 6 FD	Significant	Significant	+	+	Thomas *et al*. (1984)
13.	Flesh thickness	Muskmelon	10 x 10 HD	Highly significant	Highly significant	+	+	Lippert and Legg (1972a)
			2 x 15 L x T	Significant	Significant	+	+	More and Seshadri (1980)
			6 x 6 FD	Significant	Significant	+	+	Thomas *et al*. (1984)
			3 x 20 L x T	Significant	Significant	+	+	Dhaliwal and Lal (1996)
			6 x 6 HD	High		+	-	Munshi and Verma (1999)
14.	Cavity length	Muskmelon	8 x 8 HD	Significant	Significant	+	+	Kalloo *et al*. (1990)

FD = Full diallel HD = Half diallel L x T = Line x tester '+' = Predominant '-' = Not predominant

Table 2. Continued…

Sl. No.	Character	Crop	Material and methods used	Combining ability variance		Gene action		References
				GCA	SCA	Additive	Non-additive	
15.	Cavity breadth	Muskmelon	8 x 8 HD	Significant	Significant	+	+	Kalloo *et al*. (1990)
16.	Total soluble solids	Muskmelon	3 x 20 L x T	Significant	Significant	+	+	Dhaliwal and Lal (1996)
			6 x 6 HD	Highly significant		+	-	Munshi and Verma (1999)
17.	Sugar content	Pumpkin	6 x 3 L x T	Significant	Significant	+	+	Durgaprasad (2005)
18.	β-carotene content	Pumpkin	6 x 3 L x T	Significant	Significant	+	+	Durgaprasad (2005)
		Tomato	-			-	+	Amaral *et al*. (1997)
			15 x 3 L x T	Significant	Significant	+	+	Mahendrakar (2004)

FD = Full diallel HD = Half diallel L x T = Line x tester '+' = Predominant '-' = Not predominant

2.3 CORRELATION

The expression of a character is the consequence of a chain of inter-relationships between characters either directly or through other events. For a successful improvement programme, it is extremely important to study the inter-relationships among various characters. As most of the traits of economic importance in crop plants depend upon one or the other traits, the degree of expression of one character increases or decreases with corresponding change in the other character. Thus, plant breeder has to consider more than one character for improving a complex character like yield which is the function of several growth and yield traits. Therefore, it is improvement to know the association between yield and its components as it would provide valuable information about the correlated response to selection. The literature on association of growth and yield parameters with yield in muskmelon has been reviewed and presented hereunder:

Vijay (1987) observed positive and significant correlation of yield per vine with number of fruits per vine, fruit weight, TSS, flesh thickness and days to flowering. Number of fruits per vine had positive and significant correlation with fruit weight, flesh thickness and days to flowering. However, number of fruits per vine had negative and significant association with days to fruit maturity. Fruit weight exhibited positive and significant association with TSS, flesh thickness, vine length and days to flowering. TSS had significant and positive correlation with flesh thickness and days to flowering and it had negative and significant association with days to fruit maturity. Flesh thickness had positive and significant association with vine length and days to flowering, whereas days to flowering showed negatively significant association with days to fruit maturity. Somkuwar *et al*. (1997) observed highly significant correlation between total yield per plant and number of fruits per plant and average fruit weight in muskmelon.

Ramesh and Hariharram (2002) noted positive correlation of fruit weight with fruit polar diameter, fruit equatorial diameter, flesh thickness, seed cavity size, flesh weight and seed weight in muskmelon.

Yield per plant had significant and positive correlation with fruit weight, fruits per plant, harvest duration, rind thickness, shelf life and vine length (Choudhary *et al*., 2003b). Singh and Lal (2005) observed significant and positive correlation between marketable yield and other traits, *viz*., fruit weight, flesh thickness and vine length. These characters also exhibited positive and high direct effects on yield. The number of fruits per vine exerted a negative and indirect effects on yield through fruit weight.

Tomar *et al*. (2008) observed positively significant correlation between fruit yield and fruit weight, fruit girth, flesh thickness, fruits per plant and total soluble solids in muskmelon. Khanna *et al*. (1989) noted high positive and significant correlation between total soluble solids and vitamin C content in muskmelon. Taha *et al*. (2003) observed positively significant correlation between fruit weight and plant length and also noted the positively significant correlation between netting development, total soluble solids and number of branches in muskmelon.

Dhiman and Prakash (2005) observed that the fruit yield exhibited positive and significant correlation with total number of fruits per plot and fruit girth. Fruit length showed positive and significant association with fruit index, while fruit girth exhibited negative and significant association with fruit index in cucumber.

Yield per vine exhibited negative and significant correlation with number of days to first female flower, number of fruits per vine, average fruit weight and rind thickness in watermelon (Singh and Singh, 1988). Rolania *et al*. (2003) observed that the fruit yield had positively significant correlation with main vine length, number of primary branches per plant, inter-nodal length, number of nodes per plant, number of female flowers per plant and number of fruits per plant in watermelon.

Borthakur and Baruah (2006) observed that yield per plant was positively and significantly correlated with main creeper length, number of primary branches per plant, number of leaves per plant, length of the fruit, breadth of the fruit and number of fruits per plant in bitter gourd.

Yadav *et al*. (2006) observed that fruit weight had positive and significant correlation with fruit polar and equatorial diameter and flesh thickness in pumpkin.

3. MATERIAL AND METHODS

The investigation on combining ability and heterosis in muskmelon (*Cucumis melo* L.) was undertaken during the year 2007. The details of the experiments, materials used and techniques adopted in the present investigation are presented in this chapter.

3.1 EXPERIMENTAL SITE

The experiment was carried out in fields of Department of Vegetable Science of Kittur Rani Channamma College of Horticulture, Arabhavi, Belgaum district (Karnataka). The soils of the experimental site comprised of red sandy loam. The chemical properties of the soil are presented in Appendix I.

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 at an altitude of 640 meters above the mean sea level. Arabhavi comes under zone 3 of region 2 among the agro-climatic zones of Karnataka. It has benefits of both South-West and North-East monsoons.

The average rainfall of this area is about 566 mm distributed over a period of five to six months with peaks during September. The command area receives water from Ghataprabha Left Bank Canal from mid-July to mid-march. The meteorological data recorded during experimenting period at meteorological observatory of the Agricultural Research Station, Arabhavi is presented in Appendix II.

3.3 DETAILS OF EXPERIMENT

The experimental plots were ploughed repeatedly and land was brought to fine tilth. Ridges and furrows were opened at a distance of two meters apart. Two to three seeds of each genotype per hill were dibbled at a distance of one meter in a row. The plants were thinned to one seedling per hill after germination. About 25 tonnes of FYM and the 50 per cent recommended dose of nitrogen (50 kg/ha) and full dose of phosphorus (75 kg/ha) and potassium (50 kg/ha) were incorporated in the furrows and mixed in the soil. The remaining 50 per cent of nitrogen (50 kg/ha) was applied as a top dress on 30th day after sowing. Irrigation, weed control and other cultural practices were followed as per the package of practices of horticultural crops of University of Agricultural Sciences, Dharwad (Anon., 2006b). The vines were allowed to trail on the ground itself. Salient features of genotypes used for the experiment are presented in Table 3.

Table 3. Salient features of the parents

Sl. No.	Genotype	Accession number / name	Fruit shape	Fruit size	Fruit colour	Flesh colour
	Lines					
1.	KM-1	IC 203072	Globular	Medium	Stripped and greenish yellow	Orange
2.	KM-2	IC 203073	Ovate	Small	Stripped and yellow	Green
3.	KM-3	IC 203079	Flattened	Big	Stripped and yellow	Light orange
4.	KM-4	Gokak Local-2	Obvate	Small	Yellow	Green
5.	KM-5	Gujrat Local	Globular	Medium	Blotchy and brown	Green
6.	KM-6	Haryana Local	Obvate	Medium	Orange	Yellow
7.	KM-7	Kurnool Local-1	Globular	Medium	Orange	Orange
8.	KM-8	Kajri	Flattened	Small	Green	Green
	Testers					
1.	AR	Arka Rajhans	Oval	Medium	Creamy white	White
2.	HM	Hara Madhu	Globose	Medium	Dark green stripes and yellow	Light green
3.	PS	Punjab Sunheri	Globular	Medium	Green	Light green

3.3.1 Selection of parents for hybridisation

The entries under the investigation comprises of eight lines and three testers from germplasm collection (Table 3). The genotypes were selected on the basis of *per se* performance for yield and quality attributes. Three testers with broad genetic base were chosen for crossing with lines.

3.3.2 Hybridisation programme

Seeds of male and female parents were sown during January 2007 for development of F_1 hybrids in line x texter fashion. A total of 24 hybrids were developed by crossing eight female parents (lines) with each of three male parents (testers). Flower buds of male and female parents were selected on the previous evening prior to the day of their opening and the selected buds were covered with butter paper bags to avoid out-crossing and contamination. Pollination was carried out on the next day morning between 5.30 am and 8.00 am by using pollens of desired male parents. After pollination, the female flower buds were again covered with butter paper bags to avoid contamination and tagged with the details of male parent and date of pollination. Simultaneously, the male and female parents were selfed and bagged with butter paper bags. Crossed and selfed fruits were harvested separately at full maturity stage. The seeds were extracted from fully ripe fruits and dried under shade and preserved in butter paper bags labelled with the details of cross or entry number.

3.3.3 Experiment: Evaluation of F_1 hybrids and parents along with standard check

Number of lines : 08

Number of testers : 03

Number of hybrids : 24

Standard check : Rasik (Ankur Seeds company)

Total number of genotypes : 36

Replications : 02

Design : Randomised block design

Number of plants per genotype

per replication : 10

Plot size : 1,728 m^2

Seeds of males, females, crosses and commercial check were sown during August 2007 for evaluation in randomised block design. Sowing was done in rows of two meters apart at a spacing of one meter between plants. A total of 36 genotypes comprising one standard check, 24 hybrids, eight female parents (lines) and male parents (testers) were evaluated. General view of the experimental plot is presented in Plate 1 and fruits of parents and commercial check used in the experiment are presented in Plate 2. Cultural practices were followed as per the package of practices of horticultural crops of University of Agricultural Sciences, Dharwad.

3.4 OBSERVATIONS RECORDED

Five randomly chosen plants in each replication of each entry were labelled and used for recording all observations except earliness parameters. The mean of five plants was taken for analysis. The characters studied and techniques adopted to record the observations are given below.

3.4.1 Growth paremeters

3.4.1.1 Vine length (cm)

The length of the vine was measured from ground level to the tip of the vine 30, 60 and 90 days after sowing (DAS).

3.4.1.2 Number of branches per vine

Number of branches per vine was recorded at 30 and 60 DAS.

3.4.1.3 Number of leaves

Number of leaves per vine was recorded at 30 and 60 DAS.

3.4.2 Earliness parameters

3.4.2.1 Days to first flowering

Number of days taken from the date of sowing to the day of first flower opening was recorded.

3.4.2.2 Days to first female flowering

Number of days taken from the date of sowing to the date of first female flower opening was recorded.

3.4.2.3 Number of nodes upto first female flower

Number of nodes from ground to the node at which first female flower appeared was recorded.

Plate 1. General view of the experimental plot

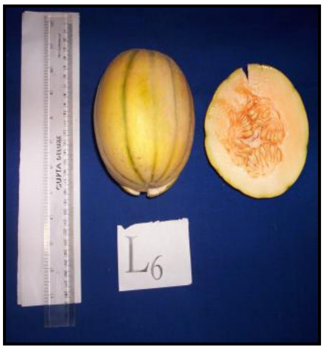
KM-1

KM-2

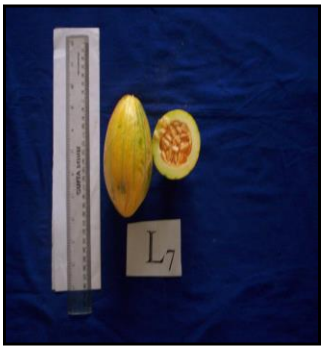
KM-3

KM-4

KM-5

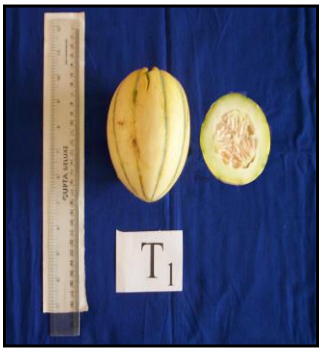


KM-6



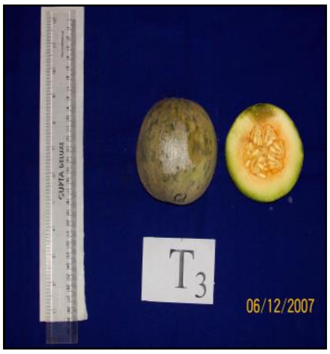
KM-7

KM-8

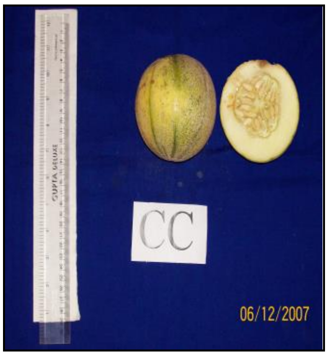


AR

HM



PS



COMMERCIAL CHECK (RASIK)

Plate 2. Fruit Characters of Parents and Commercial Check

3.4.2.4 Days to first harvest

Number of days taken for first harvesting from the date of sowing was recorded.

3.4.3 Yield and yield parameters

3.4.3.1 Number of fruiting branches per vine

Total number of fruiting branches originated from primary branches in the tagged plants were counted and the average was computed.

3.4.3.2 Number of fruits per vine

Number of fruits per vine was calculated by totalling the number of fruits harvested over all pickings and average number of fruits per plant was worked out.

3.4.3.3 Average fruit weight (g)

At third picking, ten fruits were randomly selected from each experimental plot and average fruit weight was calculated by adding the weight of fruits and divided by total number of fruits and expressed as grams per fruit.

3.4.3.4 Fruit yield per vine (kg/vine)

Total weight of fruits harvested from five tagged plants of all the harvests were added and average yield per plant was worked out and expressed in kilograms per vine.

3.4.4 Fruit quality parameters

The following observations were recorded on the five randomly selected fruits of marketable stage from each experimental plot.

3.4.4.1 Fruit shape index

Fruit shape index was obtained as a ratio by dividing longitudinal (polar) diameter by cross (equatorial) diameter (Davis *et al.*, 1964).

3.4.4.2 Flesh thickness (cm)

Randomly selected five matured fruits from each experimental plot were halved by cutting in the middle and the flesh thickness of the fruit was recorded in centimetres with the help of scale and average of five fruits was calculated.

3.4.4.3 Rind thickness (cm)

Randomly selected five matured fruits from each experimental plots were halved by cutting in the middle and rind thickness was recorded from skin of the fruit upto flesh. Rind thickness was recorded in centimetres with the help of scale and the average of five fruits was calculated.

3.4.4.4 Cavity length (cm)

Randomly selected five matured fruits from each experimental plot were halved by cutting longitudinally and length of cavity of the fruits was recorded in centimters with the help of scale and the average of five fruits was calculated.

3.4.4.5 Cavity breadth (cm)

Randomly selected five matured fruits from each experimental plot were halved by cutting horizontally and breadth of cavity was recorded in centimetres with the help of scale and the average of five fruits was calculated.

3.4.4.6 Total soluble solids (°Brix)

Total soluble solids of the juice from the flesh at the equatorial region was recorded with the help of hand refractometer and expressed in percentage.

3.4.4.7 Total sugars (%)

Extraction of sugars from flesh sample was carried out by crushing with 80 per cent ethanol. Saturated lead acetate and saturated disodium hydrogen phosphate were added to sample and centrifuged. After centrifugation, the clear supernatant was collected. For estimation of total sugars, the non-reducing sugars present in extract were hydrolysed first. This was done by adding hydrochloric acid. When non-reducing sugars were hydrolysed, the extract was cooled and pH of this was neutralised by adding NaOH solution. Extract was made upto known volume by distilled water. One ml, 3 ml and 5 ml aliquots were taken from the supernatant in three test tubes. To this, 5 ml of Somogyi's reagent was added and volume was made upto 15 ml by adding distilled water. The test tubes were heated in boiling water bath for few minutes and cooled. The tubes in which the solution had red precipitate were discarded. One ml of 2.5 per cent potassium iodide and 3 ml of 1.5 N sulphuric acid were added to each test tubes and shaken well till the golden yellow colour is formed. A blank solution was prepared by mixing 5 ml of Somogyi's reagent and 10 ml of distilled water. Blank solution was boiled in water bath and cooled. To this, one ml of 2.5 per cent potassium iodide and 3 ml of 1.5 N sulphuric acid were added. Starch was added as indicator in sample solutions and blank solution. The sample solutions and blank solution were titrated using 0.005 N sodium thiosulphate solution and end point was determined (Mazumdar and Majumder, 2003).

One millilitre of 0.005 N sodium thiosulphate solution is equivalent to 0.135 mg of 0.000135 g of hexose. Therefore percentage of total sugars was calculated as follows:

$$\begin{array}{c}\text{Per cent}\\ \text{total sugars}\end{array} = \frac{\begin{array}{c}0.000135 \text{ x volume made}\\ \text{with distilled water}\end{array} \text{ x } \begin{array}{c}\text{Non - reacter thiosulphate [(buretted reading}\\ \text{for blank) - (burette reading for sample)]}\end{array}}{\text{Weight of sample x volume of aliquot taken for estimation}} \text{ x } 100$$

3.4.4.8 β-carotene content (µg/100 g)

Carotene content in the fruit pulp was estimated by taking 5 g fresh sample and crushed in 10 to 15 ml acetone, adding few crystals of anhydrous sodium sulphate with the help of pestle and mortar. Supernatant was decanted into breaker. Repeated the process twice and transferred the combined supernatant to separating funnel and added 10 to 15 ml petroleum ether and mixed thoroughly. Two layers formed. Discarded the lower layer and collected upper layer in 100 ml volumetric flask and made up the volume to 100 ml with petroleum ether and recorded optical density at 452 nm against the solvent as blank and β-carotene content was estimated as follows (Srivastava and Kumar, 2002).

$$\begin{array}{c}\beta\text{ - carotene content}\\ (\mu\text{g}/100\text{ g})\end{array} = \frac{\text{OD x } 13.9 \text{ x } 10^4 \text{ x } 100}{\text{Weight of sample (g) x } 560 \text{ x } 100}$$

3.4.4.9 Flesh colour, skin colour and skin netting

These parameters were recorded at marketable maturity stage and presented in Appendices III and IV.

3.4.5 Pest and disease incidence

3.4.5.1 Fruit fly incidence

From each harvest, the number of fruits infested with flies were recorded and values for all the harvests were summed up to get total infested fruit number for each experimental plot. The per cent incidence of fruit fly under natural epiphytotic condition was calculated as under:

$$\text{Per cent fruit fly incidence} = \frac{\text{Number of fruits infested}}{\text{Total number of fruits}} \text{ x } 100$$

3.4.5.2 Incidence of downy mildew

The per cent disease index (PDI) for downy mildew under natural epiphytotic condition was computed by scoring the disease incidence in 0 to 5 scale as under (Pan and More, 1966):

Score	Disease incidence
0	No symptoms
1	Less than 10 isolated spots per leaf
2	10-20 isolated spots per leaf
3	More than 20 spots + patches, more than 30 per cent leaf area affected
4	Necrotic patches, 50 per cent leaf area affected
5	Necrotic patches, more than 50 per cent leaf area affected

$$\text{PDI} = \frac{\text{Total numerical rating}}{\text{Total plants observed x Maximum rating}} \text{ x } 100$$

3.5 STATISTICAL ANALYSIS

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

3.5.1 Heterosis

The mean of all the replications for each parent and hybrid 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 $(\overline{F}_1)$ over the means of better parent $(\overline{BP})$, best parent $(\overline{BTP})$ and the standard check $(\overline{SP})$.

(1) Heterosis over better parent (Heterobeltiosis)

$$= \frac{\overline{F}_1 - \overline{BP}}{\overline{BP}} \text{ x } 100$$

where, $\overline{BP}$ is the mean of superior parent involved in development of respective F_1 and $\overline{F}_1$ is the mean of the F_1.

(2) Heterosis over best parent

$$= \frac{\overline{F}_1 - \overline{BTP}}{\overline{BTP}} \text{ x } 100$$

where, $\overline{BTP}$ is the mean of the best parent identified for the respective trial and $\overline{F}_1$ is the the mean of the F_1 hybrid.

(3) Standard heterosis = $\frac{\overline{F}_1 - \overline{S}\overline{P}}{\overline{S}\overline{P}}$ x 100

where $\overline{S}\overline{P}$ is the mean of standard check and $\overline{F}_1$ is mean of the F_1 hybrid.

3.5.2 Combining ability

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

ANOVA for combining ability

Sources	Degrees of freedom	Mean sum of squares	Expected mean sum of square
Replication	(r - 1)		
Genotype	(*l* + t + *l*t – 1)	Mg	
Parents	(*l* + t – 1)	Mp	
Parents Vs crosses	1	Mpc	
Crosses	(*l*t – 1)	Mc	
Lines	(*l* – 1)	M_1	σ^2 + rCov(F.S.) – 2Cov (F.S.) + lrCov (H.S)
Testers	(t-1)	M_2	σ^2 + rCov(F.S.) – 2Cov(H.S.) + trCov (H.S.)
Line x tester	(*l*-1) x (t-1)	M_3	σ^2 + rCov(F.S.) – 2Cov(H.S.)
Error	(*l* + t + *l*t – 1) (r – 1)	M_4	Σ^2
Total	(*l*tr-1)		

Where, r = number of replications

l = number of lines

t = number of testers

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

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

Estimation of combining ability effects

The model of estimate gca and sca effects of ijk observations is 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 x j cross

e_{ijk} = error associated with observation ijk

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

General combining ability effects

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

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

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 and replications

$x...$ = total of all the crosses over all the replications

g_j = gca of j^{th} testers

$x_{.j.}$ = Total of j^{th} testers over all lines and replications

s_{ij} = sca effects of i x j cross

x_{ij} = Total of cross i x j over all replications

Standard errors of gca and sca effects

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

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

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

3.5.3 Correlation analysis

Simple correlation coefficients were worked out among different growth, yield and quality parameters where n=70 (Panse and Sukhatme, 1957).

Significance of correlation was tested by comparing with critical ‘r’ value. Critical ‘r’ value was obtained using the formula given below:

$$r = \sqrt{\frac{t^2}{t^2 + n - 2}}$$

where, r = critical coefficient value

t = table value at 5 or 1 per cent

n = number of observations used for analysis.

4. EXPERIMENTAL RESULTS

Investigation on heterosis and combining ability was carried out in muskmelon where 24 crosses were developed by crossing three testers with each of the eight lines. All the crosses were evaluated along with parents with the objectives of assessing magnitude of heterosis and identifying good combiners for various traits. The results obtained from the experiments are presented in this chapter.

4.1 ANALYSIS OF VARIANCE

The results of analysis of variance for 23 characters under study are summerised in Table 4 and presented under the following headings as components of variances.

4.1.1 Genotypes

The variance due to genotypes (crosses and parents) was highly significant for all the characters studied, *viz*., vine length at 30, 60 and 90 days after sowing (DAS), number of branches at 30 and 60 DAS, number of leaves at 30 and 60 DAS, days to first flowering, days to first female flowering, number of nodes upto first female flower, days to first harvesting, number of fruiting branches per vine, number of fruits per vine, average fruit weight, fruit yield per vine, fruit shape index, flesh thickness, rind thickness, cavity length, cavity breadth, total soluble solids, total sugars and β-carotene content of the fruit.

4.1.2 Parents

Parents differed significantly (at p=0.01) among themselves for vine length at 30, 60 and 90 DAS, number of branches at 60 DAS, number of leaves at 30 and 60 DAS, days to first flowering, days to first female flowering, number of nodes upto first female flower, days to first harvest, number of fruiting branches per vine, number of fruits per vine, average fruit weight, fruit yield per vine, fruit shape index, flesh thickness, rind thickness, cavity length, cavity breadth, total soluble solids and β-carotene content of the fruit. For total sugars, the variance due to parents was significant only at p=0.05. However, variance due to parents was not significant for number of branches at 30 DAS character.

4.1.3 Parents and crosses

The variance due to parents versus crosses was highly significant for vine length at 30, 60 and 90 DAS, number of branches at 30 and 60 DAS, number of leaves at 30 and 60 DAS, days to first flowering, days to first female flowering, number of nodes upto first female flower, days to first

Table 4. Analysis of variance (mean sum of squares) of line x tester analysis for various characters in muskmelon

Sl. No.	Character	Replica-tions	Genotypes	Parents	Parent Vs. Crosses	Crosses	Line (L)	Tester (T)	L x T	Error
	Degrees of freedom	1	34	10	1	23	7	2	14	34
1.	Vine length at 30 DAS	1.950^{NS}	10.438**	2.536**	197.690**	5.732**	13.173**	6.510^{NS}	1.900**	0.719
2.	Vine length at 60 DAS	1.828^{NS}	1186.760**	1729.425**	15442.090**	331.025**	694.910*	117.250^{NS}	179.616**	2.814
3.	Vine length at 90 DAS	22.857^{NS}	1456.147**	1457.928**	25445.340**	412.364**	1095.792**	236.250^{NS}	95.809**	5.114
4.	Number of branches at 30 DAS	0.108^{NS}	0.530**	0.062^{NS}	5.952**	0.498**	1.077**	0.549^{NS}	0.202^{NS}	0.114
5.	Number of branches at 60 DAS	0.266^{NS}	3.312**	0.998**	54.183**	2.107**	4.977**	0.591^{NS}	0.889**	0.066
6.	Number of leaves at 30 DAS	0.132^{NS}	15.745**	6.387**	202.980**	11.673**	28.476**	3.995^{NS}	4.368**	0.765
7.	Number of leaves at 60 DAS	0.343^{NS}	672.588**	259.640**	4965.531**	665.481**	1662.448**	368.078^{NS}	209.484**	9.459
8.	Days to first flowering	0.407^{NS}	22.918**	22.314**	75.801**	20.881**	57.999**	0.900^{NS}	5.176**	0.536
9.	Days to first female flowering	7.743^{NS}	102.803**	73.042**	173.355**	112.674**	312.023**	15.910^{NS}	26.823**	1.626
10.	Number of nodes upto first female flower	0.826^{NS}	1.944**	1.402**	3.019**	2.133**	4.769**	1.437^{NS}	0.915**	0.200
11.	Days to first harvest	2.400^{NS}	104.437**	44.934**	796.203**	100.231**	200.599*	37.797^{NS}	58.966**	4.718
12.	Number of fruiting branches	6.757**	14.844**	3.655**	320.678**	6.411**	4.596^{NS}	3.171^{NS}	7.782**	0.844
13.	Number of fruits per vine	0.183^{NS}	1.092**	0.729**	4.891**	1.084**	0.566^{NS}	1.809^{NS}	1.240**	0.122
14.	Average fruit weight (g)	1503.086**	89605.353**	16567.650**	147255.500**	118854.406**	55528.190^{NS}	57813.000^{NS}	159237.600**	175.086
15.	Fruit yield per vine (kg)	0.001^{NS}	0.521**	0.359**	0.010^{NS}	0.613**	0.696^{NS}	0.159^{NS}	0.636**	0.002
16.	Fruit shape index	0.003^{NS}	0.070**	0.014**	0.018**	0.097**	0.083^{NS}	0.028^{NS}	0.114**	0.002
17.	Flesh thickness (cm)	0.540^{NS}	0.775**	0.483**	5.426**	0.700**	0.721^{NS}	0.201^{NS}	0.760**	0.062
18.	Rind thickness (cm)	0.004^{NS}	0.017**	0.008**	0.049**	0.019**	0.024^{NS}	0.008^{NS}	0.018**	0.002
19.	Cavity length (cm)	7.277**	4.665**	8.036**	0.314^{NS}	3.388**	6.117^{NS}	1.935^{NS}	2.231**	0.352
20.	Cavity breadth (cm)	0.109^{NS}	3.075**	3.028**	1.716**	3.155**	4.668^{NS}	1.242^{NS}	2.572**	0.038
21.	Total soluble solids	0.304^{NS}	6.798**	1.829**	24.384**	8.193**	14.847^{NS}	4.177^{NS}	5.440**	0.086
22.	Total sugars	2.467**	3.898**	0.834*	4.864**	5.187**	8.564^{NS}	1.535^{NS}	4.020**	0.303
23.	β-carotene content (μg/100 g)	96.914^{NS}	35797.132**	5817.800**	15475.500**	49715.180**	70321.620^{NS}	92946.000^{NS}	33236.120**	272.252

DAS = Days after sowing* and ** indicate significance of values at p=0.05 and p=0.01, respectively.   NS = Non-significant harvest, number of fruiting branches per vine, number of fruits per vine, average fruit weight, fruit shape index, flesh thickness, rind thickness, cavity breadth, total soluble solids, total sugars and β-carotene content of the fruit. However, variance due to parent versus crosses was not significant for fruit yield per vine and cavity length.

4.1.4 Crosses

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

4.1.5 Lines

Lines differed significantly (at p=0.01) among themselves for vine length at 30 and 90 DAS, number of branches at 30 and 60 DAS, number of leaves at 30 and 60 DAS, days to first flowering, days to first female flowering and number of nodes upto first female flower. For vine length at 60 DAS and days to first harvest, the variance due to lines was significant only at p=0.05. However, variance due to lines was not significant for all other characters.

4.1.6 Testers

Variance due to testers was not significant for all the characters studied.

4.1.7 Line x tester

Variance due to line x tester interaction was highly significant for all the growth, earliness, yield and quality parameters studied except for number of branches at 30 DAS.

4.2 *PER SE* PERFORMANCE AND HETEROSIS

The *per se* performance of parents and F_1s and heterosis worked out over better parent, the best parent and commercial check, *i.e.*, Rasik (Ankur Seeds Pvt. Ltd.) are presented for growth, earliness, yield and quality parameters.

4.2.1 Vine length (Tables 5 and 6)

Vine length at 30 days after sowing (DAS) ranged from 18.10 (HM) to 19.30 cm (PS) among testers, 17.37 (KM-7) to 21.40 cm (KM-3) among lines and it varied from 20.74 (KM-6 x AR) to 27.64 cm (KM-3 x PS) among crosses. Magnitude of heterosis over better parent, the best parent and commercial check was highly significant in both the directions. Maximum heterosis was observed in the cross KM-4 x PS (29.49%) over better parent and the cross KM-3 x PS exhibited maximum heterosis to the extent of 29.16 per cent over the best parent and 23.95 per cent over the commercial check. All the crosses exhibited positive and significant heterosis over better parent.

Table 5. ***Per se*** **performance of parents and crosses for growth parameters in muskmelon**

Sl. No.	Genotypes	Vine length (cm)			Number of branches		Number of leaves	
		30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	30 DAS	60 DAS
	Crosses							
1.	KM-1 x AR	21.45	148.23	171.15	2.07	9.41	13.65	61.73
2.	KM-1 x HM	21.70	147.21	174.37	2.22	8.55	14.77	84.86
3.	KM-1 x PS	21.86	148.70	188.69	2.50	9.36	13.06	96.75
4.	KM-2 x AR	23.85	141.89	178.42	2.00	9.53	12.96	88.65
5.	KM-2 x HM	24.92	147.36	185.78	2.09	8.99	13.07	95.86
6.	KM-2 x PS	23.65	145.79	170.60	2.24	9.25	12.13	88.86
7.	KM-3 x AR	25.78	154.68	199.40	2.74	10.77	14.86	105.62
8.	KM-3 x HM	24.35	166.89	215.58	2.61	11.58	16.17	115.75
9.	KM-3 x PS	27.64	186.05	224.73	3.48	12.36	19.08	131.43
10.	KM-4 x AR	22.43	150.95	206.20	2.75	9.77	13.51	99.03
11.	KM-4 x HM	21.72	152.73	208.51	2.79	10.09	13.30	112.40
12.	KM-4 x PS	25.25	163.67	224.18	2.82	12.08	18.03	119.70
13.	KM-5 x AR	22.03	146.30	188.40	2.26	9.55	11.18	89.82
14.	KM-5 x HM	20.99	148.95	191.17	1.31	9.50	11.82	90.68
15.	KM-5 x PS	23.15	151.57	192.33	2.28	8.81	12.65	99.75
16.	KM-6 x AR	20.74	140.23	187.84	2.63	10.19	13.34	86.58
17.	KM-6 x HM	21.93	147.10	192.60	2.40	11.04	15.93	89.73
18.	KM-6 x PS	21.99	144.40	185.24	2.52	9.55	14.51	60.73
19.	KM-7 x AR	22.78	146.42	192.86	1.77	8.89	12.30	62.90
20.	KM-7 x HM	21.97	132.82	186.83	1.52	9.35	12.59	71.07
21.	KM-7 x PS	23.20	120.46	194.61	2.30	9.23	9.89	65.58
22.	KM-8 x AR	20.99	148.79	190.23	2.35	8.87	9.80	88.64
23.	KM-8 x HM	23.08	124.45	188.43	1.70	9.51	10.05	86.11
24.	KM-8 x PS	22.44	148.33	195.58	1.45	9.43	9.78	88.52
	Lines							
25.	KM-1	19.30	80.50	102.75	1.60	7.34	7.56	67.03
26.	KM-2	20.70	139.50	164.95	1.85	7.38	12.60	72.60
27.	KM-3	21.40	146.29	180.97	1.90	9.41	10.70	95.43
28.	KM-4	19.50	140.89	189.08	1.80	8.69	11.30	90.83
29.	KM-5	19.60	121.50	150.95	1.80	8.40	8.57	80.90
30.	KM-6	18.30	120.40	145.00	1.50	7.60	7.70	66.20
31.	KM-7	17.37	71.50	128.07	1.60	7.48	7.06	61.70
32.	KM-8	19.40	66.50	122.37	1.30	7.18	8.70	64.42
	Testers							
33.	AR	19.25	127.57	165.75	1.55	7.78	11.01	63.93
34.	HM	18.10	120.55	143.35	1.60	8.41	10.30	66.50
35.	PS	19.30	141.75	178.78	1.70	7.50	10.10	70.20
	Commercial check	22.30	138.90	166.00	2.32	7.23	11.80	78.20
	S.Em±	0.599	1.186	1.599	0.239	0.182	0.618	2.175
	C.D. at 5%	1.73	3.42	4.62	0.69	0.53	1.79	6.28
	C.D. at 1%	2.33	4.61	6.22	0.93	0.71	2.40	8.46

DAS = Days after sowing

Table 6. Heterosis (%) over better parent, the best parent and commercial check for vine length in muskmelon

Sl. No.	Genotypes	Vine length at								
		30 DAS			60 DAS			90 DAS		
		BP	BTP	CC	BP	BTP	CC	BP	BTP	CC
1.	KM-1 x AR	11.14**	0.23	-3.81**	16.20**	1.33	6.72**	3.26	-9.48**	3.10
2.	KM-1 x HM	12.44**	1.40	-2.69**	22.11**	0.63	5.98**	21.64**	-7.78**	5.04*
3.	KM-1 x PS	13.29**	2.14*	-1.97*	4.90**	1.65	7.05**	5.54*	-0.21	13.67**
4.	KM-2 x AR	15.22**	11.45**	6.95**	1.71	-3.01	2.15	7.64**	-5.64*	7.48**
5.	KM-2 x HM	20.36**	16.45**	11.75**	5.63**	0.73	6.09**	12.63**	-1.74	11.91**
6.	KM-2 x PS	14.25**	10.51**	6.05**	2.85	-0.34	4.96**	-4.58	-9.77**	2.77
7.	KM-3 x AR	20.47**	20.47**	15.60**	5.74**	5.74**	11.36**	10.18**	5.46*	20.12**
8.	KM-3 x HM	13.78**	13.78**	9.19**	14.08**	14.08**	20.15**	19.12**	14.01**	29.87**
9.	KM-3 x PS	29.16**	29.16**	23.95**	27.18**	27.18**	33.94**	24.18**	18.85**	35.38**
10.	KM-4 x AR	15.03**	4.81**	0.58	7.14**	3.18	8.67**	9.05**	9.05**	24.21**
11.	KM-4 x HM	11.38**	1.49	-2.60**	8.40**	4.40*	9.96**	10.28**	10.28**	25.61**
12.	KM-4 x PS	29.49**	18.00**	13.23**	15.46**	11.88**	17.83**	18.56**	18.56**	35.05**
13.	KM-5 x AR	12.42**	2.94**	-1.21	14.69**	0.01	5.33**	13.67**	-0.36	13.49**
14.	KM-5 x HM	7.07**	-1.91*	-5.87**	22.59**	1.82	7.23**	26.64**	1.10	15.16**
15.	KM-5 x PS	18.09**	8.81**	3.81**	6.92**	3.61*	9.12**	7.58**	1.72	15.86**
16.	KM-6 x AR	7.71**	-3.08**	-6.99**	9.93**	-4.41*	0.95	13.33**	-0.65	13.16**
17.	KM-6 x HM	19.84**	2.48**	-1.66	22.02**	0.55	5.90**	32.83**	1.86	16.02**
18.	KM-6 x PS	13.91**	2.76**	-1.39	1.87	-1.29	3.95*	3.61	-2.03	11.59**
19.	KM-7 x AR	18.34**	6.45**	2.15*	14.78**	0.09	5.41**	16.35**	2.00	16.18**
20.	KM-7 x HM	21.41**	2.66**	-1.48	10.17**	-9.21**	-4.38*	30.33**	-1.19	12.54**
21.	KM-7 x PS	20.23**	8.41**	4.03**	-15.02**	-17.66**	-13.27**	8.85**	2.92	17.23**
22.	KM-8 x AR	8.22**	-1.91*	-5.87**	16.63**	1.71	7.12**	14.77**	0.61	14.60**
23.	KM-8 x HM	18.99**	7.85**	3.49**	3.24	-14.93**	-10.40**	31.45**	-0.34	13.51**
24.	KM-8 x PS	15.70**	4.86**	0.63	4.65**	1.39	6.79**	9.40**	3.44	17.82**
	S.Em±	0.599	0.599	0.599	1.186	1.186	1.186	1.599	1.599	1.599
	C.D. at 5%	1.73	1.73	1.73	3.42	3.42	3.42	4.62	4.62	4.62
	C.D. at 1%	2.33	2.33	2.33	4.61	4.61	4.61	6.22	6.22	6.22

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

BTP = Better parent BP = Best parent CC = Commercial check

Over the best parent, 19 crosses and over the commercial check, 11 crosses exhibited positive and significant heterosis for vine length at 30 DAS.

Vine length at 60 DAS ranged from 120.55 (HM) to 141.75 cm (PS) among testers, 66.50 (KM-8) to 146.29 cm (KM-3) among lines and 120.46 (KM-7 x PS) to 186.05 cm (KM-3 x PS) among crosses. Magnitude of heterosis over better parent, the best parent and commercial check was highly significant in both the directions. Maximum heterosis was observed in the cross KM-3 x PS over better parent (27.18%), over best parent (27.18%) and over commercial check (33.94%). Out of 24 crosses, 19 crosses over better parent, six crosses over the best parent and 19 crosses over the commercial check exhibited positive and significant heterosis for vine length at 60 DAS.

Vine length at 90 DAS ranged from 143.35 (HM) to 178.78 cm (PS) among testers, 102.75 (KM-1) to 189.08 cm (KM-4) among lines and 170.60 (KM-2 x PS) to 224.73 cm (KM-3 x PS) among crosses. Magnitude of heterosis over better parent, the best parent and commercial check was highly significant in both the directions. Maximum heterosis was observed in the cross KM-6 x HM (32.83%) over better parent and the cross KM-3 x PS exhibited highest heterosis over the best parent (18.85%) and the commercial check (35.38%). Out of 24 crosses, 21 crosses over better parent, six crosses over the best parent and 22 crosses over the commercial check exhibited positive and significant heterosis.

4.2.2 Number of branches (Tables 5 and 7)

Significant differences were observed among the genotypes for the character number of branches per vine at 30 DAS. Number of branches per vine at 30 DAS varied from 1.55 (AR) to 1.70 (PS) among testers, 1.30 (KM-8) to 1.90 (KM-3) among lines and 1.31 (KM-5 x HM) to 3.48 (KM-3 x PS) among crosses. Magnitude of heterosis over better parent, the best parent and commercial check was highly significant in both the directions. Maximum positive and significant heterosis was observed in the cross KM-3 x PS over better parent (83.16%), the best parent (83.16%) and commercial check (50.00%). Many of the crosses exhibited positive and significant heterosis over better parent (21 crosses), the best parent (19 crosses) and commercial check (11 crosses).

Number of branches per vine varied significantly among the genotypes on 60 DAS. Number of branches per vine at 60 DAS varied from 7.50 (PS) to 8.41 (HM) among testers, 7.18 (KM-8) to 9.41 (KM-3) among lines and 8.55 (KM- x HM) to 12.36 (KM-3 x PS) among crosses. Magnitude of heterosis over better parent, the best parent and commercial check was highly significant in positive direction. Maximum positive and significant heterosis was observed in the cross KM-4 x PS over better parent (38.93%), the best parent (28.37%) and commercial check (67.08%). All the crosses exhibited positive

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

Sl. No.	Genotypes	Number of branches at					
		30 DAS			60 DAS		
		BP	BTP	CC	BP	BTP	CC
1.	KM-1 x AR	29.06**	8.95**	-10.77**	20.87**	0.00	30.15**
2.	KM-1 x HM	39.06**	16.84**	-4.31**	1.60**	-9.14**	18.26**
3.	KM-1 x PS	47.06**	31.58**	7.76**	24.87**	-0.53*	29.46**
4.	KM-2 x AR	7.84**	5.26**	-13.79**	22.48**	1.27**	31.81**
5.	KM-2 x HM	13.24**	10.00**	-9.91**	6.89**	-4.46**	24.34**
6.	KM-2 x PS	20.81**	17.89**	-3.45**	23.33**	-1.70**	27.94**
7.	KM-3 x AR	44.21**	44.21**	18.10**	14.45**	14.45**	48.96**
8.	KM-3 x HM	37.36**	37.36**	12.15**	23.06**	23.06**	60.16**
9.	KM-3 x PS	83.16**	83.16**	50.00**	31.35**	31.35**	70.95**
10.	KM-4 x AR	52.78**	44.74**	18.53**	12.42**	3.82**	35.13**
11.	KM-4 x HM	55.00**	46.84**	20.26**	16.10**	7.22**	39.56**
12.	KM-4 x PS	56.39**	48.42**	21.55**	38.93**	28.37**	67.08**
13.	KM-5 x AR	25.56**	18.95**	-2.59**	13.69**	1.49**	32.09**
14.	KM-5 x HM	-27.22**	-31.05**	-43.53**	12.89**	0.96**	31.40**
15.	KM-5 x PS	26.39**	20.00**	-1.72**	4.88**	-6.38**	21.85**
16.	KM-6 x AR	69.68**	38.42**	13.36**	30.96**	8.29**	40.94**
17.	KM-6 x HM	50.31**	26.31**	3.45**	31.19**	17.32**	52.70**
18.	KM-6 x PS	47.94**	32.63**	8.62**	25.66**	1.49**	32.09**
19.	KM-7 x AR	10.63**	-6.84**	-23.71**	14.19**	-5.53**	22.96**
20.	KM-7 x HM	-4.69**	-20.00**	-34.48**	11.17**	-0.64*	29.32**
21.	KM-7 x PS	35.59**	21.05**	-0.86*	23.00**	-1.91**	27.66**
22.	KM-8 x AR	51.61**	23.68**	1.29**	13.94**	-5.74**	22.66**
23.	KM-8 x HM	6.25**	-10.53**	-26.72**	12.95**	1.06**	31.53**
24.	KM-8 x PS	-14.71**	-23.68**	-37.50**	25.73**	0.21	30.43**
	S.Em±	0.239	0.239	0.239	0.182	0.182	0.182
	C.D. at 5%	0.69	0.69	0.69	0.53	0.53	0.53
	C.D. at 1%	0.93	0.93	0.93	0.71	0.71	0.71

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

BTP = Better parent BP = Best parent CC = Commercial check

Table 8. Heterosis (%) over better parent, the best parent and commercial check for number of leaves in muskmelon

Sl. No.	Genotypes	Number of leaves at					
		30 DAS			60 DAS		
		BP	BTP	CC	BP	BTP	CC
1.	KM-1 x AR	23.98**	8.33**	15.68**	-7.91*	-35.31**	-21.06**
2.	KM-1 x HM	43.45**	17.22**	25.17**	26.60**	-11.07**	8.52**
3.	KM-1 x PS	29.31**	3.65**	10.68**	37.82**	1.38	23.72**
4.	KM-2 x AR	2.86**	2.86**	9.83**	22.10**	-7.10*	13.36**
5.	KM-2 x HM	3.73**	3.73**	10.76**	32.04**	0.45	22.58**
6.	KM-2 x PS	-3.73**	-3.73**	2.80**	22.39**	-6.88*	13.63**
7.	KM-3 x AR	34.97**	17.94**	25.93**	10.68**	10.68**	35.06**
8.	KM-3 x HM	51.17**	28.33**	37.03**	21.29**	21.29**	48.02**
9.	KM-3 x PS	78.32**	51.43**	61.69**	37.72**	37.72**	68.07**
10.	KM-4 x AR	19.56**	7.22**	14.49**	9.02**	3.77	26.64**
11.	KM-4 x HM	17.65**	5.55**	12.71**	23.75**	17.78**	43.73**
12.	KM-4 x PS	59.56**	43.09**	52.80**	31.78**	25.43**	53.07**
13.	KM-5 x AR	1.54	-11.27**	-5.25**	10.53**	-6.30*	14.35**
14.	KM-5 x HM	14.76**	-6.19**	0.17	12.08**	-4.98	15.96**
15.	KM-5 x PS	25.25**	0.39	7.20**	23.29**	4.53	27.56**
16.	KM-6 x AR	21.21**	5.87**	13.05**	30.79**	-9.27**	10.72**
17.	KM-6 x HM	54.66**	26.43**	35.00**	34.93**	-5.97	14.74**
18.	KM-6 x PS	43.61**	15.16**	22.97**	-13.49**	-36.36**	-22.34**
19.	KM-7 x AR	11.67**	-2.38*	4.24**	-1.62	-34.09**	-19.56**
20.	KM-7 x HM	22.28**	-0.08	6.69**	6.86*	-24.87**	-8.31*
21.	KM-7 x PS	-2.13	-21.51**	-16.19**	-6.56*	-31.28**	-16.35**
22.	KM-8 x AR	-10.99**	-22.22**	-16.95**	37.60**	-7.11*	13.35**
23.	KM-8 x HM	-2.43**	-20.24**	-14.83**	29.49**	0.71	22.90**
24.	KM-8 x PS	-3.17**	-22.38**	7.02**	26.10**	-7.24*	13.20**
	S.Em±	0.618	0.618	0.618	2.175	2.175	2.175
	C.D. at 5%	1.79	1.79	1.79	6.28	6.28	6.28
	C.D. at 1%	2.40	2.40	2.40	8.46	8.46	8.46

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

BTP = Better parent BP = Best parent CC = Commercial check

Table 9. ***Per se*** **performance of parents and crosses for earliness in muskmelon**

Sl. No.	Genotypes	Days to first flowering	Days to first female flowering	Number of nodes upto first female flower	Days to first harvest
	Crosses				
1.	KM-1 x AR	33.36	41.90	6.70	90.00
2.	KM-1 x HM	33.04	42.10	7.10	91.70
3.	KM-1 x PS	35.12	44.80	7.10	92.85
4.	KM-2 x AR	31.98	41.29	6.40	89.12
5.	KM-2 x HM	32.19	41.08	6.00	88.70
6.	KM-2 x PS	32.06	40.14	6.30	96.05
7.	KM-3 x AR	30.15	36.17	4.40	83.38
8.	KM-3 x HM	31.26	36.08	4.48	85.74
9.	KM-3 x PS	30.15	33.12	4.15	78.11
10.	KM-4 x AR	33.35	46.55	4.62	81.18
11.	KM-4 x HM	33.35	40.95	4.55	81.93
12.	KM-4 x PS	29.75	35.53	4.18	75.24
13.	KM-5 x AR	36.15	43.21	5.10	96.27
14.	KM-5 x HM	34.54	44.61	5.40	97.90
15.	KM-5 x PS	35.81	47.73	4.50	92.93
16.	KM-6 x AR	33.35	47.05	6.20	82.86
17.	KM-6 x HM	30.28	36.15	4.20	81.35
18.	KM-6 x PS	33.77	47.55	7.00	91.71
19.	KM-7 x AR	32.36	57.90	5.40	96.05
20.	KM-7 x HM	36.75	58.12	4.80	86.82
21.	KM-7 x PS	37.72	50.61	6.00	95.75
22.	KM-8 x AR	40.26	55.10	6.78	72.25
23.	KM-8 x HM	40.73	55.90	4.70	86.70
24.	KM-8 x PS	40.27	56.26	5.90	92.90
	Lines				
25.	KM-1	36.40	44.50	5.30	94.85
26.	KM-2	31.90	43.20	5.70	102.95
27.	KM-3	32.95	42.10	4.70	96.78
28.	KM-4	33.05	44.90	4.80	96.52
29.	KM-5	35.65	48.60	6.25	86.43
30.	KM-6	35.50	52.15	6.50	91.18
31.	KM-7	36.10	56.30	6.55	89.21
32.	KM-8	40.60	58.10	7.40	93.48
	Testers				
33.	AR	43.00	55.40	6.60	98.82
34.	HM	38.65	44.80	6.20	96.93
35.	PS	35.65	42.20	5.40	98.71
	Commercial check	35.70	40.80	5.90	90.23
	S.Em±	0.518	0.902	0.316	1.535
	C.D. at 5%	1.49	2.60	0.91	4.43
	C.D. at 1%	2.01	3.51	1.22	5.97

Table 10. Heterosis (%) over better parent, the best parent and commercial check for days to first flowering and days to first female flowering in muskmelon

Sl. No.	Genotypes	Days to first flowering			Days to first female flowering		
		BP	BTP	CC	BP	BTP	CC
1.	KM-1 x AR	-8.35**	4.58**	-6.55**	-5.84**	-0.47	2.70*
2.	KM-1 x HM	-9.22**	3.57**	-7.45**	-5.40**	0.00	3.19*
3.	KM-1 x PS	-1.49*	10.09**	-1.62*	6.16**	6.41**	9.80**
4.	KM-2 x AR	0.25	0.25	-10.42**	-4.41**	-1.92	1.20
5.	KM-2 x HM	0.90	0.90	-9.83**	-4.91**	-2.42	0.69
6.	KM-2 x PS	0.50	0.50	-10.20**	-4.87**	-4.65**	-1.62
7.	KM-3 x AR	-8.51**	-5.48**	-15.55**	-14.08**	-14.08**	-11.35**
8.	KM-3 x HM	-5.41**	-2.00**	-12.44**	-14.30**	-14.30**	-11.57**
9.	KM-3 x PS	-8.50**	-5.48**	-15.55**	-21.33**	-21.33**	-18.82**
10.	KM-4 x AR	0.89	4.54**	-6.58**	3.67**	10.57**	14.09**
11.	KM-4 x HM	0.91	4.54**	-6.58**	-8.59**	-2.73*	0.37
12.	KM-4 x PS	-9.98*	-6.74**	-16.67**	-15.81**	-15.60**	-12.92**
13.	KM-5 x AR	1.40	13.32**	1.26	-11.09**	2.64*	5.90**
14.	KM-5 x HM	-3.10**	8.27**	-3.25**	-0.42	5.96**	9.34**
15.	KM-5 x PS	0.45	12.26**	0.30	13.10**	13.37**	16.98**
16.	KM-6 x AR	-6.06**	4.54**	-6.58**	-9.78**	11.75**	15.32**
17.	KM-6 x HM	-14.42**	-5.08**	-15.18**	-19.31**	-14.13**	-11.40**
18.	KM-6 x PS	-4.87**	5.86**	-5.41**	12.68**	12.94**	16.54**
19.	KM-7 x AR	-10.36**	1.44	-9.35**	4.51**	37.53**	41.91**
20.	KM-7 x HM	1.79	15.20**	2.94**	29.74**	38.05**	42.45**
21.	KM-7 x PS	5.81**	18.24**	5.65**	19.94**	20.21**	24.04**
22.	KM-8 x AR	-0.84	26.21**	12.77**	-0.54	30.88**	35.05**
23.	KM-8 x HM	5.38**	27.68**	14.09**	24.78**	32.78**	37.00**
24.	KM-8 x PS	12.98**	26.23**	12.80**	33.33**	33.63**	37.89**
	S.Em±	0.518	0.518	0.518	0.902	0.902	0.902
	C.D. at 5%	1.49	1.49	1.49	2.60	2.60	2.60
	C.D. at 1%	2.01	2.01	2.01	3.51	3.51	3.51

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

BTP = Better parent BP = Best parent CC = Commercial check

and significant heterosis over better parent and commercial check and 13 crosses over the best parent.

4.2.3 Number of leaves (Tables 5 and 8)

Genotypes differed significantly among themselves for number of leaves at 30 and 60 DAS. Number of leaves at 30 DAS varied from 10.10 (PS) to 11.01 (AR) among testers, 7.06 (KM-7) to 12.60 (KM-2) among lines and 9.78 (KM-8 x PS) to 19.08 (KM-3 x PS) among crosses. Heterosis over better parent, the best parent and commercial check was highly significant in both the directions. Maximum heterosis was observed in the cross KM-3 x PS over better parent (78.32%), the best parent (51.43%) and over the commercial check (61.69%). Out of 24 crosses, 18 crosses over better parent, 14 crosses over the best parent and 19 crosses over the commercial check exhibited positive and significant heterosis.

Number of leaves at 60 DAS varied from 63.93 (AR) to 70.20 (PS) among testers, 61.70 (KM-7) to 95.43 (KM-3) among lines and 60.73 (KM-6 x PS) to 131.43 (KM-3 x PS) among crosses. Magnitude of heterosis over better parent, the best parent and commercial check was highly significant in both the directions. Maximum positive and significant heterosis was observed in the cross KM-1 x PS (37.82%) over better parent and the cross KM-3 x PS exhibited maximum heterosis over the best parent (37.72%) and commercial check (68.07%). Many of the crosses exhibited positive and significant heterosis over better parent (20 crosses), the best parent (5 crosses) and commercial check (19 crosses).

4.2.4 Days to first flowering (Tables 9 and 10)

Days to first flowering differed significantly among the genotypes and it varied from 35.65 (PS) to 43.00 (AR) among testers, 31.90 (KM-2) to 40.60 (KM-8) among lines and 29.75 (KM-4 x PS) to 40.73 (KM-8 x HM) among crosses. Magnitude of heterosis over better parent, the best parent and commercial check was highly significant in both the directions. Negative heterosis is desirable for earliness parameters. Maximum negative and significant heterosis (-14.42%) was observed in the cross KM-6 x HM over better parent followed by KM-7 x AR (-10.36%) and KM-4 x PS (-9.98%). Maximum negative and significant heterosis over the best parent (-6.74%) was observed in the cross KM-4 x PS followed by KM-3 x AR (-5.48%) and KM-3 x PS (-5.48%). The cross KM-4 x PS exhibited maximum negative and significant heterosis over commercial check (-16.67%) followed by KM-3 x AR (-15.55%) and KM-3 x PS (-15.55%). Out of 24 crosses, 11 crosses over better parent, five crosses over the best parent and 17 crosses over the commercial check exhibited significant heterosis in desirable direction (negative).

Table 11. Heterosis (%) over better parent, the best parent and commercial check for number of nodes upto first female flower and days to first harvest in muskmelon

Sl. No.	Genotypes	Number of nodes upto first female flower			Days to first harvest		
		BP	BTP	CC	BP	BTP	CC
1.	KM-1 x AR	26.42**	42.55**	13.56**	-5.11*	4.13	-0.25
2.	KM-1 x HM	33.96**	51.06**	20.34**	-3.32	6.09**	1.63
3.	KM-1 x PS	33.96**	51.06**	20.34**	-2.11	7.43**	2.90
4.	KM-2 x AR	12.28**	36.17**	8.47**	-9.82**	3.11	-1.23
5.	KM-2 x HM	5.26**	27.66**	1.69**	-8.49**	2.63	-1.69
6.	KM-2 x PS	16.67**	34.04**	6.78**	-2.69	11.13**	6.45**
7.	KM-3 x AR	-6.38**	-6.38**	-25.42**	-13.85**	-3.53	-7.59**
8.	KM-3 x HM	-4.68**	-4.68**	-24.07**	-11.40**	-0.80	-4.98*
9.	KM-3 x PS	-11.70**	-11.70**	-29.66**	-19.29**	-9.63**	-13.43**
10.	KM-4 x AR	-3.65**	-1.70**	-21.69**	-15.90**	-6.07**	-10.03**
11.	KM-4 x HM	-5.21**	-3.19**	-22.88**	-15.13**	-5.21*	-9.20**
12.	KM-4 x PS	-13.02**	-11.06**	-29.15**	-22.05**	-12.95**	-16.61**
13.	KM-5 x AR	-18.40**	8.51**	-13.56**	11.38**	11.38**	6.69**
14.	KM-5 x HM	-12.90**	14.89**	-8.47**	13.27**	13.27**	8.50**
15.	KM-5 x PS	-16.67**	-4.25**	-23.73**	7.52**	7.52**	2.99
16.	KM-6 x AR	-4.62**	31.91**	5.08**	-9.11**	-4.13	-8.17**
17.	KM-6 x HM	-32.26**	-10.64**	-28.81**	-10.78**	-5.88*	-9.84**
18.	KM-6 x PS	29.63**	48.94**	18.64**	0.59	6.11**	1.64
19.	KM-7 x AR	-17.56**	14.89**	-8.47**	7.66**	11.13**	6.45**
20.	KM-7 x HM	-22.58**	2.13**	-18.64**	-2.68	0.45	-3.77
21.	KM-7 x PS	11.11**	27.66**	1.69**	7.33**	10.78**	6.12**
22.	KM-8 x AR	2.65**	44.25**	14.91**	-22.71**	-16.40**	-19.93**
23.	KM-8 x HM	-24.19**	0.00	-20.33**	-7.25**	0.31	-3.91
24.	KM-8 x PS	9.26**	25.53**	0.00	-0.62	7.48**	2.96
	S.Em±	0.316	0.316	0.316	1.535	1.535	1.535
	C.D. at 5%	0.91	0.91	0.91	4.43	4.43	4.43
	C.D. at 1%	1.22	1.22	1.22	5.97	5.97	5.97

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

BTP = Better parent BP = Best parent CC = Commercial check

Table 12. ***Per se*** **performance of parents and crosses for yield and yield parameters in muskmelon**

Sl. No.	Genotypes	Number of fruiting branches per vine	Number of fruits per vine	Average fruit weight (g)	Fruit yield per vine (kg)
	Crosses				
1.	KM-1 x AR	16.00	3.70	867.15	1.83
2.	KM-1 x HM	19.70	3.65	535.08	1.99
3.	KM-1 x PS	18.20	3.61	502.50	0.96
4.	KM-2 x AR	18.40	2.15	876.20	2.34
5.	KM-2 x HM	16.85	3.18	381.00	1.14
6.	KM-2 x PS	17.00	3.45	361.50	1.35
7.	KM-3 x AR	16.00	2.60	839.89	1.39
8.	KM-3 x HM	19.30	4.16	420.12	1.27
9.	KM-3 x PS	23.80	4.88	985.17	2.38
10.	KM-4 x AR	20.60	3.03	710.65	2.32
11.	KM-4 x HM	19.10	3.05	641.15	2.07
12.	KM-4 x PS	19.50	4.49	1157.39	2.36
13.	KM-5 x AR	18.10	3.55	783.85	1.59
14.	KM-5 x HM	18.40	1.85	485.98	0.99
15.	KM-5 x PS	17.50	4.18	692.95	1.80
16.	KM-6 x AR	17.25	3.25	544.62	2.28
17.	KM-6 x HM	20.45	3.18	1257.67	2.59
18.	KM-6 x PS	18.50	3.71	459.23	2.30
19.	KM-7 x AR	20.30	4.38	744.15	1.56
20.	KM-7 x HM	16.40	3.45	939.30	2.97
21.	KM-7 x PS	16.80	2.58	629.35	1.16
22.	KM-8 x AR	16.73	3.64	734.10	1.79
23.	KM-8 x HM	18.42	2.45	810.00	1.71
24.	KM-8 x PS	18.88	3.25	368.27	1.27
	Lines				
25.	KM-1	17.05	3.57	585.30	2.24
26.	KM-2	12.40	2.05	510.62	1.89
27.	KM-3	13.70	3.35	711.58	1.85
28.	KM-4	13.10	2.35	612.25	2.00
29.	KM-5	13.45	3.55	665.47	2.11
30.	KM-6	13.20	2.52	715.47	2.17
31.	KM-7	14.40	3.45	568.33	2.18
32.	KM-8	11.90	2.19	448.60	1.27
	Testers				
33.	AR	14.35	2.39	687.75	1.40
34.	HM	14.50	2.37	587.00	1.49
35.	PS	13.90	3.25	487.50	1.00
	Commercial check	17.27	3.42	753.24	1.78
	S.Em±	0.650	0.247	9.356	0.032
	C.D. at 5%	1.87	0.71	27.02	0.09
	C.D. at 1%	2.53	0.96	36.39	0.12

Table 13. Heterosis (%) over better parent, the best parent and commercial check for number of fruiting branches per vine and number of fruits per vine in muskmelon

Sl. No.	Genotypes	Number of fruiting branches per vine			Number of fruits per vine		
		BP	BTP	CC	BP	BTP	CC
1.	KM-1 x AR	-6.16**	-6.16**	-7.35**	3.64**	3.64**	8.19**
2.	KM-1 x HM	15.54**	15.54**	14.07**	2.24**	2.24**	6.72**
3.	KM-1 x PS	6.74**	6.74**	5.38**	1.12**	1.12**	5.55**
4.	KM-2 x AR	28.22**	7.92**	6.54**	-10.04**	-39.77**	-37.13**
5.	KM-2 x HM	16.21**	-1.17	-2.43*	33.97**	-10.92**	-7.02**
6.	KM-2 x PS	22.30**	-0.29	-1.56	6.15**	-3.36**	0.87*
7.	KM-3 x AR	11.50**	-6.16**	-7.35**	-22.39**	-27.17**	-23.98**
8.	KM-3 x HM	33.10**	13.20**	11.75**	24.18**	16.53**	21.64**
9.	KM-3 x PS	71.22**	39.59**	37.81**	45.52**	36.69**	42.69**
10.	KM-4 x AR	43.55**	20.82**	19.28**	26.57**	-15.13**	-11.40**
11.	KM-4 x HM	31.72**	12.02**	10.60**	28.69**	-14.56**	-10.81**
12.	KM-4 x PS	40.29**	14.37**	12.91**	38.15**	25.77**	31.29**
13.	KM-5 x AR	26.13**	6.16**	4.81**	0.00	-0.56	3.80**
14.	KM-5 x HM	26.90**	7.92**	6.54**	-47.89**	-48.18**	-45.91**
15.	KM-5 x PS	25.90**	2.64**	1.33	17.75**	17.09**	22.22**
16.	KM-6 x AR	20.21**	1.17	-0.11	28.97**	-8.96**	-4.97**
17.	KM-6 x HM	41.03**	19.94**	18.41**	26.19**	-10.92**	-7.02**
18.	KM-6 x PS	33.09**	8.50**	7.12**	14.15**	3.92**	8.48**
19.	KM-7 x AR	40.97**	19.06**	17.54**	26.81**	22.69**	28.07**
20.	KM-7 x HM	13.10**	-3.81**	-5.04**	-0.41	-3.36**	0.87*
21.	KM-7 x PS	16.67**	-1.47	-2.72**	-25.36**	-27.73**	-24.56**
22.	KM-8 x AR	16.59**	-1.88*	-3.13**	52.51**	-26.05**	-22.81**
23.	KM-8 x HM	27.07**	8.03**	6.66**	3.38**	-31.37**	-28.36**
24.	KM-8 x PS	35.79**	10.73**	9.32**	0.00	-8.96**	-4.97**
	S.Em±	0.650	0.650	0.650	0.247	0.247	0.247
	C.D. at 5%	1.87	1.87	1.87	0.71	0.71	0.71
	C.D. at 1%	2.53	2.53	2.53	0.96	0.96	0.96

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

BTP = Better parent BP = Best parent CC = Commercial check

4.2.5 Days to first female flowering (Tables 9 and 10)

Days to first female flowering varied significantly among genotypes and it ranged from 42.20 (PS) to 55.40 (AR) among testers, 42.10 (KM-3) to 58.10 (KM-8) among lines and 33.12 (KM-3 x PS) 58.12 (KM-7 x HM) among crosses. Magnitude of heterosis over better parent, the best parent and commercial check was highly significant in both the directions. Maximum negative (desirable) and significant heterosis was observed in the cross KM-3 x PS (-21.33%) over better parent followed by KM-6 x HM (-19.31%) and KM-4 x PS (-15.81%). Maximum negative and significant heterosis over the best parent was observed in the cross KM-3 x PS (-21.33%) followed by KM-4 x PS (-15.60%) and KM-3 x HM (-14.30%). Maximum negative and significant heterosis over the commercial check was observed in the cross KM-3 x PS (-18.82%) followed by KM-4 x PS (-12.92%) and KM-3 x HM (-11.57%). Out of 24 crosses, 13 crosses over better parent, seven crosses over the best parent and five crosses over the commercial check exhibited significant heterosis in desirable direction.

4.2.6 Number of nodes upto first female flower (Table 9 and 11)

Number of nodes upto first female flower differed significantly among the genotypes and it varied from 5.40 (PS) to 6.60 (AR) among testers, 4.70 (KM-3) to 7.40 (KM-8) among lines and 4.15 (KM-3 x PS) to 7.10 (KM-1 x HM and KM-1 x PS) among crosses. Magnitude of heterosis over better parent, the best parent and commercial check was highly significant in both the directions. Maximum negative (desirable) and significant heterosis over better parent was observed in the cross KM-6 x HM (-32.26%) followed by KM-8 x HM (-24.19%) and KM-7 x HM (-22.58%). Maximum negative and significant heterosis over the best parent was observed in the cross KM-3 x PS (-11.70%) followed by KM-4 x PS (-11.06%) and KM-6 x HM (-10.64%). Over the commercial check, maximum negative heterosis was exhibited by the cross KM-3 x PS (-29.66%) followed by KM-4 x PS (-29.15%) and KM-6 x HM (-28.81%) and the heterosis values were significant.

Out of 24 crosses, 14 crosses over better parent, eight crosses over the best parent and 13 crosses over the commercial check exhibited significant heterosis in desirable direction.

4.2.7 Days to first harvest (Tables 9 and 11)

Days to first harvesting varied significantly among the genotypes. It ranged from 96.93 (HM) to 98.82 (AR) among testers, 86.43 (KM-5) to 102.95 (KM-2) among lines and it varied from 72.25 (KM-8 x AR) to 97.90 (KM-5 x HM) among crosses. Magnitude of heterosis over better parent, the best parent and commercial check was highly significant in both the directions. Maximum negative (desirable) and significant heterosis was observed in the cross KM-8 x AR (-22.71%) over better parent followed by KM-4 x PS (-22.05%) and KM-3 x PS (-19.29%). Maximum negative and significant heterosis over the best parent was observed in the cross KM-8 x AR (-16.40%) followed by KM-4 x PS

(-12.95%) and KM-3 x PS (-9.63%). Over the commercial check, the cross KM-8 x AR (-19.93%) followed by KM-4 x PS (-16.61%) and KM-3 x PS (-13.43%) exhibited maximum negative and significant heterosis. Out of 24 crosses, 13 crosses over better parent, six crosses over the best parent and nine crosses over the commercial check exhibited significant heterosis in desirable (negative) direction.

4.2.8 Number of fruiting branches per vine (Tables 12 and 13)

Number of fruiting branches per vine differed significantly among the genotypes and it varied from 13.90 (PS) to 14.50 (HM) among testers, 11.90 (KM-8) to 17.97 (KM-1) among lines and from 16.00 (KM-1 x AR and KM-3 x AR) to 23.80 (KM-3 x PS) among crosses. Magnitude of heterosis over better parent, the best parent and commercial check was highly significant in both the directions. Maximum positive and significant heterosis over better parent was observed in the cross KM-3 x PS (71.22%) followed by KM-4 x AR (43.55%) and KM-6 x HM (41.03%). Maximum positive and significant heterosis over the best parent was observed in KM-3 x PS (39.59%) followed by KM-4 x AR (20.82%) and KM-6 x HM (19.94%). Maximum positive and significant heterosis over the commercial check was observed in KM-3 x PS (37.81%) followed by KM-4 x AR (19.28%) and KM-6 x HM (18.41%). Among 24 crosses developed, 23 crosses over better parent, 16 crosses over the best parent and 14 crosses over commercial check exhibited positive and significant heterosis for number of fruiting branches per vine.

4.2.9 Number of fruits per vine (Tables 12 and 13)

Number of fruits per vine varied significantly among the genotypes. It varied from 2.37 (HM) to 3.25 (PS) among testers, 2.05 (KM-2) to 3.57 (KM-1) among lines and from 1.85 (KM-5 x HM) to 4.88 (KM-3 x PS) among crosses. Magnitude of heterosis over better parent, the best parent and commercial check was highly significant in both the directions. Maximum positive and significant heterosis over better parent was observed in KM-8 x AR (52.51%) followed by KM-3 x PS (45.52%) and KM-4 x PS (38.15%). Maximum positive and significant heterosis over the best parent was observed in KM-3 x PS (36.69%) followed by KM-4 x PS (25.77%) and KM-7 x AR (22.69%). Maximum positive and significant heterosis over commercial check was observed in KM-3 x PS (42.69%) followed by KM-4 x PS (31.29%) and KM-7 x AR (28.07%). Out of 24 crosses, 17 crosses over better parent, nine crosses over the best parent and 12 crosses over the commercial check exhibited positive and significant heterosis for number of fruits per vine.

4.2.10 Average fruit weight (Tables 12 and 14)

Average fruit weight differed significantly among the genotypes and it varied from 487.50 g (PS) to 687.75 g (AR) among testers, 448.60 g (KM-8) to 715.47 g (KM-6) among lines and from

Table 14. Heterosis (%) over better parent, the best parent and commercial check for average fruit weight and fruit yield per vine in muskmelon

Sl. No.	Genotypes	Average fruit weight (g)			Fruit yield per vine (kg)		
		BP	BTP	CC	BP	BTP	CC
1.	KM-1 x AR	26.09	21.86	15.12	-18.30**	-18.30**	2.81**
2.	KM-1 x HM	-8.85	-24.80	-28.96*	-11.16**	-11.16**	11.79**
3.	KM-1 x PS	-14.15	-29.38*	-33.29*	-57.14**	-57.14**	-46.07**
4.	KM-2 x AR	27.40*	23.13	16.32	23.54**	4.46**	31.46**
5.	KM-2 x HM	-35.09*	-46.46**	-49.42**	-39.60**	-49.11**	-35.95**
6.	KM-2 x PS	-29.20*	-49.20**	-52.01**	-28.84**	-39.73**	-24.16**
7.	KM-3 x AR	18.03	18.03	11.50	-24.49**	-37.95**	-21.91**
8.	KM-3 x HM	-40.96**	-40.96**	-44.22**	-14.60**	-43.30**	-28.65**
9.	KM-3 x PS	38.45**	38.45**	30.79*	29.01**	6.25**	33.71**
10.	KM-4 x AR	3.33	-0.13	-5.65	15.98**	3.57**	30.34**
11.	KM-4 x HM	4.72	-9.89	-14.88	3.53**	-7.59**	16.29**
12.	KM-4 x PS	89.04**	62.65**	53.65**	18.21**	5.36**	32.58**
13.	KM-5 x AR	13.97	10.16	4.06	-24.81**	-29.02**	-10.67**
14.	KM-5 x HM	-26.97	-31.70*	-35.48*	-53.03**	-55.80**	-44.38**
15.	KM-5 x PS	4.13	-2.62	-8.00	-14.60**	-19.64**	1.12**
16.	KM-6 x AR	-23.88	-23.46	-27.69*	4.77**	1.78**	28.09**
17.	KM-6 x HM	75.78**	76.74**	66.97**	19.48**	15.62**	45.50**
18.	KM-6 x PS	-35.82*	-35.46*	-39.03**	5.69**	2.68**	29.21**
19.	KM-7 x AR	8.20	4.58	-1.21	-28.39**	-30.36**	-12.36**
20.	KM-7 x HM	60.02**	13.83	7.53	36.09**	32.59**	66.85**
21.	KM-7 x PS	10.74	-11.55	-16.45	-46.85**	-48.21**	-34.83**
22.	KM-8 x AR	6.74	3.16	-2.54	27.77**	-20.09**	0.56**
23.	KM-8 x HM	37.99**	13.83	7.53	14.43**	-23.66**	-3.93**
24.	KM-8 x PS	-24.46	-48.25**	-51.11**	-0.16*	-43.30**	-28.65**
	S.Em±	9.356	9.356	9.356	0.032	0.032	0.032
	C.D. at 5%	27.02	27.02	27.02	0.09	0.09	0.09
	C.D. at 1%	36.39	36.39	36.39	0.12	0.12	0.12

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

BTP = Better parent BP = Best parent CC = Commercial check

Table 15. ***Per se*** **performance of parents and crosses for fruit shape index, flesh thickness, rind thickness, cavity length and cavity breadth in muskmelon**

Sl. No.	Genotypes	Fruit shape index	Flesh thickness (cm)	Rind thickness (cm)	Cavity length (cm)	Cavity breadth (cm)
	Crosses					
1.	KM-1 x AR	1.01	2.95	0.59	7.80	6.80
2.	KM-1 x HM	1.04	2.60	0.44	4.05	3.10
3.	KM-1 x PS	1.28	1.40	0.50	5.00	3.85
4.	KM-2 x AR	1.33	3.34	0.36	6.75	5.15
5.	KM-2 x HM	1.21	2.68	0.57	6.10	4.39
6.	KM-2 x PS	0.97	2.26	0.42	5.95	5.75
7.	KM-3 x AR	1.13	2.86	0.44	5.80	4.85
8.	KM-3 x HM	1.04	3.33	0.33	5.75	6.30
9.	KM-3 x PS	1.49	3.57	0.31	6.12	4.40
10.	KM-4 x AR	0.87	2.76	0.37	7.20	6.09
11.	KM-4 x HM	0.85	2.26	0.38	7.50	6.50
12.	KM-4 x PS	1.37	3.28	0.32	7.05	5.59
13.	KM-5 x AR	1.13	2.73	0.40	3.75	3.00
14.	KM-5 x HM	0.75	1.33	0.52	4.35	3.55
15.	KM-5 x PS	0.80	2.64	0.41	5.25	5.35
16.	KM-6 x AR	0.70	2.05	0.52	6.05	7.50
17.	KM-6 x HM	1.27	3.47	0.62	7.19	7.05
18.	KM-6 x PS	0.85	2.95	0.32	4.90	5.70
19.	KM-7 x AR	1.08	2.78	0.37	8.00	5.40
20.	KM-7 x HM	1.41	3.05	0.28	7.18	5.39
21.	KM-7 x PS	1.06	2.45	0.50	8.05	4.85
22.	KM-8 x AR	1.05	2.78	0.30	6.30	4.85
23.	KM-8 x HM	1.36	1.90	0.37	4.00	2.95
24.	KM-8 x PS	0.95	2.20	0.38	7.10	5.40
	Lines					
25.	KM-1	1.22	2.45	0.50	4.70	4.10
26.	KM-2	1.12	1.25	0.52	4.55	4.03
27.	KM-3	1.23	2.92	0.34	7.35	6.10
28.	KM-4	1.14	2.00	0.51	8.45	5.75
29.	KM-5	1.10	2.04	0.43	5.40	4.40
30.	KM-6	1.12	2.71	0.58	10.70	7.80
31.	KM-7	1.12	1.73	0.44	4.70	4.00
32.	KM-8	0.96	1.59	0.42	4.68	4.03
	Testers					
33.	AR	1.21	2.14	0.52	5.55	4.65
34.	HM	1.01	1.78	0.47	5.05	4.10
35.	PS	1.07	1.96	0.48	4.75	4.05
	Commercial check	1.17	2.03	0.47	4.83	4.67
	S.Em±	0.032	0.176	0.032	0.419	0.138
	C.D. at 5%	0.09	0.51	0.09	1.29	0.40
	C.D. at 1%	0.12	0.68	0.12	1.63	0.54

361.50 g (KM-2 x PS) to 1257.67 g (KM-6 x HM) among crosses. Magnitude of heterosis over better parent, the best parent and commercial check was highly significant in both the directions. Maximum positive and significant heterosis over better parent was observed in KM-4 x PS (89.04%) followed by KM-6 x HM (75.78%) and KM-7 x HM (60.02%). Maximum positive and significant heterosis over the best parent was observed in KM-6 x HM (76.74%) followed by KM-4 x PS (62.65%) and KM-3 x PS (38.45%). Maximum positive and significant heterosis over commercial check was observed in KM-6 x HM (66.97%) followed by KM-4 x PS (53.65%) and KM-3 x PS (30.79%). Out of 24 crosses, six crosses over better parent, three over the best parent and three crosses over commercial check exhibited positive and significant heterosis for average fruit weight.

4.2.11 Fruit yield per vine (Tables 12 and 14)

Fruit yield per vine varied significantly among genotypes. It ranged from 1.00 kg (PS) to 1.49 kg (HM) among testers, 1.27 (KM-8) to 2.24 kg (KM-1) among lines and it varied from 0.96 (KM-1 x PS) to 2.97 kg (KM-7 x HM) among crosses. Magnitude of heterosis over better parent, the best parent and commercial check was highly significant in both the directions. Maximum positive and significant heterosis over better parent was observed in KM-7 x HM (36.09%) followed by KM-3 x PS (29.01%) and KM-8 x AR (27.77%). Maximum positive and significant heterosis over the best parent was observed in KM-7 x HM (32.59%) followed by KM-6 x HM (15.62%), KM-3 x PS (6.25%), KM-4 x PS (5.36%), KM-2 x AR (4.46%), KM-4 x AR (3.57%), KM-6 x PS (2.68%) and KM-6 x AR (1.78%). Maximum positive and significant heterosis over commercial check was observed in the cross KM-7 x HM (66.85%) followed by KM-6 x HM (45.50%), KM-3 x PS (33.71%), KM-4 x PS (32.58%), KM-2 x AR (31.46%) KM-4 x AR (30.34%), KM-6 x PS (29.21%) and KM-6 x AR (28.09%). Out of 24 crosses, 11 crosses over better parent, eight crosses over the best parent and 13 crosses over the commercial check exhibited positive and significant heterosis for fruit yield per vine.

4.2.12 Fruit shape index (Tables 15 and 16)

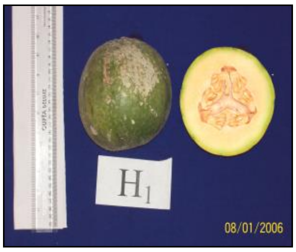
Fruit shape index is the ratio of longitudinal (polar) diameter to equatorial diameter. Genotypes differed significantly among themselves for fruit shape index and it ranged from 1.01 (HM) to 1.21 (AR) among testers, 0.96 (KM-8) to 1.23 (KM-3) among lines and it varied from 0.70 (KM-6 x AR) to 1.49 (KM-3 x PS) among crosses. Photographs of fruits of all the crosses are presented in Plate 3. Magnitude of heterosis over better parent, the best parent and the commercial check was significant in both the directions. For the fruit shape index, the negative heterosis is desirable as round fruits are preferred. Maximum negative and significant heterobeltiosis was observed in the cross KM-6 x AR (-37.78%) followed by KM-5 x HM (-25.62%) and KM-5 x PS (-24.41%). Maximum negative and significant heterosis over the best parent was observed in the cross KM-6 x AR

Table 16. Heterosis (%) over better parent, the best parent and commercial check for fruit shape index, flesh thickness and rind thickness in muskmelon

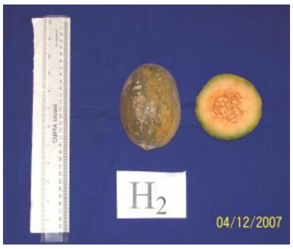
Sl. No.	Genotypes	Fruit shape index			Flesh thickness (cm)			Rind thickness (cm)		
		BP	BTP	CC	BP	BTP	CC	BP	BTP	CC
1.	KM-1 x AR	-16.12**	5.21**	-13.67**	20.41**	1.03**	45.32**	16.83**	73.53**	25.53**
2.	KM-1 x HM	2.96**	8.33**	-11.11**	6.12**	-10.96**	28.08**	-7.45**	29.41**	-6.38**
3.	KM-1 x PS	20.66**	33.33**	9.40**	-42.86**	-52.05**	-31.03**	4.17**	47.06**	6.38**
4.	KM-2 x AR	19.28**	38.54**	13.67**	55.84**	14.38**	64.53**	-30.77**	5.88**	-23.40**
5.	KM-2 x HM	19.21**	26.04**	3.41**	51.27**	-8.22**	32.01**	22.34**	67.65**	21.28**
6.	KM-2 x PS	-8.92**	1.04**	-17.09**	15.05**	-22.60**	11.33**	-13.54**	23.53**	-10.64**
7.	KM-3 x AR	-6.20**	17.71**	-3.42**	-2.05**	-2.05**	40.89**	29.41**	29.41**	-6.38**
8.	KM-3 x HM	2.96**	8.33**	-11.11**	14.04**	14.04**	64.04**	-2.94**	-2.94**	-29.79**
9.	KM-3 x PS	39.44**	55.21**	27.35**	22.26**	22.26**	75.86**	-8.82**	-8.82**	-34.04**
10.	KM-4 x AR	-24.12**	-9.37**	-25.64**	28.74**	-5.48**	35.96**	-27.45**	8.82**	-21.28**
11.	KM-4 x HM	-16.26**	-11.46**	-27.35**	13.00**	-22.60**	11.33**	-20.21**	11.76**	-19.15**
12.	KM-4 x PS	28.64**	42.71**	17.09**	63.75**	12.33**	61.58**	-32.29**	-5.88**	-31.91**
13.	KM-5 x AR	2.73**	17.71**	-3.42**	27.80**	-6.51**	34.48**	-5.88**	17.65**	-14.89**
14.	KM-5 x HM	-25.62**	-21.87**	-35.89**	-34.64**	-54.45**	-34.48**	23.53**	52.94**	10.64**
15.	KM-5 x PS	-24.41**	-16.67**	-31.62**	29.73**	-9.59**	30.05**	-3.53**	20.59*	-12.77**
16.	KM-6 x AR	-37.78**	-27.08**	-40.17**	-24.35**	-29.79**	0.98**	-0.95**	52.94**	10.64**
17.	KM-6 x HM	25.12**	32.29**	8.55**	27.86**	18.83**	70.93**	32.98**	82.35**	31.91**
18.	KM-6 x PS	-20.66**	-11.46**	-27.35**	9.04**	1.03**	45.32**	-33.33**	-5.88**	-31.91**
19.	KM-7 x AR	-4.02**	12.50**	-7.69**	29.67**	-4.79**	36.94**	-17.05**	8.82**	-21.27**
20.	KM-7 x HM	38.92**	46.87**	20.51**	71.83**	4.45**	50.25**	-37.50**	-17.64**	-40.42**
21.	KM-7 x PS	-0.47**	10.42**	-9.40**	25.00**	-16.09**	20.69**	13.64**	47.06**	6.38**
22.	KM-8 x AR	9.37**	9.37**	-10.26**	29.67**	-4.79**	36.94**	-27.71**	-11.76**	-36.17**
23.	KM-8 x HM	41.67**	41.67**	16.24**	7.32**	-34.93**	-6.40**	-10.84**	8.82**	-21.28**
24.	KM-8 x PS	-1.04**	-1.04**	-18.80**	12.24**	-24.66**	8.37**	-9.64**	11.76**	-19.15**
	S.Em±	0.032	0.032	0.032	0.176	0.176	0.176	0.032	0.032	0.032
	C.D. at 5%	0.09	0.09	0.09	0.51	0.51	0.51	0.09	0.09	0.09
	C.D. at 1%	0.12	0.12	0.12	0.68	0.68	0.68	0.12	0.12	0.12

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

BTP = Better parent BP = Best parent CC = Commercial check



KM-1 X AR

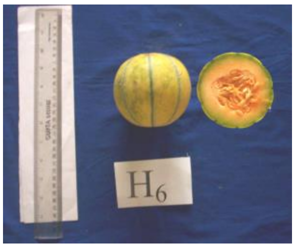


KM-1 X HM

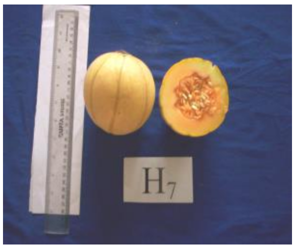
KM-1 X PS

KM-2 X AR

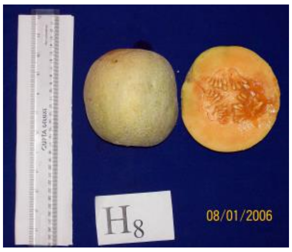
KM-2 X HM



KM-2 X PS

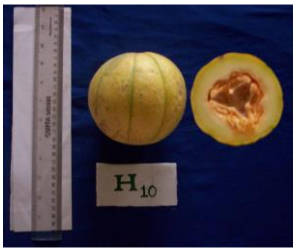


KM-3 X AR

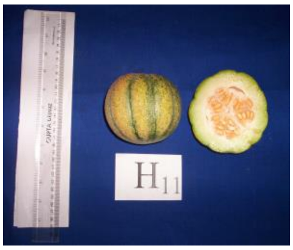


KM-3 X HM

KM-3 X PS

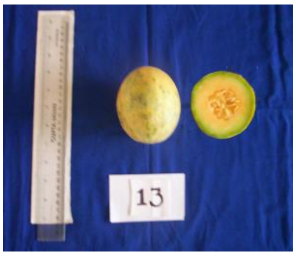


KM-4 X AR



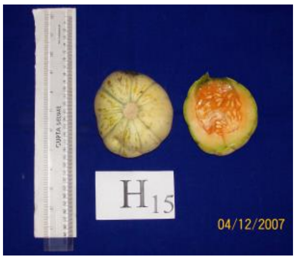
KM-4 X HM

KM-4 X PS



KM-5 X AR

KM-5 X HM



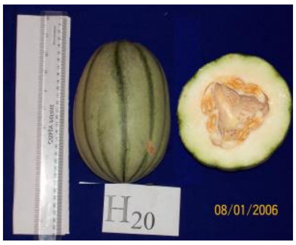
KM-5 X PS

KM-6 X AR

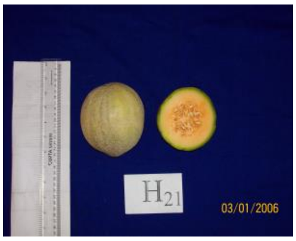
KM-6 X HM

KM-6 X PS

KM-7 X AR



KM-7 X HM



KM-7 X PS

KM-8 X AR

KM-8 X HM

KM-8 X PS

Plate 3. Fruit characters of crosses

Table 17. Heterosis (%) over better parent, the best parent and commercial check for cavity length and cavity breadth in muskmelon

Sl. No.	Genotypes	Cavity length			Cavity breadth		
		BP	BTP	CC	BP	BTP	CC
1.	KM-1 x AR	65.98**	71.43**	61.49**	65.85**	70.00**	45.61**
2.	KM-1 x HM	-13.83**	-10.99**	-16.14**	-24.39**	-22.50**	-33.62**
3.	KM-1 x PS	6.38**	9.89**	3.52**	-4.94**	-3.75**	-17.56**
4.	KM-2 x AR	48.35**	48.35**	39.75**	27.95**	28.75**	10.28**
5.	KM-2 x HM	34.06**	34.06**	26.29**	8.94**	9.75**	-5.99**
6.	KM-2 x PS	30.77**	30.77**	23.19**	42.86**	43.75**	23.13**
7.	KM-3 x AR	4.50**	27.47**	20.08**	4.30**	21.25**	3.85**
8.	KM-3 x HM	13.86**	26.37**	19.05**	53.66**	57.50**	34.90**
9.	KM-3 x PS	28.95**	34.50**	26.71**	8.64**	10.00**	-5.78**
10.	KM-4 x AR	29.73**	58.24**	49.07**	30.86**	52.25**	30.41**
11.	KM-4 x HM	48.51**	64.83**	55.28**	58.54**	62.50**	39.14**
12.	KM-4 x PS	48.32**	54.94**	45.96**	38.15**	39.75**	19.70**
13.	KM-5 x AR	-30.56**	-17.58**	-22.36**	-31.82**	-25.00**	-35.76**
14.	KM-5 x HM	-13.86**	-4.39**	-9.94**	-13.41**	-11.50**	-23.98**
15.	KM-5 x PS	10.53**	15.38**	8.69**	32.10**	33.75**	14.56**
16.	KM-6 x AR	9.01**	32.96**	25.26**	61.29**	87.50**	60.59**
17.	KM-6 x HM	42.28**	58.02**	48.86**	71.95**	76.25**	50.96**
18.	KM-6 x PS	3.16**	7.69**	1.45*	40.75**	42.50**	22.05**
19.	KM-7 x AR	70.21**	75.82**	65.63**	35.00**	35.00**	15.63**
20.	KM-7 x HM	52.87**	79.12**	68.73**	34.75**	34.75**	63.81**
21.	KM-7 x PS	71.28**	76.92**	66.66**	21.25**	21.25**	3.85**
22.	KM-8 x AR	34.76**	38.46**	30.43**	20.20**	21.25**	3.85**
23.	KM-8 x HM	-14.44**	-12.09**	-17.18**	-26.89**	-26.25**	-36.83**
24.	KM-8 x PS	51.87**	56.04**	46.99**	33.83**	35.00**	15.60**
	S.Em±	0.419	0.419	0.419	0.138	0.138	0.138
	C.D. at 5%	1.29	1.29	1.29	0.40	0.40	0.40
	C.D. at 1%	1.63	1.63	1.63	0.54	0.54	0.54

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

BTP = Better parent BP = Best parent CC = Commercial check

Table 18. ***Per se*** **performance of parents and crosses for total soluble solids, total sugars and β-carotene content of fruit in muskmelon**

Sl. No.	Genotypes	Total soluble solids (°Brix)	Total sugars (%)	β-carotene content (µg/100 g)
	Crosses			
1.	KM-1 x AR	5.10	4.15	309.00
2.	KM-1 x HM	7.72	5.82	337.70
3.	KM-1 x PS	6.26	6.12	342.45
4.	KM-2 x AR	8.18	6.75	533.05
5.	KM-2 x HM	6.85	5.68	268.60
6.	KM-2 x PS	8.30	7.31	685.60
7.	KM-3 x AR	7.18	6.43	670.30
8.	KM-3 x HM	7.07	6.45	637.40
9.	KM-3 x PS	12.70	10.84	697.35
10.	KM-4 x AR	10.07	8.71	252.80
11.	KM-4 x HM	11.26	7.55	238.75
12.	KM-4 x PS	12.55	9.90	549.99
13.	KM-5 x AR	7.89	7.60	418.42
14.	KM-5 x HM	10.01	8.47	355.10
15.	KM-5 x PS	8.65	7.30	431.25
16.	KM-6 x AR	9.33	7.93	526.07
17.	KM-6 x HM	11.95	9.35	211.05
18.	KM-6 x PS	8.34	7.51	471.35
19.	KM-7 x AR	9.16	8.60	246.05
20.	KM-7 x HM	10.82	10.40	289.45
21.	KM-7 x PS	8.82	6.84	613.10
22.	KM-8 x AR	11.75	9.57	469.74
23.	KM-8 x HM	9.70	7.85	504.49
24.	KM-8 x PS	10.43	8.77	270.55
	Lines			
25.	KM-1	5.78	7.26	458.24
26.	KM-2	7.02	7.53	423.17
27.	KM-3	7.38	6.40	428.95
28.	KM-4	7.20	6.20	315.30
29.	KM-5	8.44	7.97	298.10
30.	KM-6	8.70	7.56	425.75
31.	KM-7	8.42	7.07	400.10
32.	KM-8	8.72	8.11	401.20
	Testers			
33.	AR	8.24	6.59	348.25
34.	HM	8.06	6.65	442.98
35.	PS	8.93	7.63	440.05
	Commercial check	7.43	6.63	468.35
	S.Em±	0.207	0.389	11.667
	C.D. at 5%	0.60	1.12	33.69
	C.D. at 1%	0.81	1.51	45.37

(-27.08%) followed by KM-5 x HM (-21.87%) and KM-5 x PS (-16.67). Maximum negative and significant heterosis over the commercial check was observed in the cross KM-6 x AR (-40.17%) followed by KM-5 x HM (-35.89%) and KM-5 x PS (-31.62%). Out of 24 crosses, 12 crosses over better parent, seven crosses over the best parent and 16 crosses over the commercial check exhibited negative and significant heterosis for the trait fruit shape index.

4.2.13 Flesh thickness (Tables 15 and 16)

Genotypes differed significantly among themselves for flesh thickness. It varied from 1.78 (HM) to 2.14 cm (AR) among testers, 1.25 (KM-2) to 2.92 cm (KM-3) among lines and it ranged from 1.33 (KM-5 x HM) to 3.57 cm (KM-3 x PS) among crosses. Magnitude of heterosis over better parent, the best parent and the commercial check was highly significant in both the directions. Maximum positive and significant heterosis over better parent was observed in the cross KM-7 x HM (71.83%) followed by KM-4 x PS (63.75%) and KM-2 x AR (55.84%). Maximum positive and significant heterosis over the best parent was observed in the cross KM-3 x PS (22.26%) followed by KM-6 x HM (18.83%) and KM-2 x AR (14.38%). Maximum positive and significant heterosis over the commercial check was observed in KM-3 x PS (75.86%) followed by KM-6 x HM (70.93%) and KM-2 x AR (64.53%).

Out of 24 crosses, 20 crosses over better parent, eight over the best parent and 21 crosses over the commercial check exhibited positive and significant heterosis for the trait flesh thickness.

4.2.14 Rind thickness (Tables 15 and 16)

Rind thickness of the fruit varied significantly among the genotypes and it ranged from 0.47 (HM) to 0.52 cm (AR) among testers, 0.34 (KM-3) to 0.58 cm (KM-6) among lines and it varied from 0.28 (KM-7 x HM) to 0.62 cm (KM-6 x HM) among crosses. Magnitude of heterosis over better parent, the best parent and the commercial check was highly significant in both the directions. Maximum negative (desirable) and significant heterosis over better parent was observed in KM-7 x HM (-37.50%) followed by KM-6 x PS (-33.33%) and KM-4 x PS (-32.29%). Maximum negative and significant heterosis over the best parent was observed in cross KM-7 x HM (-17.64%) followed by KM-8 x AR (-11.76%) and KM-3 x PS (-8.82%). Maximum negative and significant heterosis over the commercial check was observed in the cross KM-7 x HM (-40.42%) followed by KM-8 x AR (-36.17%) and KM-3 x PS (-34.04%).

Out of 24 crosses, 17 crosses over better parent, six crosses over the best parent and 17 crosses over the commercial check exhibited significant negative heterosis for the trait rind thickness.

4.2.15 Cavity length (Tables 15 and 17)

Genotypes differed significantly among themselves for cavity length. It varied from 4.75 (PS) to 5.55 cm (AR) among testers, 4.55 (KM-2) to 10.70 cm (KM-6) among lines and it ranged from 3.75 (KM-5 x AR) to 8.05 cm (KM-7 x PS) among crosses. Magnitude of heterosis over better parent, the best parent and commercial check was highly significant in both the directions. Maximum negative (desirable) and significant heterosis over better parent was observed in the cross KM-5 x AR (-30.56%) followed by KM-8 x HM (-14.44%) and KM-5 x HM (-13.86%). Maximum negative and significant heterosis over the best parent was observed in the cross KM-5 x AR (-17.58%) followed by KM-8 x HM (-12.09%) and KM-1 x HM (-10.99%). Maximum negative and significant heterosis over the commercial check was observed in the cross KM-5 x AR (-22.36%) followed by KM-8 x HM (-17.18%) and KM-1 x HM (-16.14%). Out of 24 crosses, four crosses over better parent, four crosses over the best parent and four crosses over the commercial check exhibited negative and significant heterosis for cavity length.

4.2.16 Cavity breadth (Tables 15 and 17)

Cavity breadth of the fruit varied significantly among the genotypes. It ranged from 4.05 (PS) to 4.65 cm (AR) among testers, 4.00 (KM-7) to 7.80 cm (KM-6) among lines and from 2.95 (KM-8 x HM) to 7.50 cm (KM-6 x AR) among crosses. Magnitude of heterosis over better parent, the best parent and the commercial check was highly significant in both the directions. Maximum negative and significant heterosis over better parent was observed in the cross KM-5 x AR (-31.82%) followed by KM-8 x HM (-26.89%) and KM-1 x HM (-24.39%). Maximum negative and significant heterosis over the best parent was observed in the cross KM-8 x HM (-26.25%) followed by KM-5 x AR (-25.00%) and KM-1 x HM (-22.50%). Maximum negative and significant heterosis over commercial check was observed in the cross KM-8 x HM (-36.83%) followed by KM-5 x AR (-35.76%) and KM-1 x HM (-33.62%).

Out of 24 crosses, five crosses over better parent and the five crosses over the best parent and seven crosses over commercial check exhibited negative and significant heterosis for the trait cavity breadth.

4.2.17 Total soluble solids (Tables 18 and 19)

Total soluble solids (TSS) of the fruit varied significantly among genotypes and it ranged from 8.06 (HM) to 8.93°Brix (PS) among testers, 5.78 (KM-1) to 8.72°Brix (KM-8) among lines and from 5.10 (KM-1 x AR) to 12.70°Brix (KM-3 x PS) among crosses. Magnitude of heterosis over better parent, the best parent and commercial check was highly significant in both the directions. Maximum positive and significant heterosis over better parent was observed in the cross KM-3 x PS (42.21%)

Table 19. Heterosis (%) over better parent, the best parent and commercial check for total soluble solids, total sugars and β-carotene content of fruit in muskmelon

Sl. No.	Genotypes	Total soluble solids (°Brix)			Total sugars (%)			β-carotene content (µg/100 g)		
		BP	BTP	CC	BP	BTP	CC	BP	BTP	CC
1.	KM-1 x AR	-38.14**	-42.89**	-31.36**	-42.80**	-48.83**	-37.40**	-32.57	-32.57	-34.02*
2.	KM-1 x HM	-4.34**	-13.55**	3.90**	-19.71**	-28.24**	-12.22**	-26.30	-26.30	-27.89
3.	KM-1 x PS	-29.90**	-29.90**	-15.75**	-19.72**	-24.54**	7.69**	-25.27	-25.27	-26.88
4.	KM-2 x AR	-0.85**	-8.40**	10.09**	-10.30**	-16.77**	1.81**	25.96	16.32	13.81
5.	KM-2 x HM	-15.07**	-23.29**	-7.81**	-24.58**	-29.96**	-14.33**	-39.37*	-41.38*	-42.65*
6.	KM-2 x PS	-7.05**	-7.05**	11.71**	-4.19**	-9.86**	10.26**	55.80**	49.61**	46.39**
7.	KM-3 x AR	-12.98**	-19.60**	-3.36**	-2.43**	-20.71**	-3.02**	56.27**	46.28**	43.12*
8.	KM-3 x HM	-12.28**	-20.83**	-4.84**	-3.01**	-20.47**	-2.71**	43.89*	39.09*	36.09*
9.	KM-3 x PS	42.21**	42.21**	70.93**	42.14**	33.66**	63.50**	58.47**	52.18**	48.89**
10.	KM-4 x AR	22.20**	12.76**	35.53**	32.27**	7.39**	31.37**	-27.41	-44.83*	-46.02**
11.	KM-4 x HM	39.68**	26.09**	51.55**	13.53**	-6.90**	13.88**	-46.10**	-47.90**	-49.02**
12.	KM-4 x PS	40.54**	40.54**	68.91**	29.69**	22.07**	49.32**	24.98	20.02	17.43
13.	KM-5 x AR	-6.63**	-11.65**	6.19**	-4.70**	-6.29**	14.63**	20.15	-8.69	-10.66
14.	KM-5 x HM	18.53**	12.09**	34.72**	6.14**	4.44**	27.75**	-19.84	-22.51	-24.18
15.	KM-5 x PS	-3.13**	-3.13**	16.42**	-8.53**	-9.99**	10.10**	-2.00	-5.89	-7.92
16.	KM-6 x AR	7.18**	4.48**	25.57**	4.90**	-2.22**	19.61**	23.56	14.80	12.32
17.	KM-6 x HM	37.28**	33.82**	60.83**	23.70**	15.29**	41.02**	-52.36**	-53.94**	-54.94**
18.	KM-6 x PS	-6.61**	-6.61**	12.25**	-1.05	-6.90**	13.88**	7.11	2.86	0.64
19.	KM-7 x AR	8.91**	2.57**	23.28**	21.55**	6.04**	29.71**	-38.50*	-46.30**	-47.46**
20.	KM-7 x HM	28.64**	21.16**	45.62**	46.93**	28.24**	56.86**	-34.66*	-36.83*	-38.19*
21.	KM-7 x PS	-1.23**	-1.23**	18.71**	-10.35**	-15.66**	3.17**	39.33*	33.79*	30.91
22.	KM-8 x AR	34.75**	31.58**	58.14**	18.00**	18.00	44.34**	17.08	2.50	0.30
23.	KM-8 x HM	11.24**	8.62**	30.55**	-3.20**	-3.20**	18.40**	13.89	10.09	7.72
24.	KM-8 x PS	16.80**	16.80**	40.38**	8.14**	8.14**	32.28**	-38.52*	-40.96*	42.23*
	S.Em±	0.207	0.207	0.207	0.389	0.389	0.389	11.667	11.667	11.667
	C.D. at 5%	0.60	0.60	0.60	1.12	1.12	1.12	33.69	33.69	33.69
	C.D. at 1%	0.81	0.81	0.81	1.51	1.51	1.51	45.37	45.37	45.37

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

BTP = Better parent   BP = Best parent   CC = Commercial check

followed by KM-4 x PS (40.54%) and KM-4 x HM (39.68%). Maximum positive and significant heterosis over the best parent was observed in the cross KM-3 x PS (42.21%) followed by KM-4 x PS (40.54%) and KM-8 x AR (31.58%). Maximum positive and significant heterosis over commercial check was observed in the cross KM-3 x PS (70.93%) followed by KM-4 x PS (68.91%) and KM-6 x HM (60.83%).

Out of 24 crosses, 12 crosses over better parent, 12 crosses over the best parent and 19 crosses over the commercial check exhibited positive and significant heterosis for total soluble solids.

4.2.18 Total sugars (Tables 18 and 19)

Genotypes differed significantly among themselves for total sugars. It varied from 6.59 (AR) to 7.63 per cent (PS) among testers, 6.20 (KM-4) to 8.11 per cent (KM-8) among lines and it ranged from 4.15 (KM-1 x AR) to 10.84 per cent (KM-3 x PS) among crosses. Magnitude of heterosis over better parent, the best parent and the commercial check was highly significant in both the directions. Maximum positive and significant heterosis over better parent was observed in the cross KM-7 x HM (46.93%) followed by KM-3 x PS (42.14%) and KM-4 x PS (29.69%). Maximum positive and significant heterosis over the best parent was observed in the cross KM-3 x PS (33.66%) followed by KM-7 x HM (28.24%) and KM-4 x PS (22.07%). Maximum positive and significant heterosis over the commercial check was observed in the cross KM-3 x PS (63.50%) followed by KM-7 x HM (56.86%) and KM-4 x PS (49.32%). Out of 24 crosses, 11 crosses over better parent, nine crosses over the best parent and 18 crosses over commercial check exhibited positive and significant heterosis for total sugars.

4.2.19 β-carotene content (Tables 18 and 19)

Genotypes varied significantly among themselves for β-carotene content of the fruit. It ranged from 348.25 (AR) to 442.98 µg per 100 g (HM) among testers, 298.10 (KM-5) to 458.24 µg per 100 g (KM-1) among lines and it varied from 211.05 (KM-6 x HM) to 697.35 µg per 100 g (KM-3 x PS) among crosses. Magnitude of heterosis over better parent, the best parent and commercial check was highly significant in both the directions. Maximum positive and significant heterosis over better parent was observed in the cross KM-3 x PS (58.47%) followed by KM-3 x AR (56.27%) and KM-2 x PS (55.80%). Maximum positive and significant heterosis over the best parent was observed in the cross KM-3 x PS (52.18%) followed by KM-2 x PS (49.61%) and KM-3 x AR (46.28%). Maximum positive and significant heterosis over commercial check was observed in the cross KM-3 x PS (48.89%) followed by KM-2 x PS (46.39%) and KM-3 x AR (43.12%).

Out of 24 crosses, five crosses each over better parent and the best parent and four crosses over the commercial check exhibited positive and significant heterosis for β-carotene content of the fruit.

4.3 COMBINING ABILITY

4.3.1 Variance due to general combining ability and specific combining ability

The variance due to general combining ability (GCA), specific combining ability (SCA) and SCA to GCA ratio for different characters are presented in Table 20. SCA to GCA ratio was very higher for cavity breadth (31.50), total sugars (21.00), fruit yield per vine (-16.00), number of fruits per vine (-14.75) and flesh thickness (-11.66). SCA to GCA ratio was high for characters like number of fruiting branches per vine (-9.66), average fruit weight (-8.53), total soluble solids (7.24), cavity length (5.94), days to first harvesting (5.03), vine length at 60 DAS (4.28), β-carotene content (3.74) and number of branches at 60 DAS (2.47). SCA to GCA ratio was medium for characters like number of leaves at 30 DAS (1.91), number of nodes upto first female flower (1.80), number of leaves at 60 DAS (1.41), fruit shape index (-1.20), days to first flowering (1.07), days to first female flowering (1.01) and vine length at 30 DAS (1.00). SCA to GCA ratio was low for the characters like vine length at 90 DAS (0.86), number of branches at 30 DAS (0.80) and rind thickness (-0.50).

4.3.2 Combining ability effects

General combining ability effects and specific combining ability effects for various characters are presented hereunder:

4.3.2.1 Vine length (Tables 21 and 22)

For vine length at 30 DAS, only one line, *i.e.*, KM-3 (3.01) exhibited positive and significant gca effects and all other lines exhibited non-significant gca effects. None of the testers exhibited significant gca effects. None of the crosses showed significant sca effects for vine length at 30 DAS.

For vine length at 60 DAS, two lines showed positively significant gca effects and four lines showed negatively significant gca effects. Maximum positive gca effects was observed in KM-3 (21.12) followed by KM-4 (7.70). Among testers, PS (3.04) exhibited maximum positive and significant gca effects. Among crosses, four showed positively significant sca effects, whereas two crosses exhibited exhibited significantly negative sca effects. Maximum sca effect (14.08) was exhibited by the cross KM-7 x AR followed by KM-3 x PS (13.80), KM-8 x AR (9.16) and KM-4 x PS (4.84) for vine length at 60 DAS.

Among eight lines, two showed positively significant gca effects and three lines had significant negative gca effects for the character vine length at 90 DAS. Highest positive gca effects was observed in KM-3 (20.17) followed by KM-4 (19.89). Among testers, PS (3.92) exhibited positive and significant gca effects. Among crosses, four exhibited positive and significant sca effects. The

Table 20. Variance due to general combining ability (GCA) and specific combining ability (SCA) for different characters in muskmelon

Sl. No.	Character	GCA	SCA	SCA : GCA
1.	Vine length at 30 DAS	0.72	0.72	1.00
2.	Vine length at 60 DAS	20.59	88.09	4.28
3.	Vine length at 90 DAS	51.84	44.61	0.86
4.	Number of branches at 30 DAS	0.05	0.04	0.80
5.	Number of branches at 60 DAS	0.17	0.42	2.47
6.	Number of leaves at 30 DAS	1.07	2.05	1.91
7.	Number of leaves at 60 DAS	73.25	103.58	1.41
8.	Days to first flowering	2.21	2.37	1.07
9.	Days to first female flowering	12.47	12.64	1.01
10.	Number of nodes upto first female flower	0.20	0.36	1.80
11.	Days to first harvest	5.47	27.51	5.03
12.	Number of fruiting branches	-0.35	3.38	-9.66
13.	Number of fruits per vine	-0.04	0.59	-14.75
14.	Average fruit weight (g)	-9324.27	79531.57	-8.53
15.	Fruit yield per vine (kg)	-0.02	0.32	-16.00
16.	Fruit shape index	-0.05	0.06	-1.20
17.	Flesh thickness (cm)	-0.03	0.35	-11.66
18.	Rind thickness (cm)	-0.02	0.01	-0.50
19.	Cavity length (cm)	0.16	0.95	5.94
20.	Cavity breadth (cm)	0.04	1.26	31.50
21.	Total soluble solids	0.37	2.68	7.24
22.	Total sugars	0.09	1.89	21.00
23.	β-carotene content (µg/100 g)	4399.79	16476.72	3.74

Table 21. General combining ability effects for growth parameters in muskmelon

Sl. No.	Parents	Vine length at			Number of branches at		Number of leaves at	
		30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	30 DAS	60 DAS
	Lines							
1.	KM-1	-1.24	-0.04	-15.00**	-0.02	-0.71**	0.56	-9.73**
2.	KM-2	1.23	-3.07*	-14.81**	-0.17	-0.56*	-0.55	0.27
3.	KM-3	3.01**	21.12**	20.17**	0.66*	1.75**	3.44**	26.75**
4.	KM-4	0.22	7.70**	19.89**	0.50	0.83**	1.68*	19.53**
5.	KM-5	-0.86	0.86	-2.44	-0.33	-0.53*	-1.38	2.43
6.	KM-6	-1.36	-4.17**	-4.51*	0.23	0.44*	1.33	-11.83**
7.	KM-7	-0.26	-14.85**	-1.64	-0.42	-0.66*	-1.68*	-24.33**
8.	KM-8	-0.74	-7.56**	-1.66	-0.45	-0.55*	-3.39**	-3.09
	S.Em±	0.490	0.968	1.305	0.194	0.148	0.504	1.772
	C.D. at 5%	1.41	2.79	3.77	0.56	0.43	1.45	5.11
	C.D. at 1%	1.90	3.76	5.07	NS	0.57	1.96	6.89
	Testers							
9.	AR	-0.41	-0.90	-3.76**	0.04	-0.20	-0.57	-5.53**
10	HM	-0.33	-2.14*	-0.16	-0.20	0.01	0.20	2.46
11.	PS	0.74	3.04**	3.92**	0.16	0.19	0.37	3.07
	S.Em±	0.300	0.593	0.799	0.119	0.091	0.309	1.08
	C.D. at 5%	NS	1.71	2.31	NS	NS	NS	3.12
	C.D. at 1%	NS	2.31	3.11	NS	NS	NS	4.20

* and ** indicate significance of values at p=0.05 and p=0.01, respectively
DAS = Days after sowingNS = Non-significant

Table 22. Specific combining ability effects for growth parameters in muskmelon

Sl. No.	Parents	Vine length at			Number of branches at		Number of leaves at	
		30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	30 DAS	60 DAS
1.	KM-1 x AR	0.18	1.08	-3.16	-0.23	0.50	0.39	-13.86**
2.	KM-1 x HM	0.36	1.31	-3.54	0.16	-0.57	0.75	1.29
3.	KM-1 x PS	-0.54	-2.38	6.70*	0.07	0.07	-1.14	12.57**
4.	KM-2 x AR	0.12	-2.23	3.91	-0.15	0.47	0.81	3.05
5.	KM-2 x HM	1.11	4.49	7.68*	0.19	-0.27	0.16	2.28
6.	KM-2 x PS	-1.22	-2.26	-11.59**	-0.04	-0.20	-0.96	-5.33
7.	KM-3 x AR	0.26	-13.63	-10.08**	-0.24	-0.60	-1.28	-6.45
8.	KM-3 x HM	-1.24	-0.18	2.51	-0.13	0.00	-0.73	-4.31
9.	KM-3 x PS	0.98	13.80**	7.51*	0.38	0.60	2.00	10.76**
10.	KM-4 x AR	-0.30	-3.93	-3.01	-0.07	-0.68	-0.87	-5.82
11.	KM-4 x HM	-1.08	-0.91	-4.29	0.21	-0.56	-1.85	-0.43
12.	KM-4 x PS	1.38	4.84*	7.29*	-0.13	1.24**	2.71*	6.26
13.	KM-5 x AR	0.39	-1.74	1.53	0.27	0.46	-0.14	1.66
14.	KM-5 x HM	-0.74	2.15	0.70	-0.44	0.21	-0.26	-5.06
15.	KM-5 x PS	0.35	-0.41	-2.23	0.16	-0.67	0.39	3.40
16.	KM-6 x AR	-0.41	-2.78	3.04	0.08	0.13	-0.68	13.09**
17.	KM-6 x HM	0.71	5.33	4.20	0.09	0.77*	1.14	8.26
18.	KM-6 x PS	-0.30	-2.55	-7.24*	-0.17	-0.90*	-0.46	-21.35**
19.	KM-7 x AR	0.53	14.08**	5.19	-0.13	-0.07	1.27	1.91
20.	KM-7 x HM	-0.35	1.73	-4.44	-0.14	0.19	0.81	2.09
21.	KM-7 x PS	-0.18	-15.81**	-0.75	0.27	-0.12	-2.08	-4.00
22.	KM-8 x AR	0.77	9.16**	2.58	0.48	-0.20	0.49	6.41
23.	KM-8 x HM	1.24	-13.93**	-2.82	0.07	0.23	-0.02	-4.11
24.	KM-8 x PS	-0.47	4.77	0.24	-0.55	-0.03	-0.47	-2.30
	S.Em±	0.848	1.678	2.261	0.337	0.257	0.874	3.075
	C.D. at 5%	NS	4.84	6.53	NS	0.74	2.52	8.86
	C.D. at 1%	NS	6.52	8.79	NS	1.00	NS	11.93

* and ** indicate significance of values at p=0.05 and p=0.01, respectively
DAS = Days after sowingNS = Non-significant

highest positive and significant sca effects was observed in KM-2 x HM (7.68) followed by KM-3 x PS (7.51), KM4-PS (7.29) and KM-1 x PS (6.70) for vine length at 90 DAS.

4.3.2.2 Number of branches (Tables 21 and 22)

For number of branches at 30 DAS, only one line, *i.e.*, KM-3 (0.66) showed positive and significant gca effects. None of the testers and crosses exhibited significant combining ability effects for number of branches at 30 DAS.

Among eight lines, three exhibited positive and significant gca effects and five exhibited negative and significant gca effects for the character number of branches at 60 DAS. The highest positive gca effects was observed in KM-3 (1.75) followed by KM-4 (0.83) and KM-6 (0.44). None of the testers exhibited positive and significant gca effects. Among crosses, two showed positive and one cross showed negative and significant sca effects. Maximum positive sca effects was observed in KM-4 x PS (1.24) followed by KM-6 x HM (0.77) for number of branches at 60 DAS.

4.3.2.3 Number of leaves (Tables 21 and 22)

For number of leaves at 30 DAS, two lines showed positive and significant gca effects and two lines showed negative and significant gca effects. Maximum positive and significant gca effects was observed in KM-3 (3.44) followed by KM-4 (1.68). None of the testers showed significant gca effects. Among crosses, only KM-4 x PS (2.71) exhibited positive and significant sca effects.

Among eight lines, two exhibited positive and significant gca effects and three exhibited negative and significant gca effects for number of leaves at 60 DAS. Maximum positive and significant gca effects was observed in KM-3 (26.75) followed by KM-4 (19.53). Among testers, only AR (-5.53) showed significant gca effects and it was in negative direction. Among crosses, three exhibited positive and significant sca effects and two crosses exhibited negative and significant sca effects. Maximum positive and significant sca effects was observed in KM-6 x AR (13.09) followed by KM-1 x PS (12.57) and KM-3 x PS (10.76) for number of leaves at 60 DAS.

4.3.2.4 Days to first flowering (Tables 23 and 24)

Seven lines exhibited significant gca effects, of which four lines exhibited significant gca effects in negative direction, which is desirable. Maximum negative and significant gca effects was observed in the line KM-3 (-3.56) followed by KM-2 (-2.00), KM-4 (-1.96) and KM-6 (-1.61). None of the testers showed significant gca effects. Out of 24 crosses, three crosses showed negative and significant sca effects. Maximum negative sca effects was observed in the cross KM-7 x AR (-3.04) followed by KM-4 x PS (-2.66) and KM-6 x HM (-2.14).

4.3.2.5 Days to first female flowering (Tables 23 and 24)

For days to first female flowering, three lines exhibited significantly negative (desirable) and one line significantly positive gca effects. Maximum negative gca effects was observed in the line KM-3 (-9.83) followed by KM-2 (-4.16), KM-4 (-3.99) and KM-1 (-2.06). None of the testers exhibited significant gca effects. Out of 24 crosses, three crosses showed negative and significant sca effects and two crosses showed positive and significant sca effects. Maximum negative and significant sca effects was observed in the cross KM-6 x HM (-6.81) followed by KM-4 x PS (-4.95) and KM-7 x PS (-4.40).

4.3.2.6 Number of nodes upto first female flower (Tables 23 and 24)

For number of nodes upto first female flower, two lines exhibited negative and significant gca effects which is desirable. The line KM-3 (-1.12) exhibited maximum negative gca effects followed by KM-4 (-1.01). None of the testers and crosses exhibited significant gca and sca effects, respectively.

4.3.2.7 Days to first harvest (Tables 23 and 24)

For days to first harvest, three lines exhibited negative (desirable) and significant gca effects and three lines exhibited positively significant gca effects. Maximum negative gca effects was observed in the line KM-4 (-8.37) followed by KM-3 (-5.40) and KM-8 (-3.86). None of the testers exhibited significant gca effects. Among crosses, only KM-8 x AR (-10.28) showed negative and significant sca effects.

4.3.2.8 Number of fruiting branches per vine (Tables 25 and 26)

For number of fruiting branches per vine, none of the lines and testers exhibited the significant gca effects. Among crosses, two crosses exhibited positive and significant sca effects and one cross exhibited negative and significant sca effects. Maximum positive and significant sca effects was observed in cross KM-3 x PS (3.75) followed by KM-7 x AR (2.97).

4.3.2.9 Number of fruits per vine (Tables 25 and 26)

For number of fruits per vine, none of the lines exhibited the significant gca effects. Among testers, PS (0.38) exhibited positive and significant gca effects. Among crosses, only KM-7 x AR (1.01) exhibited positive and significant sca effects.

4.3.2.10 Average fruit weight (Tables 25 and 26)

For average fruit weight, five lines exhibited positive and significant gca effects and three lines exhibited negative and significant gca effects. Maximum positive and significant gca effects was

Table 23. General combining ability effects for earliness parameters in muskmelon

Sl. No.	Parents	Days to first flowering	Days to first female flowering	Number of nodes upto first female flower	Days to first harvest
	Lines				
1.	KM-1	-0.23	-2.06	1.50**	3.70*
2.	KM-2	-2.00**	-4.16**	0.77*	3.48
3.	KM-3	-3.56**	-9.87**	-1.12**	-5.40**
4.	KM-4	-1.96*	-3.99**	-1.01**	-8.37**
5.	KM-5	1.43*	0.19	-0.46	7.89**
6.	KM-6	-1.61*	-1.41	0.34	-2.50
7.	KM-7	1.54*	10.55	-0.06	5.06**
8.	KM-8	6.35**	10.76**	0.06	-3.86*
	S.Em±	0.422	0.733	0.258	1.252
	C.D. at 5%	1.21	2.11	0.74	3.61
	C.D. at 1%	1.63	2.85	1.00	4.87
	Testers				
9.	AR	-0.20	1.15	0.24	-1.42
10	HM	-0.05	-0.62	-0.41	-0.21
11.	PS	0.26	-0.53	0.18	1.63
	S.Em±	0.258	0.449	0.158	0.767
	C.D. at 5%	NS	NS	NS	NS
	C.D. at 1%	NS	NS	NS	NS

* and ** indicate significance of values at p=0.05 and p=0.01, respectively
DAS = Days after sowingNS = Non-significant

Table 24. Specific combining ability effects for earliness parameters in muskmelon

Sl. No.	Parents	Days to first flowering	Days to first female flowering	Number of nodes upto first female flower	Days to first harvest
1.	KM-1 x AR	-0.28	-2.18	-0.47	-0.09
2.	KM-1 x HM	-0.74	-0.21	0.48	0.39
3.	KM-1 x PS	1.02	2.40	-0.01	-0.30
4.	KM-2 x AR	0.10	-0.70	-0.04	-0.74
5.	KM-2 x HM	0.17	0.86	0.11	-2.38
6.	KM-2 x PS	-0.28	-0.17	-0.08	3.13
7.	KM-3 x AR	-0.17	-0.10	-0.15	2.39
8.	KM-3 x HM	0.79	1.58	0.80	3.54
9.	KM-3 x PS	-0.63	-1.47	-0.34	-5.93
10.	KM-4 x AR	1.40	4.39*	-0.03	3.15
11.	KM-4 x HM	1.26	0.56	0.44	2.69
12.	KM-4 x PS	-2.66*	-4.95**	-0.42	-5.84
13.	KM-5 x AR	0.85	-3.12	-0.10	2.00
14.	KM-5 x HM	-0.90	0.05	0.74	2.41
15.	KM-5 x PS	0.05	3.07	-0.64	-4.41
16.	KM-6 x AR	1.09	2.32	0.20	-1.02
17.	KM-6 x HM	-2.14*	-6.81**	-1.26	-3.75
18.	KM-6 x PS	1.05	4.49*	1.06	4.77
19.	KM-7 x AR	-3.04**	1.20	-0.20	4.60
20.	KM-7 x HM	1.19	3.20	-0.26	-5.84
21.	KM-7 x PS	1.85	-4.40*	0.46	1.24
22.	KM-8 x AR	0.04	-1.81	0.78	-10.28**
23.	KM-8 x HM	0.36	0.77	-0.75	2.96
24.	KM-8 x PS	-0.41	1.04	-0.03	7.32*
	S.Em±	0.731	1.275	0.447	2.172
	C.D. at 5%	2.11	3.67	NS	6.26
	C.D. at 1%	2.84	4.93	NS	8.44

* and ** indicate significance of values at p=0.05 and p=0.01, respectively
NS = Non-significant

observed in line KM-4 (139.43) followed by KM-7 (73.93), KM-8 (59.51), KM-6 (56.87) and KM-3 (51.43). Among testers, only AR (65.61) exhibited positive and significant gca effects. Among crosses, nine exhibited positive and significant sca effects and 13 crosses exhibited negative and significant sca effects. Maximum positive and significant sca effects was observed in cross KM-6 x HM (517.01) followed by KM-4 x PS (373.42) and KM-3 x PS (289.20).

4.3.2.11 Fruit yield per vine (Tables 25 and 26)

For fruit yield per vine, three lines exhibited positive and significant gca effects and five lines exhibited negative and significant gca effects. Maximum positive and significant gca effects was observed in KM-6 (0.58) followed by KM-4 (0.44) and KM-7 (0.09). Among testers, only AR (0.08) exhibited positive and significant gca effects. Among crosses, seven exhibited positive and significant sca effects and 11 crosses exhibited negative and significant sca effects. Maximum positive and significant sca effects was observed by cross KM-7 x HM (1.04) followed by KM-3 x PS (0.81) and KM-2 x AR (0.65).

4.3.2.12 Fruit shape index (Tables 27 and 28)

Among lines, four exhibited negative and significant gca effects and two lines exhibited positive and significant gca effects for fruit shape index. Maximum negative and significant gca effects was observed in KM-5 (-0.19) followed by KM-6 (-0.15). Among testers, one exhibited negative and significant gca effects. Maximum negative and significant gca effects exhibited by AR (-0.05). Among crosses, seven exhibited negative and significant sca effects and eight crosses exhibited positive and significant sca effects. Maximum negative and significant sca effects of -0.21 was observed in crosses KM-2 x PS, KM-3 x HM and KM-4 x HM.

4.3.2.13 Flesh thickness (Tables 27 and 28)

Among lines, only KM-3 (0.60) exhibited positive and significant gca effects for flesh thickness. None of the testers exhibited significant gca effects. None of the crosses exhibited positive and significant sca effects and three crosses exhibited negative and significant sca effects.

4.3.2.14 Rind thickness (Tables 27 and 28)

For rind thickness, none of the lines exhibited negative and significant gca effects and one line exhibited positive and significant gca effects. None of the testers exhibited significant gca effects. Among crosses, KM-6 x PS (-0.15) exhibited negative and significant sca effects.

Table 25. General combining ability effects for yield parameters in muskmelon

Sl. No.	Parents	Number of fruiting branches per vine	Number of fruits per vine	Average fruit weight (g)	Fruit yield per vine (kg)
	Lines				
1.	KM-1	-0.46	0.26	-62.06**	-0.21**
2.	KM-2	-1.01	-0.47	-157.40**	-0.20**
3.	KM-3	1.28	0.49	51.43**	-0.12**
4.	KM-4	1.31	0.13	139.43**	0.44**
5.	KM-5	-0.42	-0.20	-42.71**	-0.35**
6.	KM-6	0.31	-0.01	56.87**	0.58**
7.	KM-7	-0.59	0.07	73.96**	0.09*
8.	KM-8	-0.41	-0.28	59.51**	-0.22**
	S.Em±	0.531	0.202	7.638	0.026
	C.D. at 5%	NS	NS	22.06	0.07
	C.D. at 1%	NS	NS	29.70	0.10
	Testers				
9.	AR	-0.50	-0.10	65.61**	0.08**
10	HM	0.15	-0.27	-13.18	0.03
11.	PS	0.35	0.38*	-52.42**	-0.11**
	S.Em±	0.325	0.123	4.678	0.015
	C.D. at 5%	NS	0.35	13.51	0.04
	C.D. at 1%	NS	NS	18.20	0.06

* and ** indicate significance of values at p=0.05 and p=0.01, respectively
NS = Non-significant

Table 26. Specific combining ability effects for yield parameters in muskmelon

Sl. No.	Parents	Number of fruiting branches per vine	Number of fruits per vine	Average fruit weight (g)	Fruit yield per vine (kg)
1.	KM-1 x AR	-1.47	0.15	166.63**	0.16*
2.	KM-1 x HM	1.58	0.27	-86.65**	0.37**
3.	KM-1 x PS	-0.11	-0.42	-79.98**	-0.53**
4.	KM-2 x AR	1.49	-0.67	271.03**	0.65**
5.	KM-2 x HM	-0.72	0.52	-145.38**	-0.50**
6.	KM-2 x PS	-0.76	0.15	-125.64**	-0.15*
7.	KM-3 x AR	-3.20*	-1.17*	25.89	-0.37**
8.	KM-3 x HM	-0.55	0.55	-315.09**	-0.44**
9.	KM-3 x PS	3.75**	0.62	289.20**	0.81**
10.	KM-4 x AR	1.37	-0.39	-191.35**	-0.01
11.	KM-4 x HM	-0.79	-0.20	-182.06**	-0.21**
12.	KM-4 x PS	-0.58	0.59	373.42**	0.22**
13.	KM-5 x AR	0.60	0.46	63.98**	0.05
14.	KM-5 x HM	0.25	-1.07*	-155.10**	-0.50**
15.	KM-5 x PS	-0.85	0.61	91.12**	0.45**
16.	KM-6 x AR	-0.98	-0.03	-274.82**	-0.19**
17.	KM-6 x HM	1.56	0.07	517.01**	0.17**
18.	KM-6 x PS	-0.58	-0.05	-242.19**	0.02
19.	KM-7 x AR	2.97*	1.01*	-92.39**	-0.41**
20.	KM-7 x HM	-1.59	0.25	181.55**	1.04**
21.	KM-7 x PS	-1.38	-1.27*	-89.16**	-0.63**
22.	KM-8 x AR	-0.78	0.63	31.03	0.12
23.	KM-8 x HM	0.26	-0.39	185.72**	0.08
24.	KM-8 x PS	0.52	-0.24	-216.76**	-0.21**
	S.Em±	0.918	0.350	13.232	0.045
	C.D. at 5%	2.60	1.01	38.20	0.13
	C.D. at 1%	3.57	NS	51.45	0.17

* and ** indicate significance of values at p=0.05 and p=0.01, respectively
NS = Non-significant

4.3.2.15 Cavity length (Tables 27 and 28)

For cavity length, only KM-5 (-1.68) exhibited negative and significant gca effects which is desirable and two lines exhibited positive and significant gca effects. None of the testers exhibited significant gca effects. None of the crosses exhibited negative and significant sca effects and only one cross exhibited positive and significant sca effects.

4.3.2.16 Cavity breadth (Tables 27 and 28)

For cavity breadth, three lines exhibited negative and significant gca effects which is desirable and one line exhibited positive and significant gca effects. Maximum negative and significant gca effects was observed in line KM-5 (-1.19) followed by KM-8 (-0.78) and KM-1 (-0.57). Among testers, HM (-0.25) exhibited negative and significant gca effects. Among crosses, seven exhibited negative and significant sca effects and six crosses exhibited positive and significant sca effects. Maximum negative and significant sca effects was observed in cross KM-5 x AR (-1.26) followed by KM-1 x HM (-1.23) and KM-8 x HM (-1.20).

4.3.2.17 Total soluble solids (Tables 29 and 30)

For total soluble solids content of fruit, three lines exhibited positive and significant gca effects and two lines exhibited negative and significant gca effects. Maximum positive and significant gca effects was exhibited by KM-4 (2.13) followed by KM-8 (1.45) and KM-6 (0.70). Among testers, only PS (0.33) exhibited positive and significant gca effects. Among crosses, seven crosses exhibited positive and significant sca effects and six crosses shown negative and significant sca effects. Maximum positive and significant sca effects was observed in cross KM-3 x PS (3.38) followed by KM-6 x HM (1.82) and KM-8 x AR (1.71).

4.3.2.18 Total sugars (Tables 29 and 30)

For total sugars content of fruit, two lines exhibited positive and significant gca effects and two lines exhibited negative and significant gca effects. Maximum positive and significant gca effects was observed in line KM-8 (0.98) followed by KM-4 (0.97). None of the testers exhibited significant gca effects. Among crosses, two exhibited positive and significant sca effects and one cross exhibited negative and significant sca effects. Maximum positive and significant sca effects was observed in cross KM-3 x PS (2.61) followed by KM-7 x HM (1.83).

4.3.2.19 β-carotene content (Tables 29 and 30)

For β-carotene content of fruit, two lines exhibited positive and significant gca effects and five lines exhibited negative and significant gca effects. Maximum positive and significant gca effects

Table 27. General combining ability effects for fruit shape index, flesh thickness, rind thickness, cavity length and cavity breadth in muskmelon

Sl. No.	Parents	Fruit shape index	Flesh thickness (cm)	Rind thickness (cm)	Cavity length (cm)	Cavity breadth (cm)
	Lines					
1.	KM-1	0.03	-0.33	0.09*	-0.52	-0.57**
2.	KM-2	0.09**	0.11	0.03	0.13	-0.06
3.	KM-3	-0.14**	0.60**	-0.06	-0.24	0.03
4.	KM-4	-0.06*	0.11	-0.06	1.12*	0.90**
5.	KM-5	-0.19**	-0.42*	0.03	-1.68**	-1.19**
6.	KM-6	-0.15**	0.17	0.07	-0.09	1.59**
7.	KM-7	0.10**	0.11	-0.04	1.61**	0.06
8.	KM-8	0.03	-0.36	-0.07	-0.33	-0.76**
	S.Em±	0.023	0.144	0.028	0.341	0.116
	C.D. at 5%	0.06	0.41	0.09	0.98	0.32
	C.D. at 1%	0.09	0.56	NS	1.33	0.43
	Testers					
9.	AR	-0.05**	0.13	0.00	0.32	0.30**
10	HM	0.03	-0.07	0.02	-0.37	-0.25*
11.	PS	0.01	-0.06	-0.02	0.04	-0.04
	S.Em±	0.014	0.088	0.018	0.208	0.071
	C.D. at 5%	0.04	NS	NS	NS	0.20
	C.D. at 1%	0.05	NS	NS	NS	0.26

* and ** indicate significance of values at p=0.05 and p=0.01, respectively
NS = Non-significant

Table 28. Specific combining ability effects for fruit shape index, flesh thickness, rind thickness, cavity length and cavity breadth in muskmelon

Sl. No.	Parents	Fruit shape index	Flesh thickness (cm)	Rind thickness (cm)	Cavity length (cm)	Cavity breadth (cm)
1.	KM-1 x AR	-0.05	0.50	0.08	1.86*	1.92**
2.	KM-1 x HM	-0.10	0.36	-0.10	-1.20	-1.23**
3.	KM-1 x PS	0.16**	-0.86*	0.01	-0.66	-0.69*
4.	KM-2 x AR	0.21**	0.45	-0.09	0.16	-0.24
5.	KM-2 x HM	0.01	0.00	0.10	0.20	-0.46
6.	KM-2 x PS	-0.21**	-0.45	-0.01	-0.36	0.70*
7.	KM-3 x AR	-0.04	-0.52	0.08	-0.41	-0.63*
8.	KM-3 x HM	-0.21**	0.14	-0.05	0.23	1.37**
9.	KM-3 x PS	0.25**	0.38	-0.03	0.19	-0.74**
10.	KM-4 x AR	0.12*	-0.14	0.01	-0.37	-0.27
11.	KM-4 x HM	-0.21**	-0.43	0.00	0.62	0.69*
12.	KM-4 x PS	0.33**	0.57	-0.01	-0.25	-0.42
13.	KM-5 x AR	0.28**	0.37	-0.05	-1.02	-1.26**
14.	KM-5 x HM	-0.18**	-0.83*	0.06	0.27	-0.16
15.	KM-5 x PS	-0.10	0.46	-0.01	0.76	1.43**
16.	KM-6 x AR	-0.19**	-0.90*	0.03	-0.32	0.45
17.	KM-6 x HM	0.30**	0.71	0.11	1.51	0.55
18.	KM-6 x PS	-0.11*	0.19	-0.15*	-1.19	-1.01**
19.	KM-7 x AR	-0.06	-0.11	-0.02	-0.07	-0.11
20.	KM-7 x HM	0.19**	0.36	-0.13	-0.19	0.43
21.	KM-7 x PS	-0.13*	-0.25	0.14*	0.26	-0.32
22.	KM-8 x AR	-0.02	0.35	-0.05	0.18	0.15
23.	KM-8 x HM	0.21	-0.32	0.00	-1.43	-1.20**
24.	KM-8 x PS	-0.19	-0.04	0.05	1.26	1.04**
	S.Em±	0.040	0.249	0.494	0.594	0.195
	C.D. at 5%	0.11	0.72	0.14	1.70	0.56
	C.D. at 1%	0.15	NS	NS	NS	0.76

* and ** indicate significance of values at p=0.05 and p=0.01, respectively
NS = Non-significant

Table 29. General combining ability effects for total soluble solids, total sugars and β-carotene content of fruit in muskmelon

Sl. No.	Parents	Total soluble solids	Total sugars	β-carotene content
	Lines			
1.	KM-1	-2.81**	-2.38**	-100.68**
2.	KM-2	-1.40**	-1.17*	65.35**
3.	KM-3	-0.19	0.16	237.95**
4.	KM-4	2.13**	0.97*	-83.22**
5.	KM-5	-0.32	0.04	-28.81*
6.	KM-6	0.70**	0.53	-27.58*
7.	KM-7	0.43	0.87	-47.53**
8.	KM-8	1.45**	0.98*	-15.47
	S.Em±	0.170	0.318	9.526
	C.D. at 5%	0.49	0.92	27.51
	C.D. at 1%	0.66	1.24	37.05
	Testers			
9.	AR	-0.59**	-0.28	-2.22
10	HM	0.25	-0.05	-75.08**
11.	PS	0.33*	0.33	77.30**
	S.Em±	0.103	0.195	5.834
	C.D. at 5%	0.30	NS	16.83
	C.D. at 1%	0.40	NS	22.68

* and ** indicate significance of values at p=0.05 and p=0.01, respectively
NS = Non-significant

Table 30. Specific combining ability effects for total soluble solids, total sugars and β-carotene content of fruit in muskmelon

Sl. No.	Parents	Total soluble solids	Total sugars	β-carotene content
1.	KM-1 x AR	-0.67	-0.94	-18.49
2.	KM-1 x HM	1.10	0.51	83.07**
3.	KM-1 x PS	-0.44	0.43	-64.57**
4.	KM-2 x AR	0.99*	0.45	39.52
5.	KM-2 x HM	-1.18**	-0.85	-152.07**
6.	KM-2 x PS	0.19	0.40	112.55**
7.	KM-3 x AR	-1.22**	-1.20	4.17
8.	KM-3 x HM	-2.16**	-1.41	44.13
9.	KM-3 x PS	3.38**	2.61**	-48.30*
10.	KM-4 x AR	-0.63	0.27	-92.16**
11.	KM-4 x HM	-0.29	-1.12	-33.35
12.	KM-4 x PS	0.92*	0.84	125.51**
13.	KM-5 x AR	-0.37	0.09	19.06
14.	KM-5 x HM	0.91*	0.73	28.59
15.	KM-5 x PS	-0.54	-0.82	-47.65*
16.	KM-6 x AR	0.05	-0.07	125.47**
17.	KM-6 x HM	1.82**	1.13	-116.69**
18.	KM-6 x PS	-1.87**	-1.06	-8.78
19.	KM-7 x AR	0.15	0.27	-134.59**
20.	KM-7 x HM	0.97*	1.83*	-18.33
21.	KM-7 x PS	-1.11*	-2.10*	152.93**
22.	KM-8 x AR	1.71**	1.12	57.03*
23.	KM-8 x HM	-1.18**	-0.83	164.65**
24.	KM-8 x PS	-0.53	-0.29	-221.68**
	S.Em±	0.294	0.551	16.508
	C.D. at 5%	0.84	1.59	47.65
	C.D. at 1%	1.14	2.14	64.16

* and ** indicate significance of values at p=0.05 and p=0.01, respectively
NS = Non-significant

was observed in line KM-3 (237.95) followed by KM-2 (65.35). Among testers, only PS (77.30) exhibited positive and significant gca effects. Among crosses, seven exhibited positive and significant sca effects and eight crosses exhibited negative and significant sca effects. Maximum positive and significant sca effects was observed in KM-8 x HM (164.65) followed by KM-7 x PS (152.93) and KM-6 x AR (125.47).

4.4 CORRELATION STUDIES

Simple correlation coefficients among growth, earliness, yield and quality parameters are presented in Table 31.

Vine length at 60 days after sowing (DAS) was positively and significantly (at p=0.01) associated (r_p=0.674) with vine length at 30 DAS. Vine length at 90 DAS was positively and significantly (at p=0.01) associated with vine length at 60 DAS (r_p=0.880) and vine length at 30 DAS (r_p=0.721). Number of branches per vine at 30 DAS was positively and significantly (at p=0.01) correlated with vine length at 90 DAS (r_p=0.612), vine length at 30 DAS (r_p=0.610) and vine length at 60 DAS (r_p=0.590). Number of branches per vine at 60 DAS was positively and significantly (at p=0.01) associated with vine length at 90 DAS (r_p=0.804), vine length at 30 DAS (r_p=0.756), vine length at 60 DAS (r_p=0.721) and number of branches at 30 DAS (r_p=0.690). Number of leaves at 30 DAS was positively and significantly (at p=0.01) correlated with vine length at 60 DAS (r_p=0.760), vine length at 90 DAS (r_p=0.730), vine length at 30 DAS (r_p=0.685), number of branches at 60 DAS (r_p=0.793) and number of branches at 30 DAS (r_p=0.688). Number of leaves at 60 DAS was positively and significantly (at p=0.01) correlated with vine length at 90 DAS (r_p=0.710), vine length at 60 DAS (r_p=0.685), vine length at 30 DAS (r_p=0.677), number of branches at 60 DAS (r_p=0.761), number of branches at 30 DAS (r_p=0.630) and number of leaves at 30 DAS (r_p=0.643).

Days to first flowering was negatively and significantly (at p=0.01) associated with number of leaves at 30 DAS (r_p=-0.680), number of branches at 30 DAS (r_p=-0.553) and 60 DAS (r_p=-0.544), vine length at 60 DAS (r_p=-0.538) and number of leaves at 60 DAS (r_p=-0.504). Days to first female flower was positively and significantly (at p=0.01) associated with days to first flowering (r_p=0.761), while it had significant (at p=0.01) and negative association with number of leaves at 30 (r_p=-0.658) and 60 DAS (r_p=-0.627), number of branches at 60 (r_p=-0.575) and 30 DAS (r_p=-0.573) and vine length at 60 DAS (r_p=-0.570). Number of nodes upto first female flower had negative and significant (at p=0.01) association with number of leaves at 60 DAS (r_p=-0.588), number of branches at 60 DAS (r_p=-0.559) and vine length at 90 DAS (r_p=-0.526). Days to first harvest had negative and significant (at p=0.01) association with number of branches at 60 DAS (r_p=-0.621), number of branches at 30 DAS (r_p=-0.574), number of leaves at 60 DAS (r_p=-0.541), vine length at 90 DAS (r_p=-0.433), number of leaves at 30 DAS (r_p=-0.430) and vine length at 30 (r_p=-0.405) and 60 DAS (r_p=-0.313), while it had positive and significant (at p=0.05) association with number of nodes upto first female flower (r_p=0.282) and days to first flowering (r_p=0.238).

Table 31. Correlation coefficients among growth, earliness, yield and quality parameters in muskmelon

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	**1.000**	0.674**	0.721**	0.610**	0.756**	0.685**	0.677**	-0.488**	-0.474**	-0.423**	-0.405**	0.656**	0.386**	0.286*	-0.003	0.260*	-0.354**	0.566**	0.032	0.041	0.254*	0.179	0.396**
2		**1.000**	0.880**	0.590**	0.721**	0.760**	0.685**	-0.538**	-0.570**	-0.423**	-0.313**	0.570**	0.370**	0.250*	-0.002	0.043	-0.214	0.458**	0.179	0.246*	0.280*	0.142	0.135
3			**1.000**	0.612**	0.804**	0.730**	0.710**	-0.423**	-0.388**	-0.526**	-0.433**	0.628**	0.323**	0.311**	0.002	0.049	-0.337**	0.438**	0.205	0.225	0.473**	0.274*	0.134
4				**1.000**	0.690**	0.688**	0.630**	-0.553**	-0.573**	-0.316**	-0.574**	0.571**	0.446**	0.281*	0.208	0.035	-0.221	0.472**	0.048	0.243*	0.267	0.114	0.352**
5					**1.000**	0.793**	0.761**	-0.544**	-0.575**	-0.559**	-0.621**	0.699**	0.426**	0.478**	0.209	0.186	-0.322**	0.587**	0.148	0.303*	0.450**	0.300*	0.323**
6						**1.000**	0.643**	-0.680**	-0.658**	-0.403**	-0.430**	0.618**	0.378**	0.393**	0.219	0.159	-0.172	0.518**	0.045	0.216	0.282*	0.158	0.219
7							**1.000**	-0.504**	-0.627**	-0.588**	-0.541**	0.534**	0.340**	0.248*	0.054	0.167	-0.329**	0.359**	0.023	0.092	0.374**	0.245*	0.277*
8								**1.000**	0.761**	0.398**	0.238*	-0.357**	-0.318**	-0.267*	-0.284*	-0.101	-0.019	-0.433**	-0.215	-0.345**	-0.001	0.013	-0.180
9									**1.000**	0.416**	0.210	-0.323**	-0.206	-0.218	-0.045	-0.146	-0.095	-0.366**	0.049	-0.129	0.061	0.146	-0.340**
10										**1.000**	0.282*	-0.360**	-0.199	-0.469**	-0.244*	-0.249*	0.233*	-0.375**	-0.105	-0.151	-0.350*	-0.324**	-0.098
11											**1.000**	-0.478**	0.378**	0.505**	0.460**	0.170	0.358**	0.507**	-0.188	-0.301*	-0.583**	-0.419**	-0.130
12												**1.000**	0.479**	0.309**	0.189	0.090	-0.319**	0.495**	-0.040	0.053	0.446**	0.340**	0.080
13													**1.000**	0.211	0.223	0.151	-0.360**	0.516**	0.005	0.132	0.199	0.244*	0.113
14														**1.000**	0.595**	0.548**	-0.099	0.576**	0.304*	0.221	0.467**	0.396**	-0.003
15															**1.000**	0.258*	-0.224	0.458**	0.263*	0.379**	0.358**	0.397**	-0.115
16																**1.000**	-0.128	0.325**	0.075	-0.232	0.089	0.176	0.136
17																	**1.000**	-0.328**	0.088	0.110	-0.382**	-0.419**	-0.249*
18																		**1.000**	0.345	0.418	0.261	0.175	0.186

																			**	**	*		
19																			**1.000**	0.731**	0.187	0.107	-0.146
20																				**1.000**	0.151	0.028	-0.062
21																					**1.000**	0.840**	-0.001
22																						**1.000**	0.038
23																							**1.000**

Critical r_p = 0.235 at p=0.05, 0.306 at p=0.01

1. Vine length at 30 DAS
2. Vine length at 60 DAS
3. Vine length at 90 DAS
4. Number of branches at 30 DAS
5. Number of branches at 60 DAS
6. Number of leaves at 30 DAS
7. Number of leaves at 60 DAS
8. Days to first flowering
9. Days to first female flowering
10. Number of nodes upto first female flower
11. Days to first harvest
12. Number of fruiting branches per vine
13. Number of fruits per vine
14. Average fruit weight
15. Fruit yield per vine
16. Fruit shape index
17. Flesh thickness
18. Rind thickness
19. Cavity length
20. Cavity breadth
21. Total soluble solids
22. Total sugars
23. β-carotene content

Number of fruiting branches per vine was positively and significantly (at p=0.01) associated with number of branches at 60 DAS (r_p=0.699), vine length at 30 (r_p=0.656) and 90 DAS (r_p=0.628), number of leaves at 30 DAS (r_p=0.618), number of branches at 30 DAS (r_p=0.571), vine length at 60 DAS (r_p=0.570) and number of leaves at 60 DAS (r_p=0.534).

Average fruit weight was positively and significantly (at p=0.01) associated with days to first harvest (r_p=0.505), number of branches at 60 DAS (r_p=0.478), number of leaves at 30 DAS (r_p=0.393), vine length at 90 DAS (r_p=0.311) and number of fruiting branches per vine (r_p=0.309). Average fruit weight was positively and significantly (at p=0.05) associated with vine length at 30 DAS (r_p=0.286), number of branches at 30 DAS (r_p=0.281), vine length at 60 DAS (r_p=0.250) and number of leaves at 60 DAS (r_p=0.248). It had negative and significant (at p=0.01) association with number of nodes upto first female flower (r_p=-0.469), while it had negative and significant (at p=0.05) association with days to first flowering (r_p=-0.267).

Fruit yield per vine was positively and significantly associated with average fruit weight (r_p=0.595) and days to first harvest (r_p=0.460), rind thickness (r_p=0.458), total sugars (r_p=0.397), cavity breadth (r_p=0.379) and total soluble solids (r_p=0.358) at p=0.01, while fruit yield per vine was positively and significantly associated with cavity length (r_p=0.263) and fruit shape index (r_p=0.258) at p=0.05. Fruit yield per vine had negative and significant (at p=0.05) association with days to first flowering (r_p=-0.284) and number of nodes upto first female flower (r_p=-0.244).

Fruit shape index was positively and significantly (at p=0.01) associated with average fruit weight (r_p=0.548). Rind thickness was positively and significantly (at p=0.01) association with number of branches at 60 DAS (r_p=0.587), average fruit weight (r_p=0.576), vine length at 30 DAS (r_p=0.566), number of leaves at 30 DAS (r_p=0.518), number of fruits per vine (r_p=0.516) and days to first harvest (r_p=0.507). Cavity breadth was positively and significantly (at p=0.01) associated with cavity length (r_p=0.731).

Total soluble solids was negatively and significantly (at p=0.01) associated with days to first harvest (r_p=-0.583). Total sugars was positively and significantly (at p=0.01) associated with total soluble solids (r_p=0.840).

5. DISCUSSION

The main aim of any breeding programme is to enhance the yielding ability of the crop. Heterosis breeding offers quick and quantum jump in yield. F_1 hybrids derived from crossing of pure lines are exceptionally uniform in growth and development and possess better quality and adaptability to varied environmental conditions and give high early and total yields and can be exploited in rapid deployment of dominant genes for resistance to disease and pests (Riggs, 1988). For commercial use, superiority of F_1 over mid-parent is of little value; hence, heterosis over better parent, the best parent and the commercial check was worked out in the present study on muskmelon and the results obtained are discussed in this chapter.

Genetic diversity among parents can ensure higher magnitude of heterosis and variance due to genotype was highly significant for all the growth, earliness, yield and quality parameters studied in the present investigation (Table 4), indicating large amount of diversity among the genotypes studied. Such diversity has also been reported previously in muskmelon (Lal and Singh, 1997 and Vijay, 1987). Rasik was selected as commercial check as it is the commercially popular private sector (Ankur Seeds Pvt. Ltd.) F_1 hybrid of muskmelon grown in this region.

Heterosis for growth parameters is an indication of heterosis for yield as the growth and yield parameters are strongly correlated (Table 31) which was also reported previously by Munshi and Verma (1997). Significant and higher magnitude of heterosis over better parent, the best parent and commercial check was observed for vine length at 30, 60 and 90 days after sowing (DAS), number of branches at 30 and 60 DAS and number of leaves at 30 and 60 DAS. In earlier studies also, significant heterosis was reported for vine length (More and Seshadri, 1980; Gaurav *et al*., 2000; Chaudhary *et al*., 2003a and Vishwanatha, 2003) and number of branches (Choudhary *et al*., 2003a and Vishwanatha, 2003) in muskmelon.

In the present study, out of 24 crosses, 21 crosses over better parent, six crosses over the best parent and 22 crosses over the commercial check exhibited positive and significant heterosis for vine length at 90 DAS. Such higher frequency of heterosis for vine length in muskmelon was also been reported previously by More and Seshadri (1980). All the crosses exhibited positive and significant heterosis over better parent and commercial check for number of branches at 60 DAS, whereas 13 crosses exhibited significant positive heterosis over the best parent. Similar frequency of heterosis over better parent and commercial check for number of branches was reported by Choudhary *et al*. (2003a) in muskmelon. For number of leaves at 60 DAS, 20 crosses over better parent, five crosses over the best parent and 19 crosses over the commercial check exhibited positive and significant heterosis. Number of leaves is an important source trait to support high yield (sink). Heterosis for number of leaves was also reported by Vishwanatha (2003) in muskmelon.

Days to first flowering, days to first female flowering, number of nodes upto first female flower and days to first harvest are the indicators of early yield. In the present study, all these index parameters significantly varied among genotypes. For these traits, negative heterosis is considered to be desirable. For days to first flowering, out of 24 crosses, 11 crosses over better parent, five crosses over the best parent and 17 crosses over the commercial check exhibited significant and negative (desirable) heterosis. Heterobeltiosis and standard heterosis for days to first flowering was also reported by Vishwanatha (2003) in muskmelon. For the trait days to first female flowering, out of 24 crosses, 13 crosses over better parent, seven crosses over the best parent and five crosses over commercial check exhibited significantly negative heterosis. Maximum negative heterosis over better parent (-21.33%), the best parent (-21.33%) and the commercial check (-18.82%) was exhibited by the cross KM-3 x PS. This hybrid (KM-3 x PS) took least number of days (33.12) for first female flower appearance among all the genotypes. Heterosis for earliness with reference to female flower appearance has also been reported by Lal and Dhaliwal (1996) and Choudhary *et al*. (2003a) in muskmelon.

For number of nodes upto first female flower, out of 24 crosses, 14 crosses over better parent, eight crosses over the best parent and 13 crosses over the commercial check exhibited significant and negative heterosis. Maximum negative heterosis over better parent (-32.26%) was exhibited by the cross KM-6 x HM and the cross KM-3 x PS exhibited maximum negative heterosis over the best parent (-11.70%) and over the commercial check (-29.66%). Such a significant and high magnitude of heterosis (-30.33%) over the commercial check in the desirable direction was also reported by Lal and Dhaliwal (1996) in muskmelon where they used Punjab hybrid variety as standard check. However, the F_1 hybrid Rasik was used as standard check in the present investigation. Further, as many as 13, six and nine crosses out of 24 crosses exhibited the desired significant and negative heterosis over better parent, the best parent and the commercial check, respectively, for days to first harvesting. Heterosis for days to first harvesting was also reported by Munshi and Verma (1997) in muskmelon.

Yield components greatly influence the yield and expression of heterosis for number of fruiting branches per vine, number of fruits per vine and average fruit weight can greatly contribute for heterosis observed for total fruit yield per vine. For all these traits, positive heterosis is desirable. For number of fruiting branches per vine, out of 24 crosses, 23 crosses over better parent, 16 crosses over the best parent and 14 crosses over commercial check exhibited significant and positive heterosis. Heterosis for number of fruiting branches per vine was also reported by Vishwanatha (2003) in muskmelon.

Number of fruits per vine can influence yield and out of 24 crosses, 17 crosses over better parent, nine crosses over the best parent and 12 crosses over the commercial check exhibited positive and significant heterosis for number of fruits per vine. The cross KM-3 x PS showed maximum positive and significant heterosis of 36.69 per cent over the best parent and 42.69 per cent over the commercial check. Standard heterosis for number of fruits per vine was also reported by Choudhary *et al*. (2003a) in muskmelon.

Average fruit weight is an important yield contributing trait which is evident from correlation studies (Table 31). Out of 24 crosses, six crosses over better parent and three crosses over the commercial check exhibited significant and positive heterosis for average fruit weight. The cross KM-4 x PS showed maximum and significant heterosis of 89.04 per cent over better parent. Heterobeltiosis of 82.69 per cent had been previously reported by More and Seshadri (1980) in muskmelon. The cross KM-6 x HM showed maximum and significant heterosis of 66.97 per cent over the commercial check. Standard heterosis of 60.40 per cent had been reported by Lal and Dhaliwal (1996) in muskmelon.

Fruit shape index indicates shape of the fruit and is an important quality parameter attributes to consumer preference. As round fruits are preferred, negative heterosis for fruit shape index (length/breadth) is desirable. For fruit shape index, out of 24 crosses, 12 crosses over better parent, seven crosses over the best parent and 16 crosses over the commercial check exhibited negative and significant heterosis.

Flesh thickness of the fruit can influence yield and can be an important quality trait as consumer prefer thick flesh. Out of 24 crosses, 20 crosses over better parent, eight crosses over the best parent and 21 crosses over the commercial check exhibited positive and significant heterosis. The cross KM-7 x HM showed maximum heterosis of 71.83 per cent over better parent which is very high compared to 20.33 per cent as reported by Choudhary *et al*. (2003a) in muskmelon for flesh thickness. The cross KM-3 x PS exhibited maximum heterosis of 75.86 per cent over the commercial check and is very high compared to 7.81 per cent as reported by Choudhary *et al*. (2003) in muskmelon. From the correlation studies (Table 31), it was observed that rind thickness had negative and significant association with flesh thickness, which is very important quality character of the fruit as thin rind is preferred by the consumers and hence negative heterosis is desirable for rind thickness. Out of 24 crosses, 17 crosses over better parent, six crosses over the best parent and 17 crosses over the commercial check exhibited significant negative (desirable) heterosis. Heterosis for rind thickness was also reported by Thomas *et al*. (1984) in muskmelon.

Reduction in cavity size has been considered as an important objective in muskmelon improvement and cavity length and cavity breadth reduction can reduce the cavity size and hence heterosis for cavity length and cavity breadth is desirable. For cavity length, out of 24 crosses, four crosses each over better parent, the best parent and the commercial check exhibited significant and negative (desirable) heterosis. The cross KM-5 x AR showed maximum negative heterosis of -22.36 per cent over commercial check and it is low compared to -50.08 per cent as reported by Vishwanatha (2003) in muskmelon. For cavity breadth, out of 24 crosses, five crosses each over better parent and the best parent and seven crosses over commercial check exhibited negative and significant heterosis. The cross KM-8 x HM exhibited maximum negative heterosis of -36.83 per cent over commercial check. Standard heterosis of -39.66 per cent had been reported by Vishwanatha (2003) in muskmelon.

Total soluble solids of the fruit is an important quality trait where high TSS is preferred by consumers. Out of 24 crosses, 12 crosses each over better parent and the best parent and 19 crosses over the commercial check exhibited positive and significant heterosis. The cross KM-3 x PS showed maximum heterosis of 42.21 per cent over better parent. Heterobeltiosis of 36.40 per cent has been reported by Kesavan and More (1991) in muskmelon. The cross KM-3 x PS exhibited maximum heterosis of 42.21 per cent over the best parent. Heterosis of 30.77 per cent over the best parent had been reported by Lianjie *et al*. (1995) in muskmelon. The cross KM-3 x PS exhibited maximum positive and significant heterosis of 70.93 per cent over the commercial check which is very high as compared to 20.85 per cent reported by Vishwanatha (2003) in muskmelon.

Total sugars is also an important quality character where consumers prefer sweet fruits. Out of 24 crosses, 11 crosses over better parent, nine crosses over the best parent and 18 crosses over the commercial check exhibited positive and significant heterosis. The cross KM-3 x PS showed maximum heterosis of 63.50 per cent over commercial check and is high compared to 28.83 per cent reported by Moon *et al*. (2006) in muskmelon. β-carotene content improves flesh colour appearance of the fruit and also an important nutritional quality parameter of the fruit. Out of 24 crosses, five crosses each over better parent and the best parent and four crosses over the commercial check exhibited positive and significant heterosis. The cross KM-3 x PS exhibited maximum heterosis of 48.89 per cent over commercial check. Standard heterosis of 35.75 per cent had been reported by Moon *et al*. (2006) in muskmelon.

For fruit yield per vine, out of 24 crosses, 11 crosses over better parent, eight crosses over the best parent and 13 crosses over the commercial check exhibited maximum positive and significant heterosis. The hybrid which exhibited maximum heterosis over the better parent was KM-7 x HM (36.09%) followed by KM-3 x PS (29.01%) and KM-8 x AR (27.77%). Heterobeltiosis of 44.44 per cent had been reported by Choudhary *et al*. (2003a) in muskmelon. The cross KM-7 x HM exhibited maximum heterosis of 32.59 per cent over the best parent for the fruit yield per vine followed by KM-6 x HM (15.62%) and KM-3 x PS (6.25%). Heterosis of 28.15 per cent over the best parent had been reported by Munshi and Verma (1997) in muskmelon. Maximum and significant standard heterosis was observed in the cross KM-7 x HM (66.85%) followed by KM-6 x HM (45.50%), KM-3 x PS (33.71%), KM-4 x PS (32.58%), KM-2 x AR (31.46%), KM-4 x AR (30.34%), KM-6 x PS (29.21%) and KM-6 x AR (28.09%) for the fruit yield per vine. Magnitude of standard heterosis in the present study is very high compared to earlier reports (27.98%) by Vishwanatha (2003) in muskmelon.

The hybrid KM-7 x HM was the best hybrid selected with the maximum estimated total fruit yield of 49.5 tonnes per hectare. High heterosis for yield is attributed to its significant heterosis over commercial check for the trait number of fruits per vine, flesh thickness, vine length at 90 DAS, number of branches at 60 DAS and number of leaves at 30 DAS. This hybrid also exhibited heterosis over commercial check in desirable direction for earliness trait, *viz*., number of nodes upto first female flower. The best hybrid KM-7 x HM also exhibited heterosis over the commercial check for important quality traits like flesh thickness, rind thickness, total soluble solids and total sugars in desirable direction. This hybrid is also identified as good specific combiner for average fruit weight, total soluble solids content of fruit and total sugars. Heterosis and recurrent selection schemes are promising breeding methods for yield improvement using KM-7 x HM as the parents, KM-7 and HM involved in development of this hybrid are not good general combiners for yield indicating predominance of non-additive gene action. This hybrid can be commercially exploited after testing its stability for yield.

The second best hybrid selected for fruit yield per vine is KM-6 x HM with an estimated yield potential of 43.16 tonnes per hectare and its yield potentiality is attributed to its significant heterosis over the commercial check for average fruit weight as this trait is strongly correlated (r_p=0.595) with fruit yield per vine. This hybrid also exhibited significant standard heterosis for number of fruiting branches per vine, vine length at 60 and 90 DAS, number of branches at 30 and 60 DAS and number of leaves at 30 and 60 DAS and all these traits contributed for yield heterosis as these traits significantly correlated with average fruit weight and number of fruiting branches per vine. The hybrid KM-6 x HM also exhibited significant heterosis in desirable (negative) direction over commercial check for earliness characters like days to first harvest, number of nodes upto first female flower, days to first female flowering and days to first flowering. It also exhibited significant standard heterosis for quality traits, *viz*., flesh thickness, total soluble solids and total sugars. The hybrid KM-6 x HM was also identified as good specific combiner for fruit yield per vine, average fruit weight, number of branches at 60 DAS, days to first flowering, days to first female flowering and total soluble solids content of the fruit. The line KM-6 which was involved in development of this hybrid was identified as good general combiner for fruit yield per vine, average fruit weight, number of branches at 60 DAS, days to first flowering, fruit shape index and total soluble solids. The other parent which involved in development of this hybrid (HM) was identified as good general combiner for cavity breadth only and it was poor general combiner for fruit yield per vine. This hybrid can be commercially exploited or further recurrent selection schemes and heterosis breeding can be followed for yield improvement using this hybrid as non-additive component are predominant for fruit yield per vine.

The third best hybrid selected for fruit yield per vine is KM-3 x PS with an estimated yield potential of 39.66 tonnes per hectare and it is attributed to its significant heterosis over the commercial check for the trait average fruit weight. It also exhibited significant standard heterosis for the trait number of fruiting branches per vine, which had significant and positive correlation with average fruit weight. This hybrid also exhibited significant standard heterosis for number of fruits per vine, vine length at 30, 60 and 90 DAS, number of branches at 30 and 60 DAS and number of leaves at 30 and 60 DAS and these traits had directly or indirectly through average fruit weight contributed for yield heterosis. This hybrid had also exhibited standard heterosis in desirable direction (negative) for earliness characters like days to first harvesting, number of nodes upto first female flower, days to first female flowering and days to first flowering. The hybrid KM-3 x PS had also exhibited significant heterosis in desirable direction over the commercial check for quality traits like flesh thickness, rind thickness, cavity breadth, total soluble solids, total sugars and β-carotene content of the fruit. This hybrid was also identified as good specific combiner for fruit yield per vine, average fruit weight, number of fruiting branches per vine, vine length at 60 and 90 DAS, number of leaves at 60 DAS, cavity breadth, total soluble solids and total sugars content of the fruit. The line KM-3 which involved in development of this hybrid was identified as good general combiner for vine length at 30, 60 and 90 DAS, number of branches at 30 and 60 DAS, number of leaves at 30 and 60 DAS, days to first flowering, days to first female flowering, number of nodes upto first female flower, days to first harvest, average fruit weight, flesh thickness and β-carotene content of the fruit. The other parent which involved in development of this hybrid (KM-3 x PS) was PS and it was identified as good general combiner for vine length at 60 and 90 DAS, number of fruits per vine, total soluble solids and β-carotene content of the fruit. As both the parents involved in development of this hybrid are poor combiners for fruit yield per vine, non-additive component of genetic variance is predominant in this hybrid. Therefore, this hybrid can be commercially exploited or further recurrent selection and heterosis breeding can be followed using this hybrid for yield improvement.

High magnitude of heterosis observed for fruit yield per vine over the best parent and commercial check in the present investigation is attributed to better growth and yield parameters observed in hybrids compared to parents. It is also evident from correlation studies where fruit yield per vine was positively and significantly associated with average fruit weight (r_p=0.595). Growth parameters like number of fruiting branches per vine (r_p=0.309), vine length at 90 DAS (r_p=0.311), number of branches at 60 DAS (r_p=0.478) and number of leaves at 30 DAS (r_p=0.393) with their strong correlation with average fruit weight had indirectly contributed to yield heterosis. It is also evident from correlation studies carried out previously (Somkuwar *et al*., 1997; Choudhary *et al*., 2003a) in muskmelon.

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 relative magnitude of non-additive (dominance + epistasis) and additive gene action. Hence, analysis of combining ability is the potential tool for identifying prospective parents to develop commercial F_1 hybrids. General and specific combining ability effects and variances obtained from set of F_1s 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 all the characters studied.

Among the eight parents, the line KM-3 followed by KM-4 were identified as the best general combiners for vine length at 60 DAS, number of branches at 60 DAS and number of leaves at 60 DAS as these lines had maximum gca effects in order of merit. Significant gca effects in desirable direction was also reported previously in muskmelon for vine length (Kalloo *et al*., 1990; Gurav, *et al*., 2000) and number of branches (Gurav *et al*., 2000). Out of eight parents, the line KM-3 followed by KM-2 were identified as the best general combiners for days to first flowering, days to first female flowering and β-carotene content of the fruit, as these lines had maximum gca effects in order of merit. Significant gca effects in desirable direction was also reported previously in muskmelon for days to first flowering and days to first female flowering (Dhaliwal and Lal, 1996). The line KM-3 was identified as the best general combiner for number of nodes upto first female flower (-1.12) and flesh thickness (0.60) as this line had maximum gca effects. Significant gca effects in desirable direction was also reported previously in muskmelon for number of nodes upto first female flower (Dhaliwal and Lal, 1996) and flesh thickness (Lianjie *et al*., 1995; Dhaliwal and Lal, 1996 and Thomas *et al*., 1984). Out of eight parents, the line KM-4 was identified as the best general combiner for days to first harvest (-8.37), average fruit weight (139.43) and total soluble solids (2.13) as this line had maximum gca effects for these traits. Significant gca effects in desirable direction was also reported previously in muskmelon for days to first harvest (More and Seshadri, 1980; Kesavan and More, 1991), average fruit weight (Kalloo *et al*., 1990; More and Seshadri, 1980; Kesavan and More, 1991; Dhaliwal and Lal, 1996) and total soluble solids (Kesavan and More, 1991; More and Seshadri, 1980; Thomas *et al*., 1984). Among the eight lines, the line KM-5 was identified as best general combiner for fruit shape index (-0.19), cavity length (-1.68) and cavity breadth (-1.19) as this line had maximum gca effects for these traits. Significant gca effects in desirable direction was also reported previously in muskmelon for fruit shape index (Kalloo *et al*., 1990; Thomas *et al*., 1984), cavity length (Kalloo *et al*., 1990) and cavity breadth (Kalloo *et al*., 1990).

Among eight parents, the highest and significant gca effects for fruit yield per vine was observed in the line KM-6 (0.58) followed by KM-4 (0.44) and KM-7 (0.09). Significant gca effects for total fruit yield per vine was also reported by More and Seshadri (1980) and Kesavan and More (1991) in muskmelon.

The estimation of sca effects for 24 crosses has resulted into identification of good specific combiners for various traits. For fruit yield per vine, the crosses KM-7 x HM (1.04), KM-3 x PS (0.81), KM-2 x AR (0.65), KM-5 x PS (0.45), KM-1 x HM (0.37), KM-4 x PS (0.22) and KM-6 x HM (0.17) were identified as good specific combiners in order of merit.

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 find out the status of a parent or hybrid with respect to combining ability effects over a number of component characters (Arunachalam and Bandopadhay, 1979).

An exercise 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 desirable direction and ‘-1’ for significant gca effects in undesirable direction. Similarly, every character, a hybrid was score ‘0’ for non-significant standard heterosis and ‘+1’ for significant standard heterosis in desirable direction and ‘-1’ for significant standard heterosis in undesirable dirction. All the parents and crosses were scored for each character and final score was computed by adding scores obtained in all the 23 characters. Finally, the parents or hybrids were classified as low and high, based on the mean value of the total scores obtained over all the 23 characters and details are presented in Table 32 for parents and in Table 33 for F_1 hybrids.

Comprehensive assessment of parents by considering gca effects of 23 characters resulted into identification of lines, *viz*., KM-3, KM-4 and KM-6 as good combiners over all characters and

Table 32. Overall analysis of general combining ability status of the parent in muskmelon

Sl. No.	Parent	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total		gca status
																									+ve	-ve	
	Line																										
1.	KM-1	0	0	-1	0	-1	0	-1	0	0	-1	-1	0	0	-1	-1	0	0	-1	0	+1	-1	-1	-1	1	11	L
2.	KM-2	0	-1	-1	0	-1	0	0	+1	+1	-1	0	0	0	-1	-1	-1	0	0	0	0	-1	-1	+1	3	9	L
3.	KM-3	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	0	0	+1	-1	+1	+1	0	0	0	0	0	+1	15	1	H
4.	KM-4	0	+1	+1	0	+1	+1	+1	+1	+1	+1	+1	0	0	+1	+1	+1	0	0	-1	-1	+1	+1	-1	14	3	H
5.	KM-5	0	0	0	0	-1	0	0	-1	0	0	-1	0	0	-1	-1	+1	-1	0	+1	+1	0	0	-1	3	7	L
6.	KM-6	0	-1	-1	0	+1	0	-1	+1	0	0	0	0	0	+1	+1	+1	0	0	0	-1	+1	0	-1	6	5	H
7.	KM-7	0	-1	0	0	-1	-1	-1	-1	0	0	-1	0	0	+1	+1	-1	0	0	-1	0	0	0	-1	2	9	L
8.	KM-8	0	-1	0	0	-1	-1	0	-1	-1	0	+1	0	0	+1	-1	0	0	0	0	+1	+1	+1	0	5	6	L
	Tester																										
9.	AR	0	0	-1	0	0	0	-1	0	0	0	0	0	0	+1	+1	+1	0	0	0	-1	-1	0	-1	3	5	L
10.	HM	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+1	0	0	-1	1	2	L
11.	PS	0	+1	+1	0	0	0	0	0	0	0	0	0	+1	-1	-1	0	0	0	0	0	+1	0	0	4	2	H

1. Vine length at 30 DAS
2. Vine length at 60 DAS
3. Vine length at 90 DAS
4. Number of branches at30 DAS
5. Number of branches at60 DAS
6. Number of leaves at30 DAS
7. Number of leaves at 60 DAS
8. Days to first flowering
9. Days to first female flowering
10. Number of nodes upto female flower
11. Days to first harvest
12. Number of fruiting branches
13. Number of fruits per vine
14. Average fruit weight
15. Fruit yield per vine
16. Fruit shape index
17. Flesh thickness
18. Rind thickness
19. Cavity length
20. Cavity breadth
21. Total soluble solids
22. Total sugars
23. β- carotene content of the fruit

DAS – Days after sowing

Table 33. Overall analysis of heterosis status of hybrid / crosses in muskmelon

Sl. No.	Cross	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total		Status of	
																									+ve	-ve	CH	PG
1	KM-1 x AR	-1	+1	0	-1	+1	+1	-1	+1	-1	-1	0	-1	+1	0	+1	+1	+1	-1	-1	-1	-1	-1	-1	8	12	L	LxL
2	KM-1 x HM	-1	+1	+1	-1	+1	+1	+1	+1	-1	-1	0	+1	+1	-1	+1	+1	+1	+1	+1	+1	+1	-1	0	15	6	H	LxL
3	KM-1 x PS	-1	+1	+1	+1	+1	+1	+1	+1	-1	-1	0	+1	+1	-1	-1	-1	-1	-1	-1	+1	-1	-1	0	10	11	L	LxH
4	KM-2 x AR	+1	0	+1	-1	+1	+1	+1	+1	0	-1	0	+1	-1	0	+1	-1	+1	+1	-1	-1	+1	+1	0	12	6	H	LxL
5	KM-2 x HM	+1	+1	+1	-1	+1	+1	+1	+1	0	-1	0	-1	-1	-1	-1	-1	+1	-1	-1	+1	-1	-1	-1	9	12	L	LxL
6	KM-2 x PS	+1	+1	0	-1	+1	+1	+1	+1	0	-1	-1	0	+1	-1	-1	+1	+1	+1	-1	-1	+1	+1	+1	13	7	H	LxH
7	KM-3 x AR	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	-1	-1	0	-1	+1	+1	+1	-1	-1	-1	-1	+1	15	7	H	HxL
8	KM-3 x HM	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	-1	-1	+1	+1	+1	-1	-1	-1	-1	+1	17	6	H	HxL
9	KM-3 x PS	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	-1	+1	+1	-1	+1	+1	+1	+1	21	2	H	HxH
10	KM-4 x AR	0	+1	+1	+1	+1	+1	+1	+1	-1	+1	+1	+1	-1	0	+1	+1	+1	+1	-1	-1	+1	+1	-1	16	5	H	HxL
11	KM-4 x HM	-1	+1	+1	+1	+1	+1	+1	+1	0	+1	+1	+1	-1	0	+1	+1	+1	+1	-1	-1	+1	+1	-1	16	5	H	HxL
12	KM-4 x PS	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	-1	+1	+1	-1	-1	+1	+1	0	19	3	H	HxH
13	KM-5 x AR	0	+1	+1	-1	+1	-1	+1	-1	-1	+1	-1	+1	+1	0	-1	+1	+1	+1	+1	+1	+1	+1	0	14	6	H	LxL
14	KM-5 x HM	-1	+1	+1	-1	+1	0	+1	+1	-1	+1	-1	+1	-1	-1	-1	+1	-1	-1	+1	+1	+1	+1	0	12	9	H	LxL
15	KM-5 x PS	+1	+1	+1	-1	+1	+1	+1	0	-1	+1	0	0	+1	0	+1	+1	+1	+1	-1	-1	+1	+1	0	14	4	H	LxH
16	KM-6 x AR	-1	0	+1	+1	+1	+1	+1	+1	-1	-1	+1	0	-1	-1	+1	+1	+1	-1	-1	-1	+1	+1	0	12	8	H	HxL
17	KM-6 x HM	0	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	-1	+1	+1	-1	+1	-1	-1	-1	+1	+1	-1	16	6	H	HxL
18	KM-6 x PS	0	+1	+1	+1	+1	+1	-1	+1	-1	-1	0	+1	+1	-1	+1	+1	+1	+1	-1	-1	+1	+1	0	14	6	H	HxH
19	KM-7 x AR	+1	+1	+1	-1	+1	+1	-1	+1	+1	+1	-1	+1	+1	0	-1	+1	+1	+1	-1	-1	+1	+1	-1	15	7	H	LxL
20	KM-7 x HM	0	-1	+1	-1	+1	+1	-1	-1	+1	+1	0	-1	+1	0	+1	-1	+1	+1	-1	-1	+1	+1	-1	11	9	H	LxL
21	KM-7 x PS	+1	-1	+1	-1	+1	-1	-1	-1	+1	-1	-1	-1	-1	0	-1	+1	+1	-1	-1	-1	+1	+1	0	8	13	L	LxH
22	KM-8 x AR	-1	+1	+1	+1	+1	-1	+1	-1	+1	-1	+1	-1	-1	0	+1	+1	+1	+1	-1	-1	+1	+1	0	13	8	H	LxL
23	KM-8 x HM	+1	-1	+1	-1	+1	-1	+1	-1	+1	+1	0	+1	-1	0	-1	-1	-1	+1	+1	+1	+1	+1	0	12	8	H	LxL
24	KM-8 x PS	0	+1	+1	-1	+1	+1	+1	-1	+1	0	0	+1	-1	-1	-1	+1	+1	+1	-1	-1	+1	+1	+1	13	7	H	LxH

1. Vine length at 30 DAS
2. Vine length at 60 DAS
3. Vine length at 90 DAS
4. Number of branches at30 DAS
5. Number of branches at60 DAS
6. Number of leaves at30 DAS
7. Number of leaves at 60 DAS
8. Days to first flowering
9. Days to first female flowering
10. Number of nodes upto female flower
11. Days to first harvest
12. Number of fruiting branches
13. Number of fruits per vine
14. Average fruit weight
15. Fruit yield per vine
16. Fruit shape index
17. Flesh thickness
18. Rind thickness
19. Cavity length
20. Cavity breadth
21. Total soluble solids
22. Total sugars
23. β- carotene content of the fruit

DAS – Days after sowing

0 – Non-significant heterosis

+1 = Heterosis in desirable direction

-1 = Heterosis in undesirable direction

H – Highly heterotic / high combiner

L – Low heterotic / Low combiner

CH – Crosses for heterosis

PG – Parents for gca

lines, *viz*., KM-1, KM-2 KM-5, KM-7 and KM-8 were identified as poor combiners over all characters among lines. Among the testers, PS was identified as good combiner over all characters and AR and HM were identified as poor combiners over all characters.

By comprehensive assessment of crosses by considering heterosis values of 23 characters revealed that out of 24 crosses, 20 crosses were highly heterotic and four were low heterotic. Among 20 highly heterotic crosses, nine crosses involved high x low or low x high parental combinations, three crosses involved high x high parental combinations and eight crosses involved low x low parental combinations. The results indicated that high frequency of highly heterotic hybrids could be obtained from parental combination with high x low or low x high and low x low general combining ability. This explains the fact that, the parental contribution to the heterosis is mainly through non-additive gene effects.

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. SCA to GCA ratio was very high (Table 21) for the traits cavity breadth, total sugars, fruit yield per vine, number of fruits per vine and flesh thickness, indicating predominance of non-additive gene action and hence, these traits can be improved through recurrent selection for specific combining ability and heterosis breeding. Non-additive component was reasonably more than additive component for number of fruiting branches, average fruit weight, total soluble solids, cavity length, days to first harvesting, vine length at 60 DAS, β-carotene content of fruit and number of branches at 60 DAS. For these traits, simple selection and recurrent selection schemes can be followed to exploit additive and non-additive components of genetic variance. Additive genetic variance was more than the non-additive genetic variance for number of leaves at 30 DAS, number of nodes upto first female flower, number of leaves at 60 DAS, fruit shape index, days to first flowering, days to first female flowering, vine length at 30 and 90 DAS, number of branches at 30 DAS and rind thickness and hence these traits can be improved through simple selection.

Future line of work

The crosses KM-7 x HM, KM-6 x HM and KM-3 x PS were the superior hybrids selected for fruit yield per vine and can be commercially exploited after assessing their stability for yield. These hybrids can also be used further for yield improvement through recurrent selection or heterosis breeding as non-additive components of genetic variance are predominant for yield. The lines KM-3, KM-4 and KM-6 were identified as good overall combiners and can be further employed to identify new and highly heterotic hybrids.

The characters cavity breadth, total sugars, fruit yield per vine, number of fruits per vine, flesh thickness, number of fruiting branches per vine, average fruit weight, total soluble solids, cavity length, days to first harvest and β-carotene content of the fruit are predominantly controlled by non-additive gene action and hence, heterosis breeding and recurrent selection can be employed for improvement of these traits. Direct selection can be effective for improvement of traits like number of leaves, number of nodes upto first female flower, fruit shape index, days to first flowering, days to first female flowering and rind thickness as the additive component of genetic variance is predominant. For vine length and number of branches, where additive as well as non-additive gene effects are predominant, simple selection or recurrent selection can be employed for improvement of these characters.

6. summary AND CONCLUSIONS

The present investigation on combining ability and heterosis studies in muskmelon was carried out in the fields of Department of Vegetable Science of Kittur Rani Channamma College of Horticulture, Arabhavi, Belgaum district (Karnataka). Twenty-four crosses were developed by crossing eight line with each of three testers. All the crosses were evaluated along with parents in randomised block design with two replications with the objective of identifying good combiners and assessing magnitude of heterosis for various traits. Various growth, earliness, yield and quality parameters recorded were subjected to line x tester analysis. Variance due to genotype was significant for all the traits studied, *viz*., vine length at 30, 60 and 90 days after sowing (DAS), number of branches at 30 and 60 DAS, number of leaves at 30 and 60 DAS, days to first flowering, days to first female flowering, number of nodes upto first female flower, days to first harvest, number of fruiting branches per vine, number of fruits per vine, average fruit weight, fruit yield per vine, fruit shape index, flesh thickness, rind thickness, cavity length, cavity breadth, total soluble solids, total sugars and β-carotene content of the fruit. Variance due to parents was significant for all the traits except for number of branches at 30 DAS. Variance due to crosses was significant for all the characters studied.

Magnitude of heterosis over commercial check (Rasik) was very high in desirable direction and it ranged from -34.48 to 75.86 per cent for flesh thickness, -31.36 to 70.93 per cent for total soluble solids, -22.34 to 68.07 per cent for number of leaves at 60 DAS, 18.26 to 67.08 per cent for number of branches at 60 DAS, -51.11 to 66.97 per cent for average fruit weight, -46.07 to 66.85 per cent for fruit yield per vine, -37.40 to 63.50 per cent for total sugars, -16.95 to 61.69 per cent for number of leaves at 30 DAS, -43.53 to 50.00 per cent for number of branches at 30 DAS, -54.94 to 48.89 per cent for β-carotene content of the fruit, -45.91 to 42.69 per cent for number of fruits per vine, 31.91 to -40.42 per cent for rind thickness and 27.35 to -40.17 per cent for fruit shape index. High magnitude of standard heterosis was observed in favourable direction for number of fruiting branches (-7.35 to 37.81%), cavity breadth (63.81 to -36.83%), vine length at 90 DAS (2.77 to 35.38%), vine length at 60 DAS (-13.27 to 33.94%) and number of nodes upto first female flower (20.34 to -29.66%). Magnitude of standard heterosis ranged from -6.99 to 23.95 per cent for vine length at 30 DAS, 68.73 to -22.36 (desirable) per cent for cavity length, 8.50 to -19.93 (desirable) per cent for days to first harvest, 42.45 to -18.82

(desirable) per cent for days to first female flowering and 12.80 to -18.82 (desirable) per cent for days to first flowering.

Out of 24 crosses, 11 crosses over better parent, eight crosses over the best parent and 13 crosses over the commercial check exhibited positively significant heterosis for fruit yield per vine. Maximum positive and significant standard heterosis for yield was observed in the cross KM-7 x HM (66.85%) followed by KM-6 x HM (45.50%), KM-3 x PS (33.71%), KM-4 x PS (32.58%), KM-2 x AR (31.46%), KM-4 x AR (30.34%), KM-6 x PS (29.21%) and KM-6 x AR (28.09%). The hybrid KM-7 x HM was identified as best hybrid for fruit yield per vine (2.97 kg) with an estimated yield potential of 49.50 tonnes per hectare. This hybrid also exhibited significant standard heterosis in the desirable direction for number of fruits per vine, vine length at 90 DAS, number of branches at 60 DAS, number of leaves at 30 DAS, number of nodes upto first female flower, flesh thickness, rind thickness, total soluble solids and total sugars.

The cross KM-6 x HM was the second best hybrid selected for fruit yield per vine (2.59 kg/vine) with an estimated yield potentiality of 43.16 tonnes per hectare and was the top hybrid for average fruit weight (1257.67 g). This hybrid also exhibited significant standard heterosis in the desirable direction for number of fruiting branches per vine, number of branches at 30 and 60 DAS, number of leaves at 30 DAS, days to first flowering, days to first female flowering, number of nodes upto first female flower, days to first harvest, flesh thickness, total soluble solids and total sugars.

The cross KM-3 x PS was the third best hybrid selected for fruit yield per vine (2.38 kg/vine) with an estimated yield potentiality of 39.66 tonnes per hectare. This hybrid also exhibited significant and standard heterosis in the desirable direction for average fruit weight, number of fruits per vine, number of fruiting branches per vine, vine length at 30, 60 and 90 DAS, number of branches at 30 and 60 DAS, number of leaves at 30 and 60 DAS, days to first flowering, days to first female flowering, number of nodes upto first female flower, days to first harvest, flesh thickness, rind thickness, total soluble solids, total sugars and β-carotene content of the fruit.

The lines KM-6, KM-4 and KM-7 were identified as the good general combiners for fruit yield per vine in order of merit. For average fruit weight, the lines KM-4, KM-7, KM-8, KM-6 and KM-3 were identified as good general combiners and the lines KM-3, KM-2, KM-4 and KM-6 for days to first flowering, the lines, KM-3, KM-2 and KM-4 for number of nodes upto first female flower, the lines KM-4, KM-3 and KM-8 for days to first harvest, the lines KM-3 and KM-4 for vine length at 60 and 90 DAS, the lines KM-3, KM-4 and KM-6 for number of branches at 60 DAS, the lines KM-3 and KM-4 for number of leaves at 60 DAS, the lines KM-5 and KM-6 for fruit shape index, the line KM-3 for flesh thickness, the lines KM-4, KM-8 and KM-6 for total soluble solids, the lines KM-8 and KM-4 for total sugars and the lines KM-3 and KM-2 for β-carotene content of the fruit were identified as general combiners. The line KM-1 given maximum yield (2.24 kg/vine) among parents which was higher than commercial check (1.78 kg/vine).

The crosses KM-7 x HM, KM-3 x PS and KM-2 x AR were identified as good specific combiners for fruit yield per vine in order of merit. The crosses KM-6 x HM, KM-4 x PS, KM-3 x PS, KM-2 x AR, KM-8 x HM, KM-7 x HM and KM-1 x AR for average fruit weight, the cross KM-7 x AR for number of fruits per vine, the crosses KM-3 x PS and KM-7 x AR for number of fruiting branches per vine, the crosses KM-7 x AR, KM-4 x PS and KM-6 x HM for days to first flowering, the crosses KM-6 x HM, KM-4 x PS and KM-7 x HM for days to first female flowering, the cross KM-8 x AR for days to first harvest, the crosses KM-7 x AR, KM-3 x PS and KM-8 x AR for vine length at 60 DAS, the crosses KM-4 x PS and KM-6 x HM for number of branches at 60 DAS, the crosses KM-6 x AR, KM-1 x PS and KM-3 x PS for number of leaves at 60 DAS, the crosses KM-3 x PS, KM-6 x HM and KM-8 x AR for total soluble solids, the crosses KM-3 x PS and KM-7 x HM for total sugars and the crosses KM-8 x HM, KM-7 x PS and KM-6 x AR were identified as good specific combiners for β-carotene content of the fruit.

Comprehensive assessment of parents by considering gca effects of 23 characters has resulted into identification of lines, *viz*., KM-3, KM-4 and KM-6 and tester PS as good combiners (high) over all characters. Comprehensive assessment of crosses by considering standard heterosis values of all the traits revealed that, out of 24 crosses, 20 crosses were highly heterotic. Out of these 20 highly heterotic crosses, nine crosses involved high x low or low x high, three crosses involved high x high and eight crosses involved low x low parental combinations.

Studies on combining ability variance revealed that non-additive gene action was predominant for cavity breadth, total sugars, fruit yield per vine, number of fruits per vine, flesh thickness, number of fruiting branches per vine, average fruit weight, total soluble solids, cavity length, days to first harvest, vine length at 60 DAS, β-carotene content of the fruit and number of branches at 60 DAS. Additive gene action was predominant for number of leaves at 30 DAS, number of nodes upto first female flower, number of leaves at 60 DAS, fruit shape index, days to first flowering, days to first female flowering, vine length at 30 and 90 DAS, number of branches at 30 DAS and rind thickness.

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* Originals not seen

Appendix I

Physico-chemical properties of soil from experimental site

Sl. No.	Particular	Value obtained	Methods adopted
1.	Available nitrogen (kg/ha)	188.40	Alkaline permanganate method (Subbiah and Asija, 1956)
2.	Available phosphorus (kg/ha)	22.00	Calorimetry method (Olsen *et al*., 1954)
3.	Available potassium (kg/ha)	325.36	Neutral normal NH_4 OAC method (Stanford and English, 1949)
4.	Soil reaction (pH)	7.70	Potentiometry method (Jackson, 1973)
5.	Bulk density (mg/m^3)	1.17	Core method (Dhakshinamoorthy and Gupta, 1968)
6.	Water holding capacity (%)	44.53	Keen Raczkowshi box method (Piper, 1966)

Appendix II

Meteorological data recorded for experimental period (2007-08) at Agricultural Research Station, Arabhavi

Month	Rainfall (mm)		Mean maximum temperature (^{0}C)		Mean minimum temperature (^{0}C)		Mean relative humidity (%)	
	2007	2008	2007	2008	2007	2008	2007	2008
January	0.0	0.0	29.41	32.01	12.64	11.37	66.48	78.87
February	0.0	0.0	29.94	33.10	13.64	15.59	63.52	77.25
March	0.0	54.6	30.91	34.87	19.37	18.64	63.86	73.63
April	38.1	46.4	36.20	36.50	21.98	19.50	63.85	73.31
May	24.8	-	37.54	-	23.53	-	72.62	-
June	106.8	-	36.78	-	23.80	-	78.58	-
July	18.1	-	31.32	-	23.03	-	82.20	-
August	39.8	-	32.85	-	22.24	-	87.16	-
September	62.7	-	32.92	-	22.27	-	85.94	-
October	34.7	-	32.45	-	19.35	-	81.39	-
November	4.6	-	32.72	-	14.52	-	79.39	-
December	0.0	-	31.69	-	14.83	-	75.96	-

Appendix III

Flesh colour, skin colour, skin netting, per cent fruit fly incidence and downy mildew incidence of parents in muskmelon

Sl. No.	Genotypes	Flesh colour	Skin colour (Maturity)	Skin netting	Per cent fruit fly incidence (%)	Per cent downy mildew disease incidence (%)
	Lines					
25.	KM-1	Orange	Greenish yellow	-	30.23	34.90
26.	KM-2	Green	Yellow	-	32.38	37.85
27.	KM-3	Light orange	Yellow	Netted	31.00	31.75
28.	KM-4	Green	Yellow	-	32.15	32.85
29.	KM-5	Green	Brown	-	33.15	37.75
30.	KM-6	Yellow	Orange	-	30.30	31.75
31.	KM-7	Orange	Orange	-	25.40	33.35
32.	KM-8	Green	Green	-	33.35	39.70
	Testers					
33.	AR	White	Creamy white	Light netting	33.28	38.85
34.	HM	Light green	Greenish yellow	-	33.94	37.83
35.	PS	Light green	Green	Netting	30.73	30.76

'-' = Not netted

Appendix IV

Flesh colour, skin colour, skin netting, per cent fruit fly incidence and downy mildew incidence of crosses in muskmelon

Sl. No.	Genotypes	Flesh colour	Skin colour (Maturity)	Skin netting	Per cent fruit fly incidence (%)	Per cent downy mildew disease incidence (%)
	Crosses					
1.	KM-1 x AR	Light orange	Green	-	35.95	41.00
2.	KM-1 x HM	Orange	Yellow	-	37.20	43.75
3.	KM-1 x PS	Green	Yellow	-	34.50	37.35
4.	KM-2 x AR	Light orange	Yellow	Netted	30.40	40.75
5.	KM-2 x HM	White	Yellow	-	35.25	41.75
6.	KM-2 x PS	Orange	Yellow	-	32.38	35.78
7.	KM-3 x AR	Orange	Yellow	-	30.44	33.18
8.	KM-3 x HM	Orange	Light green	Netted	33.80	35.90
9.	KM-3 x PS	Orange	White	Netted	26.65	30.85
10.	KM-4 x AR	White	Yellow	-	28.95	38.55
11.	KM-4 x HM	White	Yellow	-	30.33	42.45
12.	KM-4 x PS	Light orange	Orange	-	28.47	32.90
13.	KM-5 x AR	Yellow	Yellow	-	32.42	44.05
14.	KM-5 x HM	Green	White	-	33.90	37.10
15.	KM-5 x PS	Orange	White	-	37.60	39.85
16.	KM-6 x AR	Orange	Yellowish green	-	32.55	33.25
17.	KM-6 x HM	White	Yellow	-	30.05	32.85
18.	KM-6 x PS	Yellow	Yellow	-	35.70	43.25
19.	KM-7 x AR	White	Green	-	37.60	36.20
20.	KM-7 x HM	White	Green	-	28.95	35.37
21.	KM-7 x PS	Orange	Green	Netted	32.45	36.50
22.	KM-8 x AR	Orange	Yellow	-	37.05	39.20
23.	KM-8 x HM	Orange	Green	-	35.50	44.75
24.	KM-8 x PS	White	Greenish yellow	-	33.85	42.62

'-' = Not netted

COMBINING ABILITY AND HETEROSIS STUDIES IN MUSKMELON (*Cucumis melo* L.)

NAVEEN BADIGER 2009 DR. RAVINDRA MULGE

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ABSTRACT

The investigation on combining ability and heterosis studies in muskmelon was carried out in the fields of Department of Vegetable Science of Kittur Rani Channamma college of Horticulture, Arabhavi. Totally 24 F_1 hybrids were developed by crossing eight lines with each of three testers. These hybrids were evaluated along with parents and commercial check (Rasik) in randomized block design with two replications and data was subjected to line X tester analysis. Magnitude of heterosis over commercial check was very high in desirable direction for flesh thickness (75.86%), total soluble solids (70.93%), number of leaves (68.07%) at 60 days after sowing (DAS), average fruit weight (66.97%), fruit yield per vine (66.85%), total sugars (63.50%), number of leaves at 30 DAS (50.00%), β-carotene content of the fruit (48.89%), number of fruits per vine (42.69%), rind thickness (-40.42%) and fruit shape index (-40.17%). Maximum standard heterosis for fruit yield per vine was observed in the hybrid KM-7XHM (66.85%) followed by KM-6 X HM (45.50%) and KM-3 X PS (33.71%) and these hybrids were also identified as good specific combiners for fruit yield per vine. Fruit yield per vine had positive and significant correlation with average fruit weight and days to first harvest.

Among the testers, PS and among the lines, KM-3, KM-4 and KM-6 were identified as the good overall general combiners based on the comprehensive study considering gca effects for various traits. Non-additive gene action was predominant for cavity breadth, total sugars, fruit yield per vine, number of fruits per vine, flesh thickness, number of fruiting branches per vine, average fruit weight, total soluble solids, cavity length, days to first harvest, vine length at 60 DAS, β-carotene content of the fruit and number of branches at 60 DAS. It is suggested to improve these traits for combining ability through recurrent selection schemes, which ultimately helpful for increasing yield through heterosis breeding.